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Taihoro Nukurangi

Regional Council Freshwater Management Methodologies Volume 1

accounting systems and limit setting

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Executive summary

Freshwater management in New Zealand is going through a period of rapid development, arising from work of the Land and Water Forum (LAWF), the National Policy Statement for Freshwater Management (NPSFM), and the Government's *Freshwater Reforms 2013 and beyond* document (Reforms 2013) released in March 2013. This report describes a NIWA-led project undertaken for the cross departmental Water Directorate located in the Ministry for the Environment. It explores accounting systems and limit-setting processes used by regional councils for managing freshwater resources. Regional councils are required by the NPSFM to set freshwater objectives[1] and limits[2], and the Reforms 2013 document outlines that in order to manage within limits, councils will require a way to account for all water takes and all sources of contaminants.

The project required the exploration of seven Tasks: 1) an international review of approaches to accounting and limit setting for water quantity and quality; 2) a review and evaluation of existing technical methods and systems to account for all water takes; 3) a review and evaluation of existing technical methods and systems to account for all sources of contaminants; 4) an outline of the challenges councils have faced or anticipate in the accounting processes; 5) identification of the minimum and desirable information requirements for undertaking accounting; 6) identification of indicative costs of processes and methods for accounting for all water takes and all sources of contaminants, and of limit setting; and 7) an international review of processes and methods for translating objectives to limits, a national stocktake of such processes and methods used in New Zealand, and an evaluation of these.

Our approach to this work included desktop studies for the international approaches to accounting and limit setting, as well as a national stocktake of current limit-setting processes; and structured interviews with five New Zealand councils to ask questions on these topics, including seeking information about challenges, information requirements and costs.

Task 1: International Review

The desktop international review looked at water allocation, water quantity accounting, water quality (contaminant) accounting, and the setting of limits on resource use in order to achieve certain environmental outcomes. This was done for four jurisdictions: England, Ireland (both subject to the European Union's Water Framework Directive or WFD), California in the United States, and Victoria in Australia. The review then commented on the transferability of any of these approaches to New Zealand. In summary:

- The WFD offers lessons in terms of the setting of strategic level environmental outcomes (similar to a freshwater objective) – the achievement of 'good status for water bodies by 2015, with certain exceptions – and then tasking Member States to set limits to achieve this;

- Water quantity limit setting, through the setting of minimum flows and allocation limits (in New Zealand terminology), is well developed in England;

[1] Defined in the NPSFM as describing the intended environmental outcome.
[2] Defined in the NPSFM as the maximum amount of resource use available, which allows a freshwater objective to be met.

- Ireland has well developed water quality monitoring, partially driven by WFD requirements for assessing the status of water bodies
- In the US, the identification of 'impaired' water quality in water bodies (over allocated in terms of assimilative capacity with regard to contaminant discharges) and consequent setting of total maximum load limits for discharges demonstrates how water quality/contaminant limit setting can be achieved; and
- Australia manages fresh water from a standpoint of scarcity, and has well developed national requirements for water quantity accounting which all states must comply with.

Tasks 2-5: Accounting systems for takes and contaminants

The topic of accounting systems was explored through structured interview workshops with five councils - Waikato Regional Council (WRC), Horizons Regional Council (Horizons), Tasman District Council (TDC), Auckland Council (AC), and Environment Canterbury. A series of questions elicited responses about current status of accounting systems for all water takes and all sources of contaminants, and explored challenges (Task 4), information requirements (Task 5), and costs (Task 6) of implementing such systems. After documenting responses, the five councils' systems were evaluated by comparing strengths and weaknesses with regards to six pre-established criteria: Technical robustness, practicality, transparency, effectiveness, acceptability, and adaptability. In general:

- The councils' accounting 'systems' were comprised of a number of separate components rather than one database or system;
- Water quantity accounting systems are in place, although each system has strengths and weaknesses and often non-consented takes are still not being fully accounted for;
- Water quality accounting is very new and a very challenging prospect. While some councils have produced accounts these are still more likely to be 'one-off' source analyses, with little or no regular accounting. Systems for accounting for nutrients are generally better developed than for other contaminants. All councils have some components of systems in place, as the building blocks for full systems to be developed.
- Overall, councils' accounting systems for water quantity met more of the criteria than the water quality systems;
- Most systems, both quantity and quality, have been developed with regional needs in mind and are fit-for-purpose within region. Some systems have components that may be able to be transferred between regions; and
- Many of the systems have strengths and weaknesses, and there may be potential in developing criteria for a 'good practice' system by using strengths identified in this evaluation.

Challenges and information requirements for accounting systems for water takes and contaminants were summarised from the council interview notes. Overall, while councils understand the value of such accounting, they expect significant challenges with establishing/upgrading, maintaining and quality assuring these systems. Issues with data ownership (privacy issues) and cost attribution (who benefits and therefore who should pay?) require resolution. Recent experience of six councils with developing a new database (Integrated Regional Information System or IRIS) may offer lessons in terms of establishing core fields required by all whilst allowing for regional variability.

Task 6: Costs

The councils were asked specific questions about costs incurred to undertake water quantity and quality accounting and limit-setting activities. Most regional councils were in a realistic position to comment on general level of costs. In general, what councils were able to supply was costs for information systems that make up one component of their accounting 'systems', and costs relating to the development of regional policies or plans which may have been broader in scope than limit-setting processes (implementing the NPSFM) per se. Where feasible, indicative costs were split into policy development and implementation cost categories for each process identified.

For some regional councils, water quality and quantity 'systems' could not be split easily and were lumped together. The details of what costs each council were able to supply is outlined in the body of the report, but at a summary level the development of regional plans including water quantity and quality limit-setting policies ranged from as little as $246,000 to $9 Million (M). For WRC, water quality limit-setting policies (i.e. Variation 5 and Healthy Rivers) amounted to $19.2M and its water quantity limit-setting policies (i.e. Variation 6) totalled $22.23M (these costs include policy development and implementation costs). The higher costs have typically been experienced by councils who have already been through intense planning processes including Environment Court, such as WRC's Variation 5 and 6 and Horizons' Proposed One Plan, which were broader in scope than the limit setting requirements of the NPSFM.

Costs related to information system components of water quantity accounting systems averaged from $930,000, to $2M and to $4.7M per region for policy development/implementation costs. Operational costs are in addition of these costs and ranged from $170,000 to $360,000 per year. Information system components of water quality accounting systems cost councils on average $500,000 annually, where these costs were able to be separated.

However, care has to be taken with the interpretation of these cost ranges, as the approach to implementing systems/policies differed considerably between councils. In some cases, where systems had been established many years ago, only the last two years of costs were accounted for, so that total costs were underestimated. In addition, the regions differed widely in terms of water quality and quantity management requirements, and therefore, costs to meet these requirements varied widely. Each council had their own way of recording budgets, which makes comparisons even more difficult.

Task 7: Limit setting

The topic of limit setting involved a desktop review and the council interview workshops, and used the objectives-limits cascade (Figure S1-1) as a 'yardstick' for comparison.

The desktop review first revisited international approaches (Task 1) to limit setting, and added Queensland, Australia into the mix. The review concluded that:

- The objectives–limits cascade (Figure S1-1) exists more or less in these other countries at least down the cascade as far as box 3, setting concentration-based receiving water standards (for quality) and setting minimum flows and allocation limits (for quantity);
- All countries have the same struggle with the linkages between objectives and water quality criteria (e.g. multi-stressor complications) and needing to accommodate practicalities of existing uses and social economic effects;
- A key challenge is in defining the limits to resource use (box 5) to achieve the receiving water standards. The US have pursued this with Total Maximum Daily Loads (TMDLs) which are triggered once over-allocation occurs. This is made more complicated in some jurisdictions where the responsibility for policy and river basin planning is often separated from the responsibility for administering abstraction and discharge licensing.

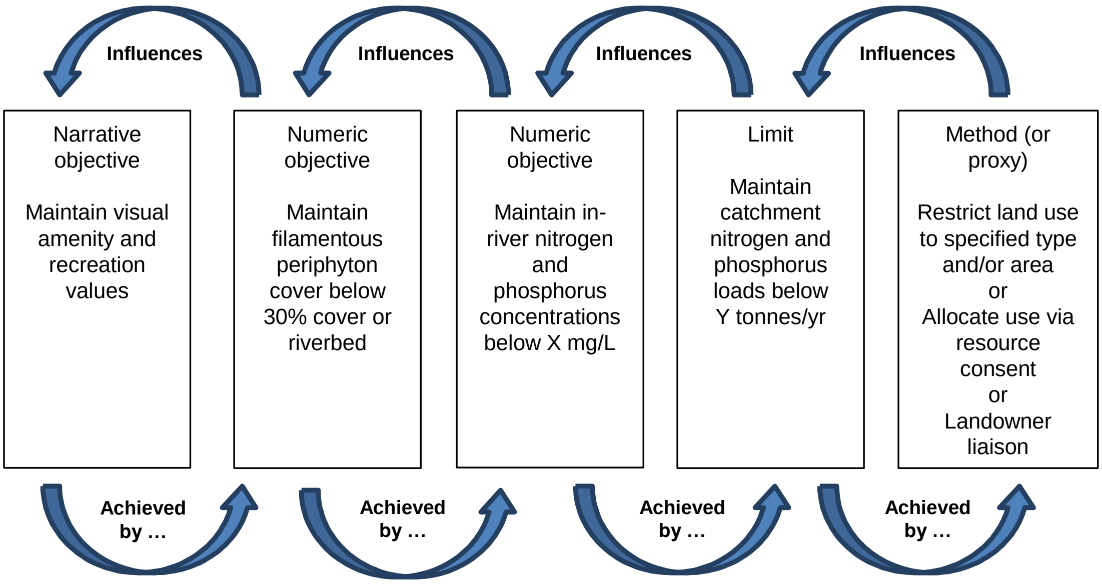


Figure S1-1: Objective-limits cascade example (From NPSFM Implementation guide, and Environment Canterbury 2012). In the text below, the boxes are referred to by number from left to right.

Next a desktop review of existing literature and case-study regional plans explored this story further. In general:

- At regional level, most have got to the third box (numeric objectives for receiving water concentrations) in the objectives–limits cascade (Figure S1-1).
- Progress to the fourth and fifth boxes (limits and methods) varies and only occurs for catchment-scale examples, generally where obvious over-allocation has prompted the action (e.g. TMDLs in the US for impaired water bodies, New Zealand lakes examples such as Taupo, Rotorua Te Arawa lakes, Waihora/Ellesmere, Wainono lagoon, and for the Manawatu River). In New

Zealand we are also trying to set resource limits pre-emptively before over-allocation occurs (e.g. Lake Benmore, Hurunui). To do this, a clear picture of water abstractions and contaminant sources (i.e. accounting) is needed, in order to assign roles and responsibilities across enterprises at the catchment scale.

We then used four criteria to evaluate whether the limit-setting processes of the councils we visited in this study were: technically robust, practical, transparent, and adaptable. Our evaluation of councils suggests that overall councils are making good progress with limit setting, particularly in high risk catchments and lakes. As with the accounting systems:

- Limit-setting is better developed and accepted for water quantity in particular through the setting of minimum flows and increasingly with setting allocation limits;
- Progress with water quality limit setting is generally accelerating although variable by contaminant, with councils exploring different methods and some waiting to learn from the experiences of others; and
- Limit-setting processes have strengths and weaknesses, and the strengths could be explored to help identify good practice examples.

Councils have noted that there are many challenges to limit setting, including time and staff resourcing to go through these processes (especially in a collaborative way). There are process and technical uncertainties, although some councils have identified management approaches that can be used to overcome these challenges.

Overall, there are some ‘lessons learned’ from overseas and current New Zealand good practice identified in this report that might help with any next steps in regard to either the development of accounting systems or limit-setting processes, whether it be via national guidance or national direction. In terms of accounting for water takes, Australia’s legislated requirements for accounting and the Standard developed by the Bureau of Meteorology to guide that may provide useful. Tasman District Council and Auckland Council have robust water take accounts that have been in place for some time. Horizons’ water accounting for telemetered takes illustrates perhaps an ideal - but not always scalable or affordable – system, and their ownership of the telemetry systems demonstrates one way to tackle data ownership questions. Waikato Regional Council have developed a method for estimate permitted takes. In terms of water quality accounting, lessons can be learned from the US Federal EPAs approach to reporting on water quality state, linked to the identification of ‘impaired’ or over-allocated catchments. Waikato Regional Council’s accounting for Lake Taupo and Environment Canterbury’s approaches to sub-regional planning (such as the Hurunui-Waiau) demonstrate good practice in accounting for all sources of contaminants, although in general water quality accountings systems are not as well developed and regular (e.g. annual) accounting is not yet common.

For limit setting, the challenge of moving from numeric objectives (such as receiving water standards) to catchment load limits or individual enterprise load limits (i.e. moving from the third to fourth and fifth boxes in Figure S1-1) is an international one. Other jurisdictions have similar approaches to New Zealand’s NPSFM: minimum flow setting and water allocation is well developed in England and Australia, whereas the US in particular demonstrates good practice in water quality limit setting using TMDLs. Councils in general are using methods and processes that are equivalent to international approaches, for both setting water quantity limits (e.g. physical habitat modelling) and water quality limits (Nutrient Discharge Allowances or NDAs being based on TMDL approaches).

Initial thoughts as to topics that might be useful in any guidance or direction include: the provision of glossary of terms and definitions, provision of worked examples of the Figure S1-1 cascade for both quality and quantity, boxes including international and New Zealand case studies; including a mountains to sea context - Ki uta ki tai – in limit setting; and reviewing and including other requests for help made by councils.

1 Introduction

Freshwater management in New Zealand is going through a period of rapid development, arising from work of the Land and Water Forum (LAWF), the National Policy Statement for Freshwater Management (NPSFM), and the Government's *Freshwater Reforms 2013 and beyond* document (Reforms 2013) released in March 2013. The Water Directorate was established within the Ministry for the Environment (MfE) in August 2012, and includes staff from MfE, the Ministry for Primary Industries (MPI), and other government departments. The Water Directorate's work programme includes a wide range of policy development and implementation planning arising from these national initiatives and documents.

A NIWA-led consortium has been contracted by the Water Directorate to carry out a project exploring accounting systems and limit-setting processes used by regional councils for managing freshwater resources. Regional councils are required by the NPSFM to set freshwater objectives[3] and limits[4], and the Reforms 2013 document outlines that in order to manage within limits, councils will require a way to account for all water takes (Reforms 2013 p38) and all sources of contaminants (Reforms 2013 p48).

1.1 Project Tasks

There are seven Tasks included in the project:

1. International Approaches

- Carry out a desk top study to identify and summarise accepted international approaches in up to six countries e.g. Canada, Australia, European Union, and United States for:
  - Assessing the water available for allocation.
  - Accounting for all water abstracted.
  - Accounting for all sources of contaminants.
  - Translating objectives into limits.
- Provide an assessment of the applicability of the approaches for use at managing freshwater in NZ.

Accounting

2. Accounting for water takes (Water Quantity)

- Identifying and documenting existing technical practices, processes, methods and systems to account for all takes of freshwater resources being used by councils (or proposed to be used). In particular:
  - Any material differences in the assessment processes for different types of takes.

[3] Defined in the NPSFM as describing the intended environmental outcome.
[4] Defined in the NPSFM as the maximum amount of resource use available, which allows a freshwater objective to be met.

- Unmeasured takes (including those authorised by Section 14(3)(b) and (d) of the Resource Management Act 1991).
- Unauthorised takes.

- Identifying existing practices for assessing the impacts of land use change on water availability for the purposes of setting objectives and limits.
- Identify and evaluate the technical methods used by councils for assessing the water available for allocation.
- Undertake a critical evaluation of the technical methods and processes used.

3. Accounting for contaminants (Water Quality)

- Identifying and documenting existing and proposed technical practices, processes, methods and systems being used (or proposed to be used) by councils to account for all sources of contaminants.
- Identifying existing approaches for assessing the impacts of land use change on water quality as part of the accounting process.
- Undertake a critical evaluation of the technical methods and processes in use or proposed.

4. Challenges

- Outline the difficulties and debates/tensions Councils have faced or anticipate in determining the water available for allocation and the accounting processes outlined above, and how any uncertainties have been managed.

5. Information requirements

- Identify the minimum and desirable information requirements for effectively assessing the water available for allocation and accounting for all water abstractions and all sources of contaminants.

6. Costs

- Document the indicative costs of the processes, methodologies and tools councils are using (or propose to use) and identification of any significant capability and capacity issues.

7. <u>Linking Objectives with Quality and Quantity Limits under the National Policy Statement for Freshwater Management</u>

- Carry out a desk top study to identify and evaluate comparable international approaches that translate and/or link objectives to limits. Focus on documenting definitions, mechanisms/methods/tools used to provide links, highlighting similarities and differences. Queensland, Australia, may be one international example of a jurisdiction providing links between objectives and limits. The exact definitions provided for these terms will need to be clearly detailed to ensure the approaches can be used in the New Zealand context.

- National Stocktake: Document the methodologies councils are using to translate/link objectives and limits in the process of implementing the NPSFM (e.g. Biggs Method, Lake Taupo, Lake Rotorua). This should include councils that have provided links and also those who have proposed links between objectives and limits. This should include all the information they are using to arrive at objectives and limits (e.g., the use of standards, guidelines, models, technical experts, council and community discussion). Document what is working well and the difficulties, debates/tensions Councils have faced/anticipate facing in the process, and how uncertainties have been/will be managed.

- Based on the information obtained in undertaking the national stocktake critically evaluate the methodologies Councils are using to link objectives and limits. Indicate if and where guidance/direction on processes and technical methods, that link objectives and limits, would significantly reduce technical difficulties, debates and/or tensions when setting objectives and limits.

1.2 Methodology

In order to address these Tasks, the NIWA-led team proposed:

- A desktop review for Task 1;

- A desktop review for Task 7; and

- A series of structured interviews with five selected councils, to address Tasks 2-6 and contribute to Task 7. This was carried out by first visiting one council as a pilot, and then adjusting the approach and questions after consultation with the Water Directorate.

More detailed methodology comments are provided in the relevant sections of this report. Section 2 of this report summarises the results of the review of international approaches (task 1). Section 3 evaluates the current state of the five accounting systems that were reviewed through the pilot and four other council visits, and identifies challenges, information requirements and costs related to accounting systems (Tasks 2-6). Section 4 looks at limit setting and in particular the processes used to link limits to freshwater objectives, by way of further reference to international approaches, a national stocktake, regional case studies, and the limit-setting evaluation for the five councils visited in this study (Tasks 6 and 7).

1.3 A note on terminology

This report is focussed on accounting systems for all takes and all sources of contaminants, and implementation of the NPSFM via the setting of freshwater objectives and limits. Where we use these terms, it is in the NPSFM context. For the international review, we try to provide links between other jurisdictions' definition of terms and the New Zealand equivalent.

2 International approaches

2.1 Methodology

This section seeks to learn from existing practices elsewhere, considering how other countries and regions have addressed their freshwater management issues, and whether they may be transferable to the New Zealand context.

As per Task 1 of the project, the purpose of this review to identify and summarise accepted international approaches in up to six countries, for:

- Assessing the water available for allocation
- Accounting for all water abstracted[5]
- Accounting for all sources of contaminants[6]
- Translating objectives into limits.

In each case, attention is given to definitions, the mechanisms/methods/tools used, and similarities or differences. This ultimately leads to an assessment of the applicability of the approaches for use in managing freshwater in New Zealand. There is overlap with the fourth bullet and material on limit setting contained in Section 4 of this report; the reader is referred to that section for further discussion on that topic.

The review is limited to a concise desktop study of authoritative material. This material is primarily drawn from government websites or those of affiliated agencies (useful sites are summarised in Appendix A). The review essentially entailed a search through these websites, seeking relevant material, following whatever leads had the potential to bear fruit. Sources of information presented here are thus noted as URLs in footnotes so that interested readers may readily dig further should they need to. A few key papers are noted. An important caveat to bear in mind when considering this review is that the work was not completed by individuals with direct experience in the regions studied. It is thus possible that relevant material has been missed, for not being online or not apparent on key websites.

Given the purpose and limited scope of the review, it is important to select a limited number of informative regions as the basis of the review. That is, up to six regions or jurisdictions and with environmental conditions and freshwater issues comparable to New Zealand's. Several criteria were used in identifying these regions:

1. Comparable climate (i.e., temperate, humid to sub-humid)
2. Comparable hydrology (i.e., significant river and aquifer systems, gentle to moderate topography)
3. Comparable land use (i.e., significant and well-developed pastoral agriculture, particularly dairying, as well as urban centres)

[5] Accounting for all takes involves identifying and recording all water takes including those not requiring a permit.
[6] Accounting for all sources of contaminants involves identifying where the contaminants to be managed are coming from in a catchment, including identifying urban and rural sources, point sources, and diffuse sources by land use type. It may also include identification of hot spots. Accounting can be carried out before limits are set and management actions are included in Regional Plans, to help inform those decisions. Accounting can also be carried out at intervals once Plans are implemented, to assess the impact of management actions taken

4. Comparable water resource issues (e.g., water shortages, nutrient or sediment pollution from point and non-point sources)
5. Accessible online material (e.g., documents written in English and on government websites)
6. Distinct methods or approaches (i.e., one standardised approach for the entire region)
7. Diversity of approach (i.e., consider distinctly different countries as well as regions).

Criterion 5 eliminated many countries that would have informative water management practices (e.g., Denmark, Russia) as their documents would not be written in English.

Upon considering all possible countries and their sub-regions, those that meet at least some of the above criteria are:

- Australia: Victoria, New South Wales, Tasmania
- Canada: Ontario, Saskatchewan
- USA: California, Oregon, Washington, Wisconsin, Illinois, Indiana, Ohio, Pennsylvania, New York
- UK: England and Wales
- Ireland

Further refinement to identify the final selection of regions/countries resulted in the following list, with particular reasons for their inclusion noted:

- Victoria, Australia: Of the Australian states and territories, Victoria's climate is most similar to New Zealand's. It is the centre of dairying in Australia with significant urban development. Both rivers and aquifers serve as important water resources.
- England and Wales: Water management has received much scientific attention in the past, leading to some unique approaches.
- Ireland: Dairy practices are comparable to NZ's and nutrient enrichment is a key concern.
- California, USA: Significant water use for mixed agriculture (including dairying) and concern for both water quantity and quality. Underpinned by extensive research by research agencies and academia.

In both Australia and the USA, water resources are managed at multiple levels – national (federal), cross-border, state or territory, sub-state regional, and local – and while there will be some similarities among the lower levels, there are differences in how each of the lower levels manage freshwater. Water quality limits in California, for example, are led at the national level and determined at the state or sub-state level, while water quantity limits are led and set at the state level. Canada's provinces were ultimately omitted because their freshwater challenges are not as severe as other regions already on the list and would not be as informative as the other regions considered.

For each of these four regions, the review considers the four bullet points outlines at the start of section 2.1 as well as their applicability to New Zealand. A summary table provides a quick summary and comparison between the reviews. Task 7 included mention of Queensland, Australia as having potential to inform limit-setting approaches, and for this reason a review of Queensland's approaches to limit-setting only (i.e. not accounting systems) is also included.

2.2 England and Wales

England and Wales are generally wetter on the west and drier on the east, due to the different air masses that meet over the British Isles. On average it rains one in three days in the UK, with an average rainfall of 897 mm/year (EA 2001). The wettest place is Snowdonia in Wales (average annual totals exceeding 4,000 mm/year), but parts of the east, such as East Anglia, receive less than 550 mm/year.

In 1997-98, the top two abstraction uses of water were: public water supply (45.4%) and electricity (32.1%), where the latter is predominantly non-consumptive. Demand for irrigation is concentrated mainly in East Anglia and parts of the Midlands. Despite only accounting for around one per cent of total abstraction, irrigation is concentrated into a few months when water resources are most scarce, and little of the water is returned to the environment[7].

Freshwater management issues in England and Wales include periodic water scarcity, environmental degradation due to over-abstraction, and degraded water quality from both point and non-point sources.

England and Wales (and Ireland in section 2.3) are subject to the European Union (EU) Water Framework Directive (WFD), so we give a brief overview of the WFD in regards to technical aspects of limit setting here. The WFD was adopted in October 2000[8], and under the WFD general objective (Article 4) Member States are obliged[9] to maintain or restore all surface water bodies to 'good status' by 2015. This is an 'aim to achieve objective' that is tempered by considerations of feasibility and economic assessments that consider disproportionate cost and affordability. Good status is comprised of Good Ecological Status (GES), and Good Chemical Status (GCS). The WFD also introduces the principle of preventing any further deterioration of status, with exemptions. Water bodies are classified into five status levels (high, good, moderate, poor, bad). Water quantity is considered as a hydromorphological component of GES (Redeker 2009). GES is a 'reference' condition, allowing for only a slight deviation from a natural (low anthropogenic impact) condition. This reference condition is established on a case by case basis by Member States and while guidance on how to do this is provided, there is potential for different interpretation of the GES (which is therefore probably equivalent to a narrative objective). On the other hand, GCS is defined in terms of compliance with all the quality standards established for chemical substances at European level (see section 2.2.3), and so may be more closely aligned to New Zealand's numeric objectives. For groundwater, the WFD presumes that it should not be polluted at all, so it sets standards for a few chemicals (such as nitrates) and prohibits

[7] Water resources strategy, at http://www.environment-agency.gov.uk/research/library/publications/40731.aspx
[8] http://ec.europa.eu/environment/water/water-framework/
[9] Although there are exemptions, see also pers. com from Stuart Kirk in Section 4.2.2

direct discharges to groundwater. Groundwater levels are controlled using 'quantitative status', which limits the quantity available for abstraction to the portion of the overall recharge not needed by the ecology of connected ecosystems (surface waters or wetlands) - defining this as the sustainable groundwater resource. These 'status' requirements drive the management of water quantity and water quality across the EU.

The WFD also requires (Article 13) the development of River Basin Management Plans (RBMP) to integrate freshwater management at river basin (or catchment, in New Zealand terminology) scale. The RBMP is a detailed account of how the objectives set for the river basin (ecological status, quantitative status, chemical status and protected area objectives) are to be reached within the timescale required[10]. RBMPs have a six-year life (e.g., 2009-2015).

2.2.1 Water available for allocation

Water allocation in England and Wales has until recently been managed by the Environment Agency (EA[11]), although from April 2013 the EA becomes an England only agency[12], and taking over responsibility for Wales is Natural Resources Wales. This review is based on water management approaches developed for England and Wales under the WFD.

England and Wales are divided into seven regions (River Basin Districts or RBDs), each with their own Catchment Abstraction Management Strategies (CAMS). The Anglian region, for example, has 13 CAMS[13]. The Resource Assessment and Management (RAM) Framework is the tool used to estimate environmental flow requirements (Acreman et al. 2008).

The first stage of the CAMS process –the resource assessment – identifies the resource availability status within water bodies after considering the needs of the environment. A water balance is calculated for the catchment (including abstractions)[14]. The resource assessment also identifies parts of catchments where abstraction is causing, or has the potential to cause, environmental damage (and catchments not meeting their Environmental Flow Indicators (EFIs)).

The EFI[15] is a percentage deviation of the current or target flow from the natural river flow represented using a flow duration curve. It depends on the ecological sensitivity of the river in question. EFIs are set through expert opinion and at a level to support GES. They are based on scientific research[16] spanning the entire UK, tailored for different rivers or geological conditions. EFIs are used to indicate where abstraction pressure may cause an undesirable effect on river habitats and species (i.e. where flows may cause the river to drop below GES.

The amount of allocable surface water is determined from hydrological modelling using historical data, abstraction scenarios and EFIs. Resource availability is expressed as a surplus or deficit of water resources in relation to the EFI. This is calculated by taking the natural flow of a river, adding back in discharges and taking away existing abstractions. This

[10] http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm
[11] http://www.environment-agency.gov.uk/research/planning/33106.aspx
[12] http://www.environment-agency.gov.uk/aboutus/145716.aspx
[13] http://www.environment-agency.gov.uk/business/topics/water/119931.aspx
[14] http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/LIT_4892_20f775.pdf
[15] EFI factsheet http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/LIT_7935_7aa365.pdf
[16] http://www.wfduk.org/sites/default/files/Media/Environmental%20standards/Environmental%20standards%20phase%201_Finalv2_010408.pdf

results in a scenario showing both a recent actual and fully licensed river flow. The difference between the fully licensed scenario flow and EFI gives the amount of water which is available for abstraction (i.e., the allocable water in New Zealand terms) and when it is available[17]. To reflect the natural variability in flows through the year, resource availability is calculated at four different flows, low flow (Q95); below moderate flows (Q70); moderate flows (Q50); and higher flows (Q30).

This analysis is conducted at "assessment points" (APs), points in a catchment which are selected as the foci of resource assessment and abstraction licensing. The Nene Catchment Allocation Management Strategy[18] provides an example that is repeated across the EA's jurisdiction.

For groundwater, CAMS assesses the quantitative status (abstraction pressures) based on the current groundwater abstraction impacts on each groundwater body. This includes the impact of groundwater abstraction on surface water flows, i.e. they are considered as integrated systems.

The second stage of the CAMS process, the licensing strategy, sets out how the EA intends to manage abstraction licensing within each catchment. It identifies what resources are available, what conditions might apply to new licences and whether licences will be replaced with the same conditions. Abstractors within England and Wales require a licence (i.e. a consent) from the EA if their takes may be 20 m^3/day or greater[19]. To date these licences have been issued on a first come first served basis. This means the EA has a legal duty to protect the rights of existing users and the environment from derogation before considering the needs of new applicants. The 2003 Water Act made it a legal requirement for all new licences to be time-limited. Licenses include conditions such as the quantity of water allowed to be taken over a certain period or the rate at which it can be taken.

Setting "hands-off-flow" (HoF) conditions on abstraction licences for surface waters or "hands-off-level" (HoL) conditions for groundwater abstraction licences is one way in which the EA seeks to ensure that EFIs are met. HoF are thresholds (i.e., management flows or restrictions in New Zealand terminology) at which abstraction must cease. HoF conditions are based on outputs from CAMS while taking into consideration WFD requirements[20]. From the EA website:

> *"The 'Environmental flow indicator' (EFI) in CAMS tells us how much water we need to protect for the environment, so we use HoF conditions to ensure that abstractions do not cause river flows to fall below the environmental flow indicators. We base these thresholds on best available data and information about in-river needs and minimum flows required to sustain ecology and protect other abstractors. If an applicant can demonstrate that applying a lower (or no) HoF will still meet these and the requirements of the WFD, we will consider their proposal. These situations are rare."*[21]

[17] EFI factsheet http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/LIT_7935_7aa365.pdf
[18] http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/LIT7777_9cf68a.pdf
[19] http://www.anglianwater.co.uk/_assets/media/a-right-to-water-full-report.pdf
[20] http://cdn.environment-agency.gov.uk/geho0812busi-e-e.pdf
[21] http://cdn.environment-agency.gov.uk/geho0812busi-e-e.pdf

For many rivers, HoFs are tiered in such a way that abstraction is gradually ramped down as river flow drops below incrementally lower thresholds. This appears to be similar to the use of allocation blocks with differing minimum flows and use of ‘partial restrictions’ or ‘flow sharing’ above minimum flows in some parts of New Zealand (e.g. Canterbury). Groundwater abstraction licences may have HoL conditions such as cessation of pumping when a certain groundwater level has been reached.

The third stage of CAMS involves identifying the nature of the abstraction pressures and suitable solutions for redressing these issues. As of 2008, a third of England and Wales’ catchments were over licenced (where an abstraction license is the equivalent of a water take resource consent in New Zealand) or over abstracted, a third had additional water available, and a third had no more water available[22].

2.2.2 Water use accounting

The WFD requires (Article 11) Member States to keep a register or registers of water abstractions.

The EA website states water abstraction licences usually have a requirement for metering to measure how much water is abstracted[23]. This enables the EA to:

- ensure society's need for water is balanced with that needed to maintain a healthy aquatic environment;
- allocate spare resources to new abstractors;
- charge spray irrigators for the water they take;
- check compliance with licence conditions; and
- provide the government with information on water usage.

An online service is provided on the EA website for businesses to send in water abstraction returns[24].

Water companies account for almost half of the freshwater abstractions[25], providing water to municipalities and industry, though 70% is returned to the environment as treated effluent. Irrigation use is only 1% of abstractions (section 2.2)[26]. The 34 private water companies are regulated by Offwat[27], and provide annual returns on a number of service levels including water quality and quantity, which in turn includes efficiency initiatives and metering. This information may also be summarised by the EA regions in state of environment reporting (see Figure 2-1 below).

In 2010 around a third of homes had water meters and most domestic customers could choose whether to have one fitted[28]. The EA 2009 Water Resources Strategy for England and Wales sets an objective to achieve ‘near-universal’ metering of households, starting in areas with the most water stress.

[22] http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/geho1208bpas-e-e.pdf
[23] http://www.environment-agency.gov.uk/business/topics/water/123416.aspx
[24] http://www.environment-agency.gov.uk/business/topics/117611.aspx
[25] http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/geho1208bpas-e-e.pdf
[26] http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/geho1208bpas-e-e.pdf (page 8)
[27] http://www.ofwat.gov.uk/
[28] http://www.water.org.uk/home/resources-and-links/uk-water-industry/resources

State of the Environment (SoE) reports have been produced for the seven regions, and these include a chapter on water (for example for the Anglian River Basin District or RBD[29]). In terms of water resources, an example summary from the same Anglian report was:

- In 2008, 800,000 million litres of freshwater were abstracted in the Anglian RBD, with approximately 60% of abstracted freshwater coming from surface water and 40% from ground water sources (Figure 9 – reproduced as Figure 2-1).
- 90% of abstraction was for public water supply.
- The agricultural sector accounted for 4% of the total freshwater abstractions.

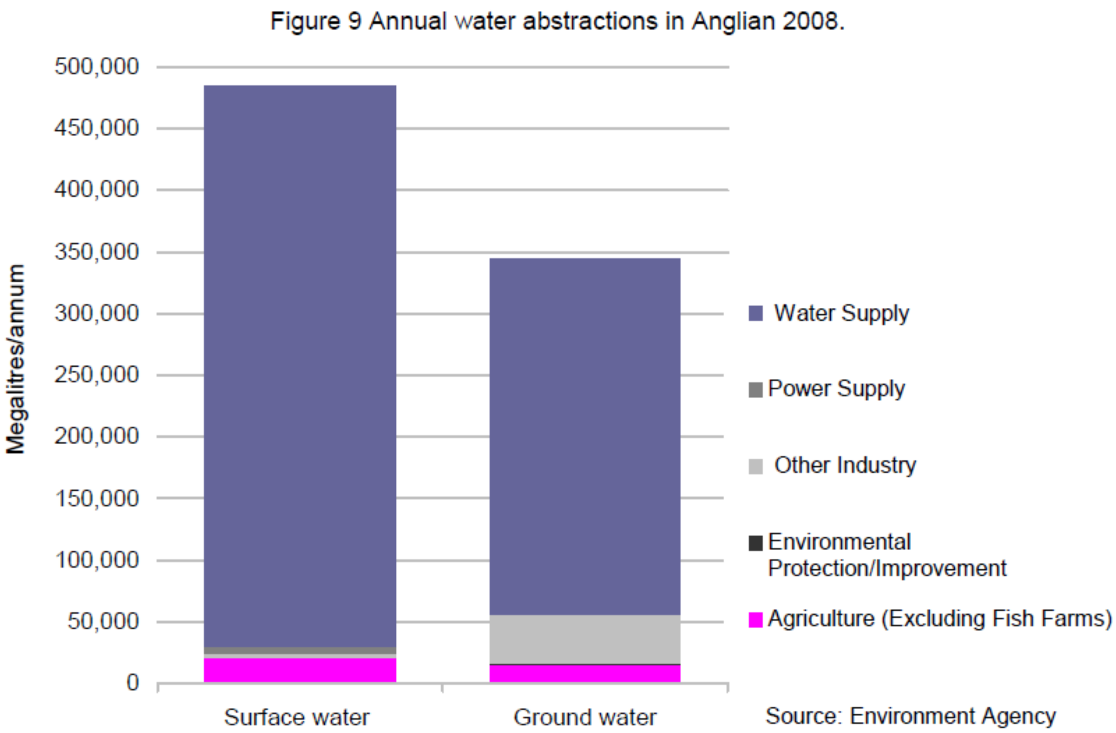


Figure 2-1: Example reporting: annual accounts for the Anglian RBD 2008.

The report also includes comments about household use, derived from water company returns, for example from the same report for the Anglian RBD:

- In 2009-10, people in the Anglian RBD used an average of 147 litres of water/day, compared to the industry average of 146 litres/person/day.
- They were each using less water on average than they did in the previous two years (150 litres/person/day in 2007-08 and 149 litres/person/day in 2008-09).
- There were large differences in the amount of water used by households with water meters and those without.

[29] http://www.environment-agency.gov.uk/research/library/publications/34059.aspx

2.2.3 Water contaminant accounting

The EA are responsible for managing water quality, and since the implementation of the WFD they do this by classifying water bodies in terms of ecological and chemical status. The WFD contains an annex which lists the elements that define the ecological status classes, which include several 'water quality' measures such as clarity, oxygenation and nutrients, as well as hydrological alteration. The achievement of good chemical status is based on thresholds know as Environmental Quality Standards (EQS) (Howard-Williams et al. 2010), which can be set by Member States for all except the 'Priority substances' that are set by the EU (WFD Article 16). The UK Technical Advisory Group (UKTAG[30]) is a working group of experts drawn from UK environment agencies and conservation agencies. One role of the UKTAG is to develop and make recommendations to the UK's government administrations on the environmental standards for implementing the WFD[31].

The 2012 UKTAG report states that for some standards, biological data collected from hundreds of sites can be used to develop the standards, which correspond directly with the biological definition of good status. In other cases, such as for estuaries and coastal waters there are insufficient data to derive standards in this way. In such cases, the UKTAG uses the current scientific understanding of the causes of ecological change, and relies on advice from independent experts from a range of scientific disciplines. The UKTAG has used this 'expert' approach to identify limits for river flow and water levels, and for standards for particular chemicals, expressed as concentrations.

The 2012 UKTAG report also states that in most cases, data from monitoring are used to make a comparison of water quality with the standard. In others, calculations with mathematical models are also used to assess whether a standard is passed or failed. This is not dissimilar to the use of OVERSEER to test farm-scale, or models such as CLUES to estimate catchment scale, nutrient losses in New Zealand.

The WFD explicitly requires Member States to monitor and report on the status of their water bodies. The EA undertakes monitoring including:

- surveillance - to identify long term changes, trends, and inform future monitoring networks. Maps of surveillance network locations are available[32].
- operational - to help classify water bodies which are at risk of failing to meet objectives. The monitoring in these water bodies is tailored to assess the pressures and risks identified, and location of operational monitoring sites will change over time.
- investigative - to assess why a water body is failing to achieve its objectives and decide what action is needed.
- groundwater monitoring - to determine the quantitative status of groundwater bodies.
- protected area monitoring - in surface and ground waters used for the abstraction of drinking water; habitat and species protection areas designated

[30] http://www.wfduk.org/
[31] http://www.wfduk.org/sites/default/files/Media/UKTAG%20Summary%20Report_final_260412.pdf
[32] http://www.environment-agency.gov.uk/research/planning/33264.aspx

under the Habitats Directive, or any other protected area established by EU legislation.

An England and Wales report on water quality was published in 2007[33] and provided a comprehensive assessment of water quality states, trends and threats. Figure 2-2 shows a map of groundwater nitrate levels.

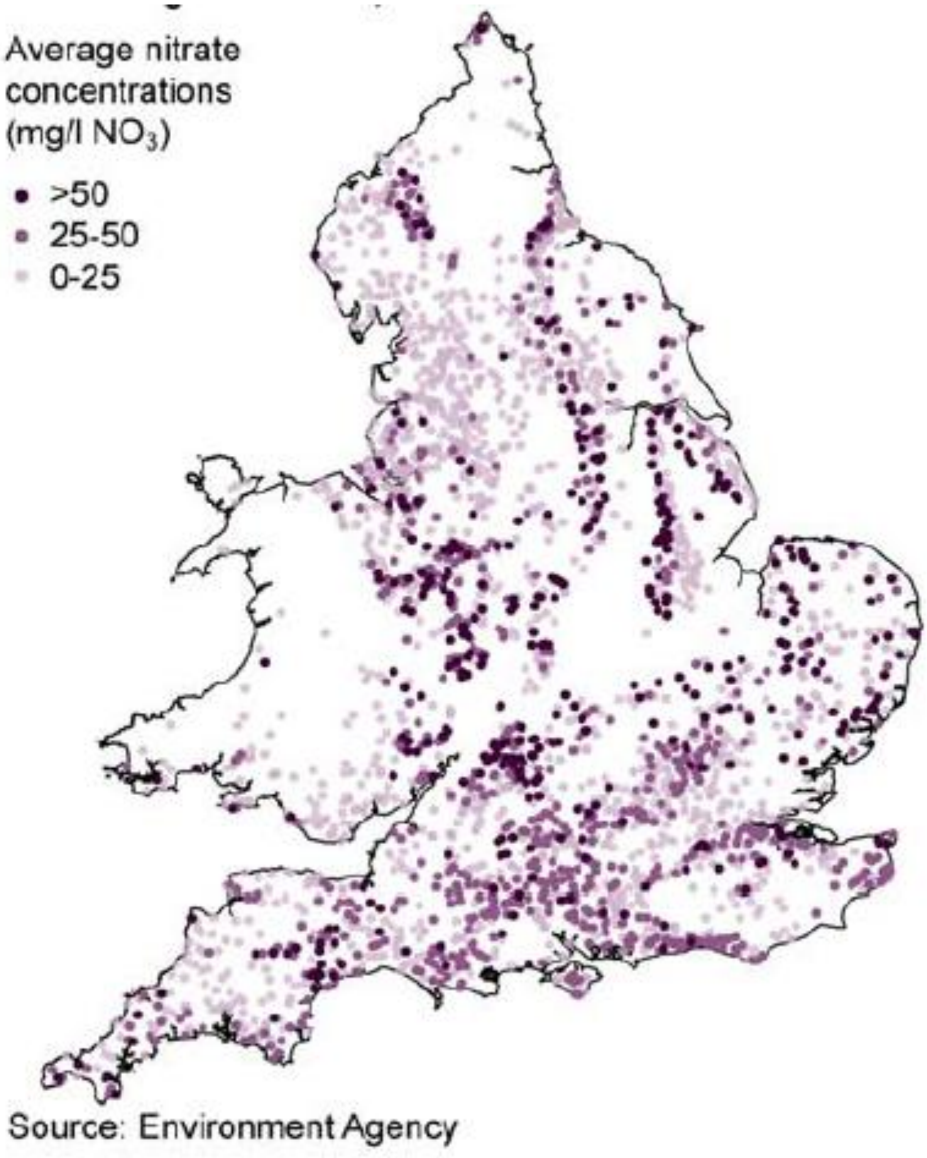


Figure 2-2: Example reporting: Nitrate in groundwater, 2000-2005. Note the reporting as the nitrate molecule not as N in nitrate (as is done in NZ).

As above, each of the seven water management regions produce SoE reports. These provide results on water quantity, water quality, and achievement of the WFD. Figure 2-3 reproduces a map from the Anglian RBD that reports the ecological status of its surface waters.

[33] http://www.environment-agency.gov.uk/research/library/publications/33983.aspx

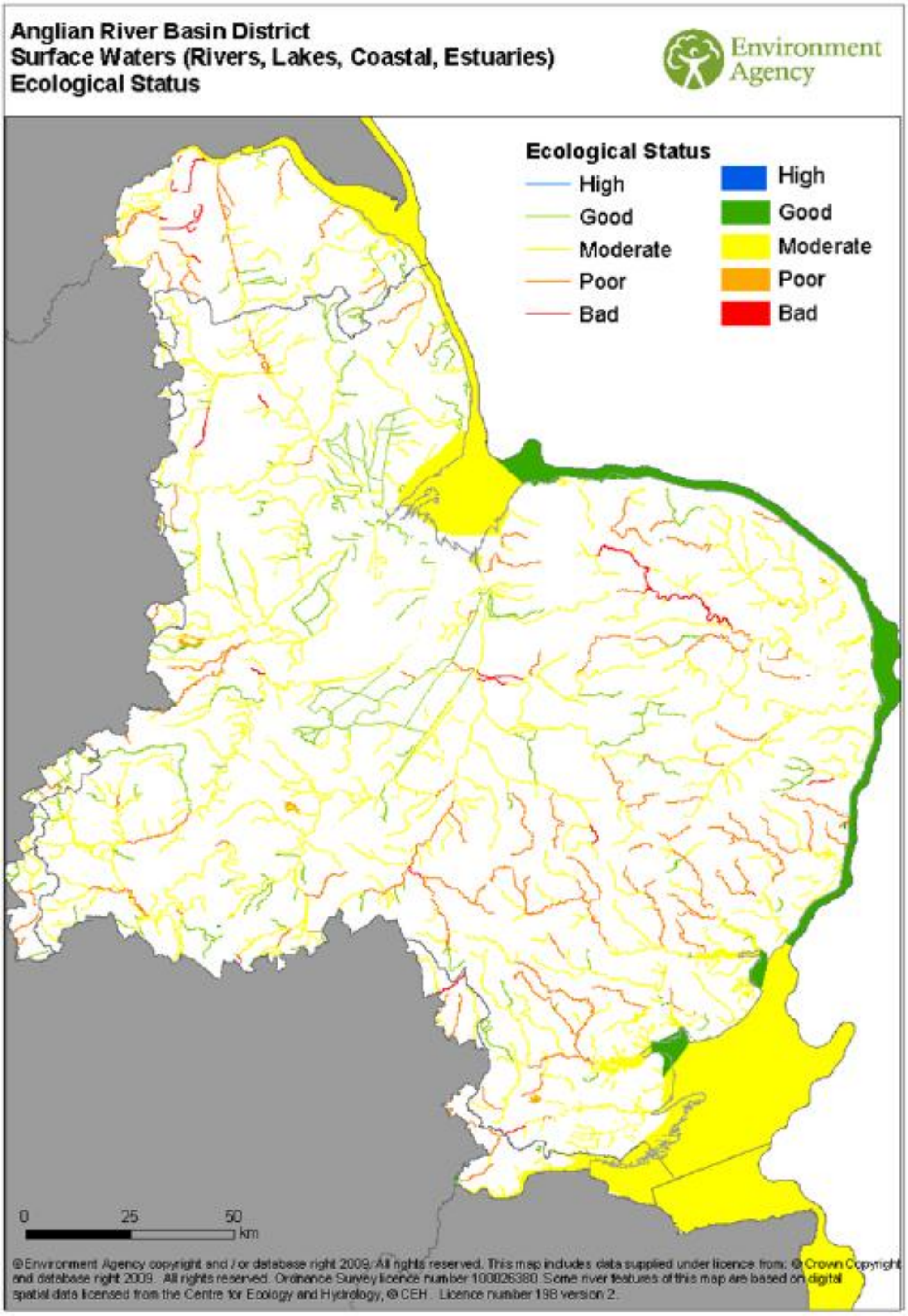


Figure 2-3: Example reporting: Ecological status in the Anglian RBD, 2009.

The report also provides information about how water bodies are performing against 'good chemical status' (GCS), such as in Figure 2-4 below. Similar reporting is given for groundwater.

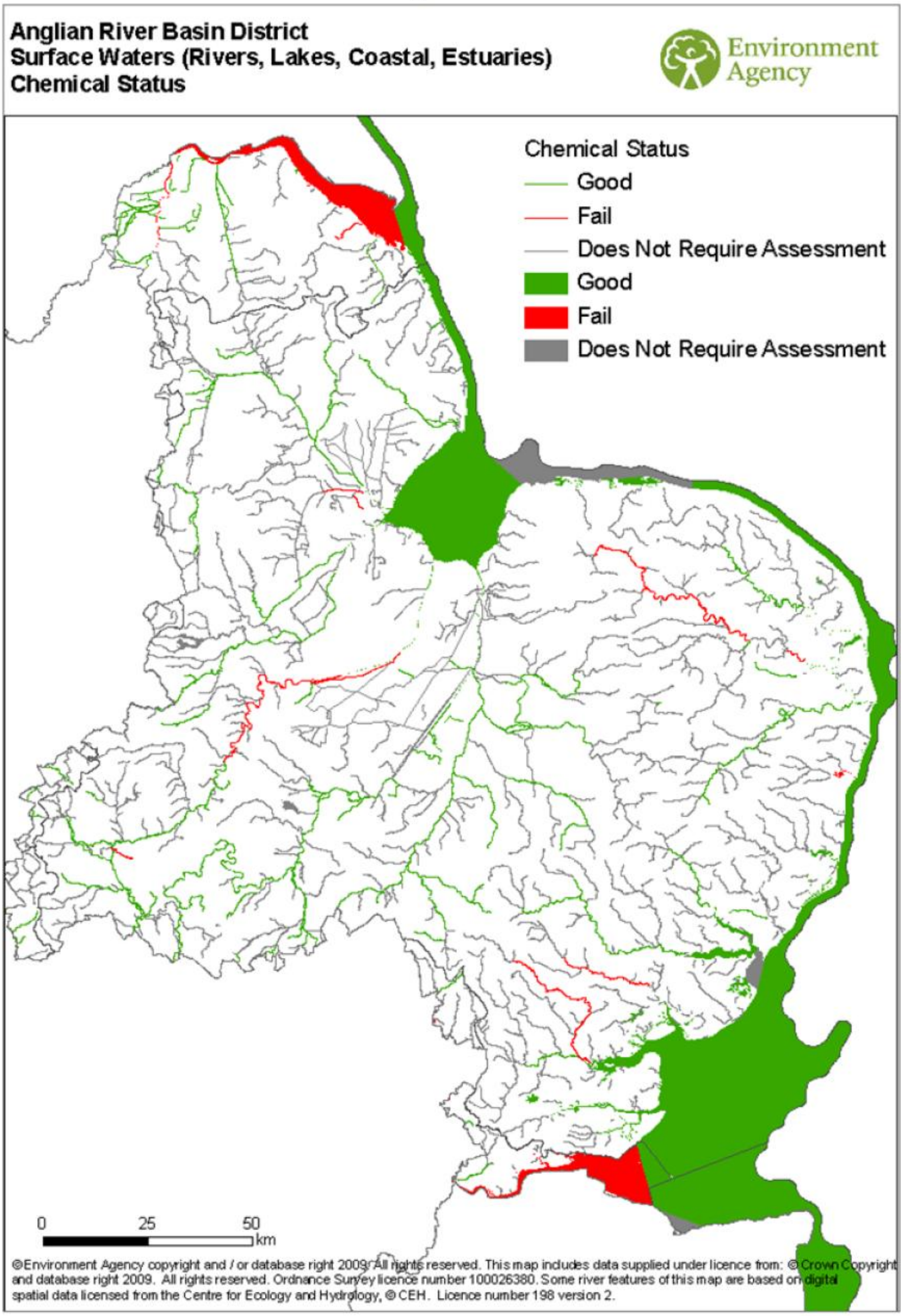


Figure 2-4: Example reporting: Chemical status for the Anglian RBD, 2009.

2.2.4 Translating objectives into limits

For water quantity limit setting, the process of converting objectives (e.g., WFD mandate to achieve GES) into measurable limits is outlined in section 2.2.1, where the process for setting (in New Zealand terminology) minimum flows and an allocation limit is described. Through CAMS, first the limits are set and then abstraction strategies are developed to allocate the resource.

For water quality, again the WFD mandate for GES drives the setting of 'standards' (a numeric objective, concentration in g/L). The EA then uses standards to suggest, for example, limits on the amount of water that can be abstracted, and restrictions on how much pollutant can enter the environment[34].

The expert panel UKTAG is used to set the standards that link the EA's water allocation and water quality limits to WFD objectives. For example, the process for developing standards for specific pollutants is described by UKTAG, and includes a risk assessment to identify potential chemicals that might be specific pollutants, and then a further five steps to derive a standard:

- Step 1: Identify what may be at risk - including aquatic animals and plants, sediment-dwelling organisms, or predators that feed on aquatic organisms.
- Step 2: Collate information on the effects on aquatic biota and decide which are critical.
- Step 3: Use these data to derive Predicted No-Effects Concentrations (PNEC)
- Step 4: Set up a peer review of the PNECs to seek confirmation that they are valid scientifically, and that the data used to derive them are sound and complete.
- Step 5: Look at the practicalities of implementing a standard – Assess whether data uncertainties are sufficiently small to use the PNES as the basis for a standard; if so, this standard is recommended for identification as a Specific Pollutant.

The UKTAG goes on to recommend implementation of these standards through the controls set in discharge permits, for example designing the operation of the discharge to meet a 99 percentile standard in the receiving water, or more extreme percentiles, and setting absolute limits on discharge quality. While this makes the limits to resource use clear for point dischargers, it is not clear what the link is between these standards and resource uses that produce diffuse pollutants.

2.2.5 Applicability to New Zealand

England and Wales have developed systems that enable them to set limits which implement the WFD mandated objectives nation-wide. Methods for deriving water quantity limits are similar to those used in New Zealand (e.g., hydrologic rules of thumb, and instream physical habitat modelling). Methods for water quality numeric objective setting to implement the WFD, by way of EQSs seem to follow similar principles to the (Figure 4-1) objectives-limits

[34] http://www.wfduk.org/sites/default/files/Media/UKTAG%20Summary%20Report_final_260412.pdf

cascade but it is not as clear how the final step to limits for diffuse source pollution/contaminants is undertaken.

The WFD has some common elements with the current approach to freshwater management in New Zealand. For example:

Table 2-1: Summary of WFD and New Zealand equivalent concepts.

WFD	NZ
River basin scale integrated management plans	Catchment scale integrated management plans
Aim to achieve good status mandated at EU level	Value judgment made as to freshwater objective being sought (currently at regional level), but must at least meet the NPSFM requirement of safeguarding life supporting capacity, ecosystem processes and indigenous species
Member States responsible for setting limits to achieve this good status	Regions are responsible for setting limits to meet freshwater objectives
Public participation is required in river basin management planning	A more collaborative approach to plan development is being encouraged through the Reforms 2013 document

Howard-Williams et al. (2010) and Snelder et al. (2010), amongst others, have commented to LAWF about the applicability of the WFD to New Zealand. Snelder et al. (2010) recognised three principles of the WFD which would prove useful for New Zealand. These were: making science-informed value judgements and expressing these as objectives; requiring the use of spatial frameworks; and using science to define standards. LAWF recommendations to Government included an increase in national level policy (such as the NPSFM and Reforms 2013) in regard to freshwater objective and limit setting. Further discussion on the transferability of WFD concepts to limit setting are included in section 4.2.

2.3 Ireland

Ireland has a temperate oceanic climate with mean annual precipitation ranging from 750 to 1250 mm[35], and lacks temperature extremes[36]. The land area is 84,421 km^2 and the landscape comprises central plains surrounded by coastal mountains[37], the highest of which reaches 1041 m. Land uses are predominantly agricultural with the largest proportion of area being permanent grassland pastures. The primary freshwater management issue is water quality[38], deriving from point source municipal wastewater discharges and non-point agricultural runoff.

In Ireland, the “coordination and oversight” of the technical aspects of the WFD has been delegated by the Department of the Environment, Community and Local Government (DECLG) to the Irish Environmental Protection Agency (EPA), while retaining ownership of the economic and policy aspects of the Directive[39]. The technical aspects include water quantity and quality issues, including water body classification, River Basin Management Plans (RBMPs), monitoring and reporting. Ireland has seven River Basin Districts (RBDs), four wholly within Ireland and three that cross boundaries with Northern Ireland. There is also an eighth, which lies wholly within Northern Ireland. Key pieces of legislation for the

[35] http://www.met.ie/climate/rainfall.asp
[36] http://en.wikipedia.org/wiki/Climate_of_Ireland
[37] http://en.wikipedia.org/wiki/Geography_of_Ireland
[38] http://www.epa.ie/irelandsenvironment/water/
[39] http://www.epa.ie/water/watmg/wfd/

management of water in Ireland are listed on the EPA website[40]. One of these is the European Communities Environmental Objectives (Surface Waters) Regulations 2009, which requires relevant Irish authorities to undertake activities in order to achieve the purpose of the WFD, with environmental objectives set that reflect the WFD requirement for good status and so on. The Surface Water Regulations also include the requirement to set EQS's for water quantity and quality[41]. This include emission controls to achieve EQS set in Schedules 5 and 6, and the development of emission inventories for priority substances. Tables 9, 10, 11 and 12 of Schedules 5 and 6 contain the EQS, including receiving water standards in Table 9. There is an equivalent Groundwater Regulation.

2.3.1 Water available for allocation

Due to the moist climate, water demand for irrigation is insignificant relative to significant parts of New Zealand[42]. The issue of water quantity is not highly ranked on either the Department of Environment, Community and Local Government website[43] or the EPA website[44], nor is it discussed in the Water chapter of Ireland's State of the Environment report for 2012[45]. Water scarcity thus does not appear to be a significant concern and the issue of an allocable volume of water has not been scrutinised to the degree comparable to New Zealand.

The EPA is responsible for a national programme for the collection, analysis and distribution of surface water quantity data[46]. There are 703 active hydrometric stations, with continuous water level records maintained at 680 of these.

RBMPs may identify abstractions as pressures, for example in the Easter River Basin District abstraction is only 1 of eight pressures on freshwater bodies[47], and the Eastern RBMP provides a map of abstraction pressures. A commentary on abstraction (ERBMP p7-13) states that while regulatory controls including the Water Supplies Act address abstractions to a certain extent, this may be supplemented in future by a requirement for licensing. Changing legislation to address this will likely happen at the national (not RBD) level.

2.3.2 Water use accounting

While rural water use is insignificant, municipal water use is not. Non-domestic uses are already metered, and current reforms[48] are leading to domestic water use monitoring, with the dual objectives of reticulation and demand management. Meters are linked to demand management via a user-pays charge, where volumetric use is charged above a no-fee threshold. News coverage in Ireland indicates that meters will likely be installed outside people's homes and will provide automated readings[49]. As of 30 January 2013, no meters had been installed. No reliable accounts of water use in Ireland could be found, though there are indications that the dominant user is industry, followed by domestic supply. If legislation requiring licensing for abstractions is introduced in the future, this will likely change.

[40] http://www.epa.ie/water/waterleg/
[41] http://www.irishstatutebook.ie/2009/en/si/0272.html
[42] ec.europa.eu/environmen
[43] http://www.environ.ie/en/
[44] http://www.epa.ie
[45] http://www.epa.ie/pubs/reports/indicators/irelandsenvironment2012.html
[46] http://www.epa.ie/water/wm/hydrometrics/
[47] RBMP for Eastern RBD, http://www.wfdireland.ie/docs/1_River%20Basin%20Management%20Plans%202009%20-%202015/ERBD%20RBMP%202010/
[48] http://www.environ.ie/en/Environment/Water/WaterSectorReform/
[49] http://www.thejournal.ie/irish-water-meters-775936-Jan2013/

2.3.3 Water contaminant accounting

According to Ireland's State of the Environment 2012 report[50], Ireland has better than average water quality compared to other EU Member States. The report goes on to say:

> *The principal and most widespread cause of water pollution in Ireland is nutrient enrichment resulting in the eutrophication of rivers, lakes and tidal waters from agricultural run-off and discharges from municipal waste water treatment plants. Following the enactment of the Waste Water Discharge Regulations 2007, the EPA set up a licensing and certification regime for municipal waste water discharges, to reduce the pollution of waters from these sources. On the agricultural side, implementation of the Good Agricultural Practices Regulations and, in particular, the increase in farm storage for manure and slurry, and the reduced usage of inorganic fertilisers have had beneficial effects.*

Water quality monitoring is led by the EPA[51], with data collected by the EPA and other agencies including local authorities, central and regional fisheries boards (inland), and Waterways Ireland[52]. Long-term surface and groundwater monitoring includes almost 2500 sites on more than 1700 rivers and streams, 42 locations on 11 canal water bodies, 222 lakes, and 211 groundwater locations. Chemicals and contaminants monitored include ammonium, nitrate, phosphate, faecal coliforms, and organic substances (e.g., pesticides). The EPA website states that, approximately half of the 953 sites assessed are polluted due to what may be termed 'large point sources' such as municipal wastewater treatment plants. The other half are polluted as a result of diffuse sources, particularly agricultural activities, as well as a range of other activities such as forestry and peat harvesting[53].

Ecological Status	Number of Water Bodies	% of Water Bodies
High	204	13
Good	612	39
Moderate	435	28
Poor	295	19
Bad	18	1
Total	1,564	

Figure 2-5: Example reporting: The ecological status of Ireland's monitored water bodies.[54]

[50] http://www.epa.ie/pubs/reports/indicators/irelandsenvironment2012.html
[51] http://www.epa.ie/irelandsenvironment/
[52] http://www.epa.ie/pubs/reports/water/waterqua/waterqualityinireland2007-2009.html
[53] http://www.epa.ie/irelandsenvironment/water/
[54] http://www.epa.ie/media/00061_EPA_SoE12_Chp04.pdf

Monitoring results are presented in SoE reports[55] and are viewable via an online spatial database server[56]. Examples of the results are reproduced in Figure 2-5 and Figure 2-6.

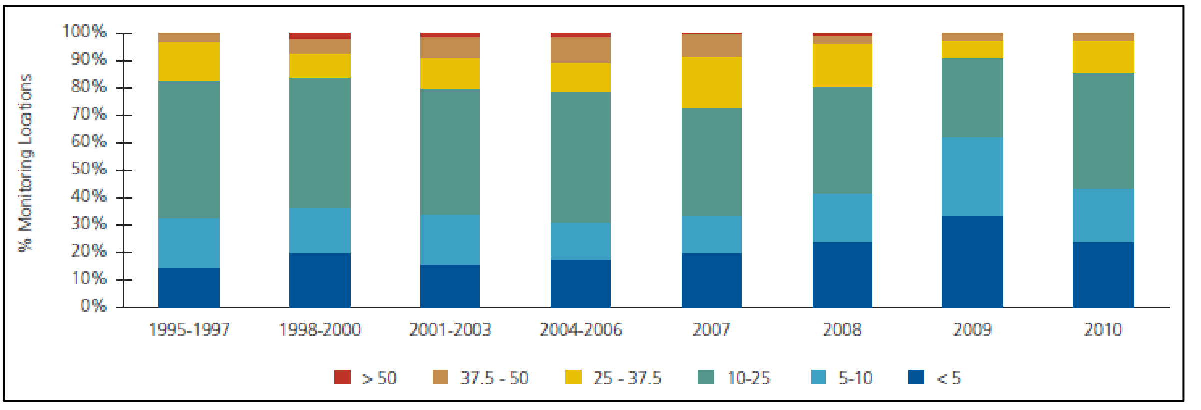


Figure 2-6: Example reporting: Trends in Nitrate Concentrations at Groundwater Monitoring Locations 1995–2010.[57]Concentrations are mg nitrate/L. Note the reporting as the nitrate molecule not as N in nitrate (as is done in New Zealand).

An example of the online map is reproduced in Figure 2-7.

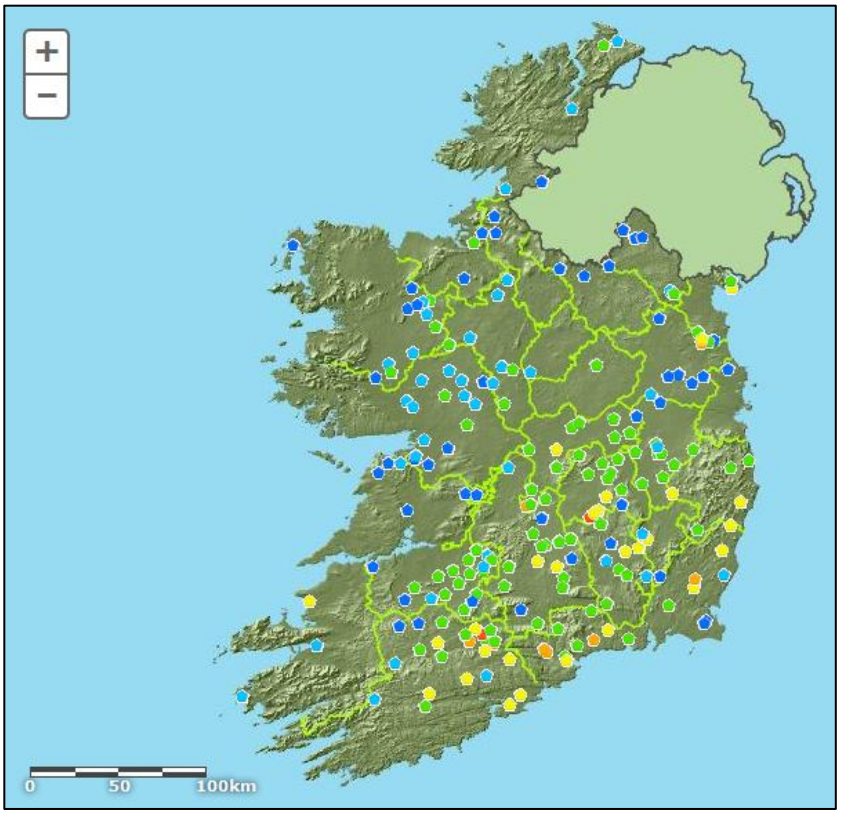


Figure 2-7: Example reporting: Interactive, online map of groundwater quality measurements across Ireland. Note, there was no legend and the meanings of the colours was not readily apparent even though the logical implication is clear.

[55] http://www.epa.ie/pubs/reports/indicators/irelandsenvironment2012.html
[56] http://www.epa.ie/monitoringassessment/assessment/spatial/#d.en.42876
[57] http://www.epa.ie/media/00061_EPA_SoE12_Chp04.pdf

2.3.4 Translating objectives into limits

As an EU Member State, Ireland and its seven River Basin Districts must determine limits to achieve the WFD mandated objectives. RBMPs are the vehicle by which the mandated objectives are to be achieved – that is, how GES will be maintained or restored, and what measures will be used to achieve this. Limit setting for water quantity (in terms of methods used to set minimum flows) is unclear, as the relevant material is absent from the primary online source[58]. The lack of requirement for water abstraction licensing may mean that less work has been done on this area, and the example RBMP reviewed did not offer any clarification. For water quality, EQS have been derived in the Surface Water and Groundwater Regulations. Drinking water safety is one important criterion, with the threshold value for groundwater being 0.035 mg/l P for Phosphate (as an annual mean concentration), and a threshold of 50 mg/L of nitrates[59] (equivalent to the New Zealand Drinking Water Standard Maximum Acceptable Value (MAV) of 11.3 mg/L nitrate-N).

2.3.5 Applicability to New Zealand

In terms of transferring these findings to the New Zealand context, the following may be stated:

- Ireland's relatively high water availability and low irrigation use provide New Zealand with little useful precedent in terms of water quantity limit setting or of rural water use monitoring.
- Ireland's shift to municipal metering is geared towards managing the utility as well as managing demand via the associated user-pays system – some for free, more for fee. Both are plausible in New Zealand but are primarily a matter of water governance and infrastructure management than of resource limit setting.
- The WFD drives mandated qualitative (or narrative) objectives, in terms of achieving GES for water bodies. As stated above (2.2.5) the lessons offered here are to a certain extent already being taken up in New Zealand by way of the NPSFM and Reforms 2013 work.
- While there is much literature on how to improve water quality, very little of it sheds light on how water quality limits have been set, to achieve WFD GES. For groundwater sources used for drinking supplies, an annual average limit of nitrate concentration is prescribed for health purposes. This particular example is already implemented in New Zealand.
- Ireland's water quality monitoring system is far more intensive than New Zealand's, with 2500 river and stream sites compared to New Zealand's roughly 800 (both NIWA and council) for a much larger land area. New Zealand could improve its water quality monitoring systems, depending on additional central and/or regional government funding, and perhaps supplemented by citizen science initiatives as discussed in the recent Peak Report[60] produced as part of New Zealand's National Science Challenges.

[58] http://www.wfdireland.ie/index.html
[59] http://www.epa.ie/irelandsenvironment/water/
[60] http://www.msi.govt.nz/assets/Update-me/National-Science-Challenges/Peak-Panel-report.pdf

2.4 California, USA

California's climate varies from Mediterranean to alpine subarctic, receiving from 300 to over 3000 mm of precipitation each year. California has 103 rivers, 5000 lakes, 460 groundwater basins, and 700 "major" reservoirs[61]. Key legislation in the US includes the Clean Water Act (CWA) which provides the basic structure for regulating discharges of pollutants and regulating quality standards for surface waters[62].

Management of California's water is the responsibility of the Department of Water Resources (DWR). The DWR is responsible for developing the California Water Plan, which is a five year review of the state and trend of California's water dependent natural resources[63]. The Plan also looks at ways to reduce water demand, increase water supply, reduce flood risk, improve water quality, and enhance environmental and resource stewardship.

Water rights, including abstractions from and discharges to water bodies, are granted by the State Water Resources Control Board, which sits within the California Environmental Protection Agency (Cal EPA[64]). There are an estimated 37,000 water rights[65]. The Board's purpose is to achieve the highest reasonable quality for waters of the State, while allocating those waters to achieve the optimum balance of beneficial uses. These narrative objectives are significantly different from the EU's WFD approach of reducing the deviation from a natural reference condition. There are nine Regional Water Quality Control Boards, whose purpose is to develop and enforce water quality objectives and implement plans to protect California's water resources, recognising local differences in climate topography, geology and hydrology. Among the regional boards' remits is the development of river basin plans and water quality monitoring.

2.4.1 Water available for allocation

Applications for new water rights in California must include a Water Availability Assessment (WAA) – i.e., sufficient information to demonstrate a reasonable likelihood that additional water is available for appropriation, however for the Board to grant the permit it must itself find that there is indeed available water[66]. As part of the process are considerations of:

- the public interest; and
- protection of existing beneficial uses, which include but are not limited to water abstraction, recreation and the preservation of fish and wildlife habitat.

Suggested methods[67] for carrying out such a WAA include investigating rainfall and stream flow data, modelling rainfall/runoff, quantifying water demand at all points upstream of the evaluation point (point of diversion/take), assessing potentially required bypass flow (minimum flows to protect fish habitat). Bypass flow or minimum flows may be estimated

61 http://www.waterboards.ca.gov/waterrights/water_issues/programs/water_availability/docs/water_%20availability_presentation.pdf
62 http://www2.epa.gov/laws-regulations/summary-clean-water-act
63 http://www.waterplan.water.ca.gov/index.cfm
64 http://www.waterboards.ca.gov/waterrights/
65 http://www.waterboards.ca.gov/waterrights/water_issues/programs/water_availability/docs/water_%20availability_presentation.pdf
66 http://www.waterboards.ca.gov/waterrights/water_issues/programs/water_availability/
67 http://www.waterboards.ca.gov/waterrights/water_issues/programs/water_availability/docs/water_%20availability_presentation.pdf

using rule of thumb methods (such as median February flow) and are calculated on a case-by-case basis.

The state also provides a list of water bodies[68] that are considered to be fully appropriated (fully or over-allocated).

2.4.2 Water use accounting

The amount of water used is accounted for in two predominantly different ways in California.

As of 2012, those who divert water and file statements are required to measure the monthly amount of water diverted using the best available technology and best professional practices, and to report these amounts the following year[69]. A range of measuring devices and products is given, but "best professional practices" are not readily discernable. Annual accounts of such data are not recorded on the web sites searched.

At the state level, total rural water use is estimated by the DWR using agrohydrological models, driven by meteorological, land use and crop data and knowledge of management practices[70]. Several models are used for this purpose[71]: Consumptive Use Program (CUP), Consumptive Use Programe+ (CUP+), and SIMETAW, each developed in partnership between the California DWR and the University of California, Davis. Results comprise water use for 20 crop categories for each year resolved to five different scales (state down to county), and presented in spreadsheets[72].

2.4.3 Water contaminant accounting

The (Federal) CWA gives states the primary responsibility for protecting and restoring surface water quality. This requires states to develop lists of impaired waters (which are too polluted or otherwise degraded to meet the water quality standards set by the state). Once a water body is agreed to exceed those standards, the CWA requires states to establish priority rankings for waters on the lists and develop Total Maximum Daily Loads, or TMDLs, for these waters[73], which apply at the daily rather than annual time-step. These are equivalent to water quality load limits in New Zealand's context, while the water quality standards are the equivalent of New Zealand's receiving water concentration-based standards (also called numeric objectives in Figure 4-1 (e.g. nitrogen concentrations)). Thus there is a tiered trigger system whereby concentration based standards (objectives) are considered sufficient in high quality environments and the extra step of moving to load limits is only triggered when the standards are failed. However this means that load limits are used in only a *reactive* way rather than a *pre-emptive* way to allocate resource before over-allocation (pollution exceeding the standards) occurs. For example California has 1,021 water bodies in this (over-allocated or 'exceeding standards') state[74], as reported to the EPA in 2010 (reporting required every 2 years under the CWA). Federal regulations require that the TMDL development document, at a minimum, account for contributions from point sources (federally permitted discharges) and contributions from nonpoint sources[75]. Although

68 http://www.waterboards.ca.gov/waterrights/water_issues/programs/fully_appropriated_streams/
69 http://www.waterboards.ca.gov/waterrights/water_issues/programs/diversion_use/water_use.shtml
70 http://www.water.ca.gov/landwateruse/
71 http://www.water.ca.gov/landwateruse/models.cfm
72 http://www.water.ca.gov/landwateruse/anaglwu.cfm
73 http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/index.cfm
74 http://iaspub.epa.gov/waters10/attains_nation_cy.control?p_report_type=T
75 http://www.waterboards.ca.gov/water_issues/programs/tmdl/background.shtml

the abbreviation stands for "Total Maximum Daily Load," the limitations contained in a TMDL may be other than "daily load" limits.

The TMDL strategy in California relies on an adaptive process that matches management capabilities with scientific understanding. There are five steps: involve stakeholders; assess water body; define the Total Load and develop allocations; develop Implementation Plan; and amend the basin plan[76].

Water quality monitoring in California is highly convoluted, with 10 different agencies contributing data in one way or another, working together under the auspices of the CA Water Quality Monitoring Council. The most relevant members, from New Zealand's perspective, are the State Water Resources Control Board and Regional Water Quality Control Boards[77]. These boards monitor "ambient" conditions (i.e., periodic and systematic monitoring of physical, chemical or biological data), TMDL implementation monitoring, and several other matters. The two most relevant programmes to this review are the Surface Water Ambient Monitoring Program (SWAMP) and the Groundwater Ambient Monitoring and Assessment Program (GAMA)[78].

GAMA monitors and assesses the quality of all priority groundwater basins that account for over 90% of all groundwater used in the state and over 95% of wells used for public drinking water. Some of the chemical constituents sampled include volatile organic compounds, pesticides, stable isotopes (H, O, C), trace metals, nutrients (N, P), and bacteria. For each of the 116 Priority Basins, results are assembled into Data Summary Reports (DSRs). GAMA also compiles its monitoring results with existing groundwater quality data from several agencies into a publicly-accessible internet database, GeoTracker GAMA, of over 200,000 wells.

SWAMP[79] is responsible for assessing water quality in all of California's surface waters, looking at:

- Status: What is the overall quality of California's surface waters?
- Trends: What is the pace and direction of change in surface water quality over time?
- Problem Identification: Which water bodies have water quality problems and which areas are at risk?
- Diagnostic: What are the causes of water quality problems and where are the sources of those stressors?
- Evaluation: How effective are clean water projects and programs?

Indicators measured include water flows, suspended sediment, and a wide suite of water quality parameters (dissolved oxygen (DO), temperature, nutrients, coliforms, chlorophyll *a*) as well as periphyton, macroinvertebrates and fish assemblages and habitat.

[76] http://www.waterboards.ca.gov/water_issues/programs/tmdl/background.shtml
[77] http://www.mywaterquality.ca.gov/monitoring_council/docs/invntry120308.pdf
[78] http://www.waterboards.ca.gov/water_issues/programs/gama/
[79] http://www.waterboards.ca.gov/water_issues/programs/swamp/about.shtml

2.4.4 Translating objectives into limits

Water quantity limits in California include the setting of policy for maintaining instream flows in northern California coastal streams[80]. This policy was developed using physical habitat modelling to provide estimates of habitat suitable for salmonids, and is focussed on that single instream 'value'. The policy prescribes measures such as the season of diversion, minimum (bypass) flow (i.e. minimum flow), and maximum cumulative diversion (i.e. allocation limit).

Water quality limits in the US take the form of TMDLs[81]. A TMDL is defined as an estimate of the maximum amount of a pollutant that a water body can receive while still meeting water quality standards (and is thus aligned with the NPSFM definition of a limit). It is allocated among the various sources of each particular pollutant, such as sediment, nitrogen, phosphorus and temperature. TMDLs must consider and include allocations to both point sources and nonpoint sources of listed pollutants. Point sources receive a waste-load allocation (WLA) while non-point sources receive a load allocation (LA). Establishment of numerical TMDLs is led by state EPAs, with final approval submitted to the federal EPA.

In setting TMDLs, at least in California, there are five steps:

1. Stakeholder involvement provides input to RWQCBs;
2. Water body assessment: pollution sources and loads are determined for different times of the year, and their overall effects determined;
3. Define total load and develop allocations;
4. Develop implementation plan; and
5. Amend the basin plan.

Furthermore, each TMDL must contain the following elements:

- A problem statement;
- Numeric targets that define the desired future condition;
- Source analysis that identifies the amount, timing and origin of pollutants;
- Allocations of pollutant burdens, which may be specific to agencies or persons (businesses), or generally by source category or sector;
- Implementation plan describes actions to alleviate the impairment;
- Linkage analysis describes how the implementation plan will achieve the relevant standards;
- Monitoring strategy to assess TMDL performance and potential revisions; and
- Margin of safety.

[80] http://www.waterboards.ca.gov/waterrights/water_issues/programs/instream_flows/docs/ab2121_0210/may2010policysecurea.pdf
[81] http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/index.cfm

For California, recently developed TMDLs for mercury, pathogens, sediment, and nutrients are available on the water boards website and show how the TMDLs are developed[82].

2.4.5 Applicability to New Zealand

California offers both water quantity and quality lessons to New Zealand, but perhaps the most useful is the application of TMDLs in the setting of contaminant limits.

In general the philosophy of the approaches (steps 1-5 and bullets above) are similar with what is being attempted in New Zealand under limit setting. The concept of a tiered trigger-based process is a potentially useful approach, e.g. moving to load limits in pressured catchments rather than everywhere. However triggering a response only when standards are breached (the Californian approach) is ‘blunt’ and can be considered ‘reactive’. Identifying at risk catchments and moving to a load based system early would enable councils to pre-emptively manage the contaminant load before limits are breached. An example of this is Lake Benmore, where Environment Canterbury are trying to set load limits before the onset of eutrophication rather than after.

2.5 Victoria, Australia

Victoria’s gradient in mean annual rainfall is comparable to New Zealand’s, more so than all other states except Tasmania, but it also has sub-humid grasslands which Tasmania lacks. Victoria has around 85,000 km of streams, rivers and creeks, and these rivers systems and aquifers are significantly used as water sources. Victoria is the centre of dairy farming in Australia, and has other comparable land uses to New Zealand.

Key legislation for water management in Australia includes the National Water Initiative (NWI) 2004[83]. The NWI offers a cohesive national approach to the way Australia manages, measures, plans for, prices, and trades water. Also at the commonwealth level, the Water Act 2007 directs the management of the Murray-Darling River Basin but also directs the development of national water accounts (for quantity). A National Water Management Strategy[84] outlines policy, processes and guidelines to help water quality management in Australia.

For Victoria, the Water Act 1989 provides the framework for allocating surface water and groundwater throughout Victoria[85], while the Environmental Protection Act 1970, and policies to implement that Act, aims to prevent pollution and environmental damage by setting environmental quality objectives and establishing programs to meet them. One such policy is the State Environment Protection Policy (Waters of Victoria), which sets a three stage framework to help protect and rehabilitate Victoria’s surface water environments[86]. The three stages are: to document beneficial uses of water (i.e., values of water in New Zealand terminology); set quality objectives and indicators to maintain these values, and develop an attainment program or action plan to achieve this. These indicators are simply the water quality variables monitored (e.g., pH, salinity, turbidity, chemical concentrations). There is overlap here with Victoria’s River Health Strategy and program, which by collectively treating

[82] For California, recently developed TMDLs for mercury, pathogens, sediment, and nutrients are available on the water board website and show how the TMDLs are developed.
[83] http://nwc.gov.au/nwi
[84] http://www.environment.gov.au/water/policy-programs/nwqms/index.html
[85] http://environmentvictoria.org.au/content/water-policies-and-legislation
[86] http://www.epa.vic.gov.au/about-us/legislation/water-legislation/water-related-policies

the problems of low flows, declining water quality and degraded riverine habitats, aims to restore stressed rivers while protecting healthy ones[87].

Water management issues in Victoria include the complex management of the Murray-Darling catchment, environmental protection and water shortages.

2.5.1 Water available for allocation

Water allocation in Victoria is managed in accordance with the Water Act 1989, by the Department of Environment and Primary Industries. It uses the Water Allocation Framework to strike a balance among demands for consumptive uses, the environment, and other non-consumptive uses. The water allocation framework takes a whole-of-system approach, considering all water resources together (surface and groundwater) for both consumptive and environmental purposes at all phases of the water cycle.

A distinction is made between a water “entitlement” and an “allocation”. A water entitlement is the maximum amount of water authorised to be taken and used by a person under specific conditions/specifications. The Water Act 1989 permits water takes for domestic and stock purposes without an entitlement. Water allocation is a balancing act between consumptive uses (i.e., urban, irrigation, stock, domestic, commercial) and environmental uses (wetlands, aquatic biota, estuaries, rivers or streams and groundwater-dependent ecosystems).

A water allocation is the amount of water that can be used under an entitlement to water, each year. The allocation depends on the conditions during the year and in a dry year an allocation will be reduced, i.e. the limit is time-varying.

In Australia, high demand for water resources for irrigation means that water resources have become over-allocated. Australia, and Victoria in particular, provides for Environmental Water Reserve or EWR[88]. Mandated by the Water Act 1989, EWRs can be water held in storage and released to a river, it can be run-of-river flow and it can be groundwater. Environmental water is made available by developing abstraction licensing conditions and allocation caps, but also is provided through specific environmental entitlements held by an organisation for that purpose (in Victoria, the Victorian Environmental Water Holder).

Environmental entitlements can be a combination of water in storage, environmental flow requirements (EFR – minimum flows) and protection of the flows remaining in the river after the other demands have been met (‘above cap’ flows). Environmental entitlements make it possible to actively manage water to meet specific environmental needs such as fish spawning triggers or maintaining critical habitats during drought[89].

2.5.2 Water use accounting

Australia has federal level legislation (the Water Act 2007) that directs the Australian Bureau of Meteorology to compile and deliver comprehensive water information across Australia, by way of an annual National Water Account[90]. The Bureau has produced a standard for national water accounting, which guides how general water accounting reports are developed. The purpose of such a report is to provide information useful to users of that

[87] http://www.water.vic.gov.au/environment/rivers/river-health-program
[88] http://www.water.vic.gov.au/allocation/water_allocation_framework/environmental_water_reserve
[89] http://www.water.vic.gov.au/allocation/environmental-entitlement-requests
[90] http://www.bom.gov.au/water/nwa/

report for making and evaluating decisions about the allocation of resources[91]. Regulations have been developed so that the Bureau can request and receive the appropriate information from water managers to enable the accounts to be built.

Victoria has a Water Register, which is a public register of all water-related entitlements in Victoria[92]. The Water Register website provides access to entitlement records, describes water availability and provides a forum for trading of water entitlements. Annual water accounts are produced for Victoria[93] with state-wide climatic data, and hydrological and water use data partitioned into its 29 river basins. These reports include:

- the state's water availability (rainfall, stream flow, groundwater levels, storage levels), water taken for consumptive purposes, and environmental water entitlements; and
- water availability and use for the 29 river basins.

These reports are derived from both measured data and results of hydrological modelling. They may be considered highly detailed (the 2010-11 report stretches to 346 pages) state of the freshwater environment, resource and management reports. An example surface water summary from the Snowy River basin is shown in Figure 2-8 below.

Basin accounts can also be accessed from an online map[94]. More information on water reporting can be found at the websites of catchment authorities, such as Melbourne water[95].

2.5.3 Water contaminant accounting

Through the National Water Quality Management Strategy (NWQMS) the Australian Government is working in collaboration with States and Territories to develop Water Quality Improvement Plans (WQIP) to reduce pollution being released into aquatic ecosystems with high ecological, social and/or recreational values across the country[96]. WQIPs aim to significantly reduce the discharge of pollutants to agreed 'hotspots', of which there are a very small number across Australia. The WQIP development process involves first identifying the environmental values of water, and then determining water quality objectives and load targets for pollutants of concern. The WQIP also develops environmental flow objectives and environmental water provisions. Finally, the WQIP outlines a series of actions at a catchment level, including control of point and diffuse sources, market-based instruments and adaptive management, and monitoring programs. There are 3 such 'hotspots' in Victoria for which WQIPs have been developed. The WQIP process includes a step to determine where and from what sources degradation of water quality is occurring. It recommends use of the ANZECC guideline in developing local water quality objectives, e.g. for instream concentrations of some contaminants. While the WQIP Implementation Guidelines[97] suggest the use of scenarios to determine the most cost effective way to meet the objectives, they stop short of explaining exactly how targets are set to meet objectives. While this WQIP approach has similarities to the New Zealand NPSFM approach, it applies to very few water bodies.

[91] http://www.bom.gov.au/water/standards/documents/awas1_v1.0.pdf
[92] http://waterregister.vic.gov.au/
[93] http://www.water.vic.gov.au/monitoring/accounts
[94] http://www.water.vic.gov.au/monitoring/accounts/map - although author notes problems with data access
[95] http://www.melbournewater.com.au/content/water_storages/water_report/water_report.asp
[96] http://www.environment.gov.au/water/policy-programs/nwqms/wqip/index.html
[97] http://www.environment.gov.au/water/publications/quality/pubs/nwqms-implementation-guidelines.pdf

Table 17-3 Balance of surface water in the Snowy basin

Water account component	2010–11 (ML)	2009–10 (ML)
Major on-stream storage		
Volume in storage at start of year	-	-
Volume in storage at end of year	-	-
Change in storage	**-**	-
Inflows		
Catchment inflow from Victoria[1]	1,014,200	380,600
Catchment inflow from NSW[2]	312,600	178,400
Rainfall on major storages	-	-
Return flow from irrigation	-	-
Treated wastewater discharged back to river	-	-
Sub-total	**1,326,800**	**559,000**
Usage		
Urban diversions	820	790
Licensed diversions from unregulated streams	500	800
Small-catchment dams	3,400	3,400
Sub-total	**4,700**	**5,000**
Losses		
Evaporation losses from major storages	-	-
Evaporation from small-catchment dams[3]	700	700
In-stream infiltration to groundwater, flows to floodplain and evaporation[4]	n/a	n/a
Sub-total	**700**	**700**
Water passed at outlet of basin		
River outflows to the ocean	1,321,400	553,300

Notes:
(1) Inflows have been back-calculated from outflows plus diversions.
(2) Inflows from NSW were recorded on the Snowy River at Burnt Hut Crossing (gauge 222013).
(3) Evaporation losses are calculated by subtracting estimated usage from the total water harvested.
(4) Assumed to be zero because data is not available.
n/a: No information available

Figure 2-8: Example surface water accounting, Snowy River Basin.

The State Environment Protection Policy (SEPP) (Waters of Victoria) includes water quality objectives for DO, conductivity, pH and turbidity and also nutrient objectives, developed for different spatial units in the state. These are developed using a risk-based approach, and numbers used are concentrations (not loads) based on ANZECC guidelines. While the administrator of this legislation, the Victoria state EPA, issues licences for point-source discharges[98], compliance information in regard to those licences could not be located at the primary source.

770 surface water sites are monitored in Victoria, and look at not just water quantity (How much water is there? Where is the water? How much water is being used? What is the water being used for?) but also water quality (What is the quality of the water?). Information is made available through the Victoria Water Resources Data Warehouse[99].

2500 monitoring-specific bores throughout Victoria are also monitored, as well as groundwater subject to a Groundwater Management Plan or in a Water Protection Area (which are designated to protect drinking water sources).

[98] http://www.epa.vic.gov.au/your-environment/water/protecting-victorias-waters/regulatory-controls
[99] http://www.vicwaterdata.net/vicwaterdata/home.aspx

The review has been unable to find other information with regard to accounting for contaminant sources.

2.5.4 Translating objectives into limits

Stream Flow Management Plans (SFMP), developed under the Water Act 1989, complement Environmental Water Reserves. A SFMP aims to provide for the stream's environmental needs (environmental flow regime) as well as an agreed, reliable and equitable water distribution between users such as rules for flow sharing in times of scarcity.

Victoria has developed the FLOWS method for assessing the environmental water requirements as part of the water allocation process. The FLOWS method describes key flow components as part of a recommendation for an environmental flow regime – rather than a minimum flow recommendation. Another key element of the method is that it provides a documented objective setting process that links environmental objectives to flow objectives (the EFR) and recommendations. The method involves 6 steps:

1. Identify the current environmental assets
2. Identify assets expected to be associated with a 'healthy' waterway
3. Develop environmental objectives
4. Identify key flow related events and flow components to meet each environmental objective
5. Develop flow objective
6. Develop recommendations to meet each flow objective

FLOWS provides consistency in terms of recommended hydrological tools for analysis and the use of a hydraulic model as a tool in the interpretation and development of recommendations[100].

WQIPs also link required environmental states that meet identified water values to limits, by determining water quality objectives and load targets for pollutants of concern. The process for this is driven by the 1998 Implementation guidance, as in section 2.5.3 above[101].

Targets are set in the overarching Victoria River Health Strategy for the state e.g., 95% of all highland and upland and 60% of all lowland monitoring sites meet SEPP environmental quality objectives (specific rivers are not named in this target). Under Victoria's River Health program, Catchment Management Authorities (CMAs) develop Regional River Health Strategies in consultation with the community and key groups and individuals. These individual strategies assess risks and provide objectives to improve the health of the rivers, in part through EWR management.

2.5.5 Applicability to New Zealand

In comparison to New Zealand, where until recently our abundant freshwater has not been under high demand, Australia approaches water management from a position of scarcity. For example, minimum flows (in New Zealand terminology) are environmental water

[100] http://www.water.vic.gov.au/environment/rivers/flows/assessment
[101] http://www.environment.gov.au/water/publications/quality/pubs/nwqms-implementation-guidelines.pdf

requirements or EWRs in Australia, and aim to provide already allocated water back to the rivers to restore or maintain instream values.

This history of high demand and water scarcity means that Australia's systems for monitoring water resource availability are well developed, and the mandated requirements for the Bureau of Meteorology to produce annual water accounts will offer lessons to New Zealand. For example, a standard has been developed to set out requirements for general water accounting reports (Australian Water Accounting Standard 1: Preparation and Presentation of General Purpose Water Accounting Reports) which could be the basis for a similar system in New Zealand. It includes advice on the structure and content of general purpose water accounting reports, describing the key elements as: water assets; water liabilities; net water assets; changes in water assets; and changes in water liabilities. General principles included in the standard include: fair presentation, accrual basis of water accounting, materiality, offsetting, frequency of reporting, comparative information, consistency of presentation, error corrections, events after the reporting period, and quantification.

The implementation guidance for the standard includes a wide range of illustrative accounts, and one example is shown here in Figure 2-9.

Statement of Water Assets and Water Liabilities for Integrated Catchment

as at 30 June 2X11

	2X11 ML	2X10 ML
WATER ASSETS		
Surface water assets		
Catchment and unregulated storage	**455 000**	325 000
Regulated river storage	**1 650 000**	1 550 000
Utility network storage	**70 000**	50 000
Total surface water assets	**2 175 000**	1 925 000
Groundwater assets		
Groundwater storage	**255 000**	250 000
Total groundwater assets	**255 000**	250 000
Other water assets		
Claims to water: intervalley	**30 000**	30 000
TOTAL WATER ASSETS	**2 460 000**	2 205 000
WATER LIABILITIES		
Allocation water liabilities	**150 000**	100 000
Other water liabilities	**30 000**	30 000
TOTAL WATER LIABILITIES	**180 000**	130 000
NET WATER ASSETS	**2 280 000**	2 075 000
Net water assets at beginning of reporting period	**2 075 000**	2 600 000
Change in net water assets	**205 000**	(525 000)
NET WATER ASSETS	**2 280 000**	2 075 000

Figure 2-9: Illustrative accounts from the Australian Bureau of Meteorology Standard. Note the X in the dates is from the Standard document, and illustrates that they are examples only.

2.6 Summary

The above reviews of the four jurisdictions are summarised in the following simple table (Table 2-2).

Table 2-2: Summary of review of international approaches for Victoria, Australia, England and **Wales, Ireland, and California USA.** Note that acronyms used have been introduced in the text.

Topic	England and Wales	Ireland	California, USA	Victoria, Australia
Available water for allocation	Environmental limits are known and set for the entire country. Available water is primarily existing water minus environmental flows.	Not an issue, no current licensing for water abstractions, but demand increasing in some river basins.	Some physical habitat modelling is used to define minimum (bypass) flows. Individual WAAs must be carried out with applications for water licences.	Well defined water allocation framework under Water Act 1989
Accounting for water abstracted	Metering of abstraction licences; management of water companies information	Household water metering is pending.	At the state level, agricultural modelling is used to estimate actual water use.	Significant work has gone in to developing water accounts – best example of this
Accounting for sources of contaminants	Via reporting on chemical status of water through WFD	Via reporting on chemical status of water through WFD Extensive and intensive water quality monitoring of rivers, canals, lakes and groundwaters.	Biennial reporting on impaired waters status to Federal EPA	Unclear – though report on water quality at 770 sites
Translating objectives into limits	Mandated EU objectives are translated into limits by Member States; RMPS	Mandated EU objectives are translated into limits by Member States; RBMPs	Water quantity objectives relating to fish habitat set minimum (bypass) flow requirements EPA set TMDL framework with threshold below which TMDLs must be set	Through SFMPs and FLOWS method of assessment for water quantity, through SEPP implementation for water quality (river health)
Applicability to New Zealand	National level approaches to setting water quantity limits and abstraction licensing, and water quality standard setting through expert panel approach (UKTAG)	Similar water quality pressures, monitoring requirements	Lessons to be learned by way of limit setting using TMDLs in a reactive way (after trigger level reached)	Water accounting in Australia offers opportunities for exploration, also derivation of limits for quality and quantity

2.7 Queensland, Australia

As stated at the beginning of this section, we include here a brief review of Queensland's approaches to limit-setting.

In Queensland, the management of water quantity falls under the Water Act 2000. Chapter 2 of the Water Act aims to 'advance sustainable management and efficient use of water and other resources by establishing a system for the planning, allocation and use of water.'[102] A person wishing to take water, with exception of a few authorised (permitted) activities, requires an entitlement (consent) to do so.

Under the Water Act, water resource basin plans are developed, which states the strategic goals of the catchment, states how much water (surface and ground) is available and sets the principles for sharing the water amongst competing sector interests. The plan sets environmental flow objectives (EFOs) and objectives for water security. For example from the Fitzroy basin water resource plan (WRP), the EFOs include[103]: seasonal base flow objectives, set as percentages of baseflow for three water flow 'seasons' of the year; medium to high flow objectives, set as percentages of mean annual flow; first post-winter flow event objectives and performance indicators; and groundwater objectives.

Implementation of this water resource plan is via another plan, a resource operations plan (ROP), which includes the rules for trading of water allocations as well as rules for how operators of water supply schemes must operate their schemes and share the resource available at any point in time. Water identified as available for allocation is outlined in the ROP.

Once approved, plans are valid for 10 years, at which time a new water resource plan (and resource operations plan) must be completed. This work is administered by the Department of Natural Resources and Mines.

Recent Queensland state legislation for managing freshwater quality includes the Environmental Protection Act 1994, which has a purpose of sustainable ecological development, and the subsequent Environmental Protection (Water) Policy 2009 (EPP Water), the purpose of which is to protect Queensland's water environment whilst allowing for development that is ecologically sustainable. This purpose is to be achieved by:

> *(a) identifying environmental values and management goals for Queensland waters; and*
>
> *(b) stating water quality guidelines and water quality objectives to enhance or protect the environmental values; and*
>
> *(c) providing a framework for making consistent, equitable and informed decisions about Queensland waters; and*
>
> *(d) monitoring and reporting on the condition of Queensland waters*[104].

The EPP Water sets a broad environmental outcome (narrative objective) requiring Environmental Values (EVs) to be enhanced or protected for water bodies. Water bodies fall into two categories, those named and with specific identified EVs in a schedule to the EPP Water, and others where the EPP Water suggests default EVs for the water body. For high ecological value waters the desired state is 'the biological integrity of an aquatic ecosystem that is effectively unmodified or highly valued' whereas for highly disturbed waters the desired state is 'the biological integrity of an aquatic ecosystem that is measurably degraded

[102] http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/W/WaterA00.pdf
[103] http://www.nrm.qld.gov.au/wrp/fitzroy.html
[104] http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/E/EnvProWateP09.pdf

and of lower ecological value than waters [of intermediate disturbance].' There are also intermediate slightly disturbed and moderately disturbed categories.

The EPP Water identifies default EVs including producing aquatic foods for human consumption, aquaculture, agricultural purposes, recreation or aesthetic purposes (including primary, secondary and visual recreational use), drinking water, industrial purposes, and cultural and spiritual values of water.

Under the EPP Water, EVs and water quality objectives can be developed for a river catchment through a process of planning and stakeholder consultation. Once these catchment EVs have been set, they are added to the EPP Water schedule of named catchment values. For example, this has been carried out for the Fitzroy river catchment[105].

The EPP Water uses indicators and water quality guidelines for environmental values, where a water quality guideline is defined as 'quantitative measures or statements for indicators, including contaminant concentration or sustainable load measures of water that protect a stated environmental value.' The EPP Water process is administered by the Department of Environment and Heritage Protection.

The framework for deriving water quality guidelines and objectives is outlined in a factsheet[106] which states that a hierarchical approach is used to derive recommended indicators for certain EVs from (in order of preference) site specific information, Queensland water quality guidelines (QWQ), Australian water quality guidelines (AWQ – the ANZECC guidelines), and any other published guidelines. This may be done by measuring direct impact on biological organisms, or by establishing an acceptable departure from a reference condition.

The same factsheet outlines the relationship between water quality guidelines and water quality objectives, which apply to receiving waters, and protect EVs from the discharge of contaminants to receiving waters. Water quality objectives are expressed as contaminant concentrations, loads or as a narrative statement. The start point for water quality objectives is the appropriate identified water quality guidelines but the EPP Water allows that these may be modified in consideration of the economic and social impacts of protecting an EV.

As outlined in section 2.5.3, in addition to these state level water quality management requirements there is a (federal) National Water Quality Management Strategy which requires the development of Water Quality Improvement Plans for any water quality 'hotspots' identified in the state. Queensland has two such WQIPs, one for Moreton Bay and one that covers the Great Barrier Reef[107].

The issue of translating objectives into limits is explored further in Section 4 of this report.

[105] http://www.ehp.qld.gov.au/water/policy/fitzroy-basin-environmental-values.html
[106] http://www.ehp.qld.gov.au/water/pdf/deriving-local-water-quality-guidelines.pdf
[107] http://www.environment.gov.au/water/policy-programs/nwqms/wqip/hotspots.html

3 Accounting systems

Accounting for all existing uses of water and existing sources of contaminants is important for a number of reasons with regard to freshwater management, including:

- To inform decisions on objectives and limits: an understanding of the existing uses of water and existing sources of contaminants is needed when testing the economic and social impacts of various scenarios for objectives and limits.
- To inform decisions on how to manage within limits, once set: for example, to determine the most equitable and cost-effective way to reduce current discharges.
- Ongoing accounting and reporting will provide feedback to communities on their progress, and act as a trigger for changes in management e.g. when existing initiatives are not having the required effect and targets are not being met.
- Consistent regional and national accounting and reporting will provide information for investors on catchments where there is "headroom" for expansion; and information for central government on whether further assistance and/or intervention is required.

Accounting for all water takes involves identifying who is taking water, and collecting information or estimating their use, reporting and verifying. This includes unmetered takes, takes that do not require a consent (e.g. stock water, as in section 14 (3) (b) of the RMA) and unauthorised takes. Simple models can be used to estimate permitted, stock water and domestic takes e.g. multiplying stock numbers by average daily intake, with intake coefficients validated using sample surveys and other data e.g. from metered takes. LAWF in its recommendations envisaged that all water takes would be accounted for (except firefighting).

In terms of accounting for all sources of contaminants, contaminant sources may in some cases be able to be individually identified and measured (e.g. large point sources), and in other cases only broad identification will be possible (e.g. estimated loads generated by each land use type). Modelling is needed to identify and estimate diffuse discharges from farmland, urban run-off, native bush, plantation forests, and septic tanks. A range of accounting/estimation methods can be used, e.g.:

- Export coefficients by land use type for sediment, N and P e.g. in the Lake Managers' Handbook (N and P) and the Waikato (sediment),
- N leaching models e.g. the Lilburne model in Canterbury which estimates N discharges from rural land uses based on N leaching models including OVERSEER and SPASMO,
- Catchment models e.g. CLUES, Rotan in Rotorua
- Risk factor modelling and mapping to identify hot spots e.g. LRI erosion index, recent LCR mapping of N and P leaching
- Faecal typing, isotope footprinting.

LAWF in its recommendations envisaged a catchment contaminant account or database that would be updated over time as land uses and discharge-related practices change. Some councils already undertake accounting for certain sources of contaminants; others conduct 'one-off' exercises for particular areas of concern in their region, which in this report we refer to as source analyses.

3.1 Methodology

For this study, we addressed the accounting systems Tasks 2-6 (as outlined in Section 1) by collecting information through structured interview workshops with a number of councils.

The first step was to develop questions that would be asked at council workshops. The questions were initially discussed at the project kick-off workshop (7 May 2013), and then further developed by the project team. A final draft was completed, incorporating feedback from Water Directorate staff. There were a total of 63 questions (covering accounting systems, limit setting, challenges, and information requirements) for water quantity, 56 (on the same topics) for water quality, and 10 separate questions for costs. An introduction and definitions of key terms was included at the beginning of the questions document. The questions covered not just accounting systems, but also limit setting, to assist with Task 7 (see section 4). The final questions are attached as Appendix B.

An initial approach for a typical workshop was developed by the project team, which separated the questions into technical categories based on water quantity, water quality, and costs. There were potential risks with this approach, including:

- That benefits to cross-germinating ideas and discussion between quality and quantity staff were lost; and
- That technical staff who could contribute more on either the accounting systems or limit-setting questions would be 'inactive' for periods of time.

Nevertheless this was the preferred approach suggested to the councils on initial contact, although further sections of the report will reflect how the interview workshops were carried out with each council.

In order to ensure, within the limited timeframe of the project, that the data collected was appropriately addressing the project Tasks, a pilot was carried out with one council, to test both the approach to the workshop and the technical content of the questions. Following the pilot, a workshop was held the Water Directorate (29 May 2013) at which the approach and questions were reviewed and refined, before the project team went to talk to the next four councils. In all cases, notes were taken in answer to the questions and circulated to the relevant council staff to correct any errors of fact. These notes were then used at the evidence base for the evaluation step, as follows.

The project Tasks require an evaluation of the technical methods and processes used by the councils in accounting and limit setting. Draft criteria for this evaluation were developed at the project kick-off workshop at the Water Directorate (7 May 2013), which were tested at the pilot, and again reviewed and refined at a follow-up workshop the Water Directorate (29 May 2013) before being applied to the other councils. The criteria developed for the evaluation are shown in Table 3-1. The evaluation has been made 'on balance' based on the evidence collected at the council workshops. A 'Yes/No' evaluation was made, but strengths and potential weaknesses of the systems have been noted as much as was possible, to allow the detail behind the Yes or No evaluation to be understood.

Table 3-1: The six criteria developed for accounting systems evaluation. These criteria were developed with the Water Directorate at a workshop held on 7 May 2013.

Criteria	includes
Technically robust	Is it sufficiently accurate? Is it based on sound science? Is it comprehensive? Does it integrate e.g. surface water and groundwater, estuaries?
Practical	Does it work for the council (technically feasible)? Is it timely? Is it updatable? Is it future-proofed, so it is practical over time? Is there a physical database?
Transparent	Is it accessible to water users? Is it accessible to others (stakeholders)?
Effective	Does it do what we need it to do? Is it fit for purpose? i.e. for the 3 potential uses of accounting systems Is it cost-effective?
Acceptable	Will users uptake the system? Is it politically acceptable?
Adaptable	Is it flexible for a range of water management units (WMU) or catchments? Is it scalable from WMU to catchment to region to national?

3.2 Waikato Regional Council

The pilot workshop was held in Hamilton on Wednesday May 22 with Waikato Regional Council (WRC). In terms of logistics for the workshop, the questions were shared with WRC 2 days before the planned workshop, and after reviewing the questions WRC provided 11 staff to attend the workshop who covered a range of expertise from database design and management, water quantity and quality experts, consents staff, policy staff and group managers. After opening comments by WRC, the Water Directorate and the NIWA-led consortium project manager, the attendees split into two (quantity and quality) groups and worked through the questions. After finishing the water quantity questions, that group also discussed the costs questions.

Observations of the group interactions included:

- A mixture of technical, consent and policy staff ensured more in-depth answers to the questions;
- The normal group management issues apply, in that particular group members can contribute a lot or a little, and progress through the interview questions has to be managed; and
- The water quantity group were able to move through the questions much more easily. This may have been due to a combination of the questions asked, how much time WRC have spent looking at the issues, and the knowledge of people present in the group.

At the end of the day, the groups returned together and WRC staff provided feedback on the content of the questions, and the approach to the workshop. This was used to refine and adjust the questions and approach following discussion with the Water Directorate.

3.2.1 Results – the evaluation of accounting systems

Water quantity

Description of water quantity accounting system

The WRC accounting 'system' is made up of 4 components:

Figure 3-1: Schematic diagram of WRC's water accounting system.

- The consents database Resource Use Authorisation Management System (RUAMS), which collects data on consent type, source, primary purpose, secondary purpose and tertiary purpose, location, maximum rates of take, daily volumes, annual and seasonal volumes, period of consented take, commencement and expiry dates, irrigation area, consumptive or non-consumptive takes, consented diversions. The database holds all consents for WRC, not just those related to water takes and use.
- A GIS tool for spatial accounting and management across any user defined area. It was built internally and is based upon the River Environment Classification (REC) catchments and it is linked to the consent information stored in RUAMS.
- A time-series management database (WISKI[108]) that stores the monitoring water use data, including paper returns and telemetered information. WISKI is also used by the council to store other time-series data (such as river flow records)
- A spreadsheet of permitted RMA section 14 (3)(b) (here after s14) takes also feeds in to the GIS system.

[108] WISKI stands for Water resources Information System Kisters, where Kisters is the company who owns and develops this time series management, storage and interpretation tool box.

In August 2013 WRC will replace RUAMS with the Integrated Regional Information System or IRIS. IRIS is a SQL server database with a web-browser interface that is highly flexible, and will manage all consents for WRC. The specifications for the fields in IRIS came from the input of 6 regional councils and is considered to be very robust for many variable situations.

Example of water quantity accounts

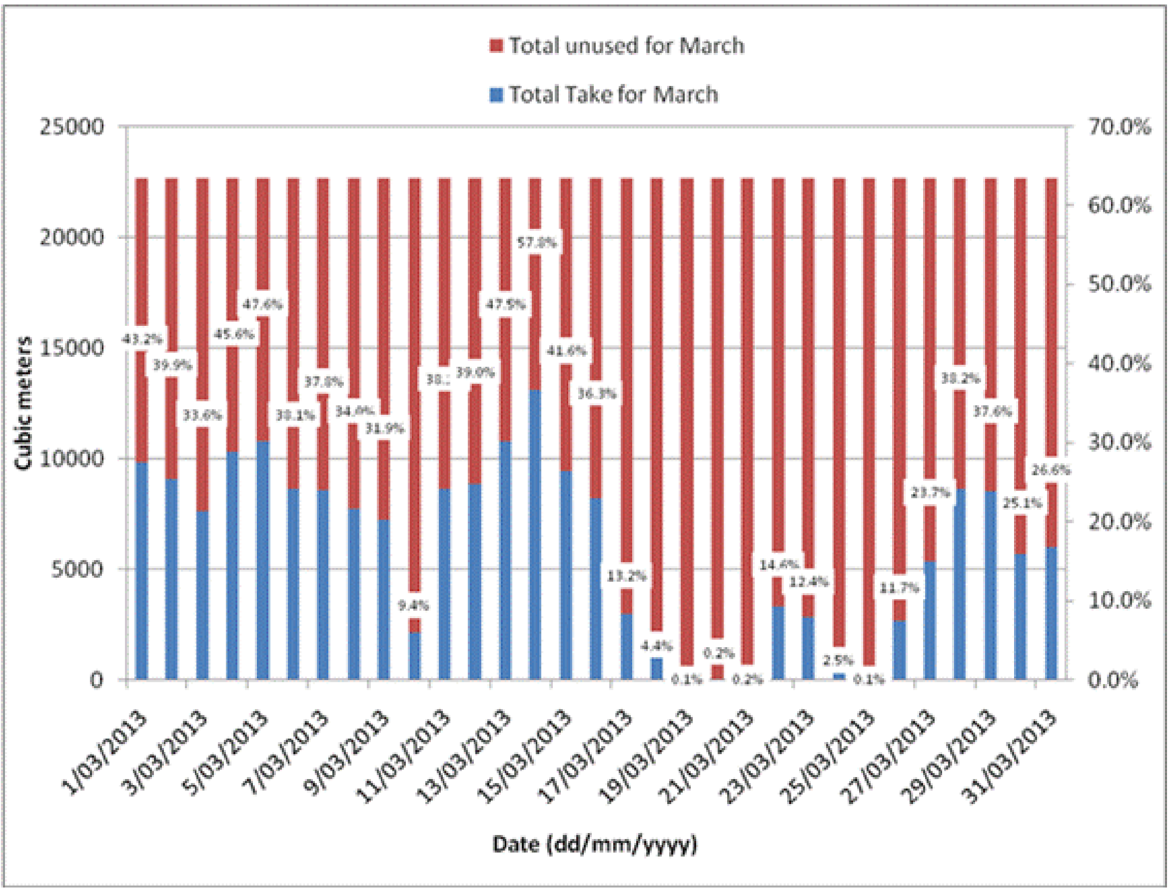


Figure 3-2: The allocated and actual daily use in a part of Waihou catchment in March 2013.

Figure 3-2 shows an example of water accounts that can be produced from the WRC accounting system. The water accounts for the telemetered consents in a part of Waihou catchment for March 2013 are shown in Figure 3-2. The second Y-axis shows the water allocation/use as a percentage of total availability for the entire Waihou catchment (the part shown is only 65% of the whole catchment).

Evaluation of water quantity accounting system

Table 3-2: Evaluation of WRC water quantity accounting system.

Criterion	Evaluation	Comments
Technically robust	Yes	Strengths WRC's accounting system uses four components and is one of the best systems in New Zealand that incorporates all water takes accurately (i.e. not only consented takes). Therefore, the system can produce highly accurate and comprehensive water accounts to underpin water management within limits. Sound science and research underpin consented allocation rates and volumes for farming activities, municipal and community water supplies, industrial and commercial supplies. Irrigation water demand, which result in highest summer water use, has been determined using a sophisticated soil-crop-climate-water balance modelling of IRRICALC. In addition the model has taken the efficiency of different irrigation systems into account (e.g. centre-pivot efficiency is higher than K-Line). The IRRICALC model has been verified using a 3-year field program under different climate, soil, crop and irrigation management. The other water take applicants (e.g. industrial) need to demonstrate that the volumes they are applying for are reasonable. WRC requires water meters to be sufficiently calibrated, at installation and then every 5th year, to meet the standards stipulated by the council. WISKI (time-series management database) stores water meter data for easy retrieval. The upgrade to IRIS will facilitate some automated links between two databases and improve the overall accuracy in water accounting. Permitted activity (PA) water use is accounted for using a calibrated model. This includes stockwater and domestic water use and has been calibrated against some small community schemes which had water meters measuring their collective use. This model may be considered to be the only PA water use model available in the country and other regional councils also use this model (e.g. Environment Canterbury). WRC's surface water-groundwater interaction management strategy is set out in the Waikato Regional Plan (WRP). The nature of hydraulic connection is assessed on a case by case basis by evaluating depletion of one resource due to abstraction in the other. The hydraulic connectivity estimates are included in the GIS database 'water allocation calculator' (which is the primary "accounting" tool used by WRC). Potential weaknesses There are some uncertainties associated with full capability of IRIS. To be able to meet WRC system needs some additional specialist software probably needs to be developed to work alongside IRIS. Quality control for the system uses manual checks only. There is no automated checking built into the system. There is potential for inconsistencies and errors with such manual checks. There is no electronic link between RUAMS and WISKI databases. The information from the RUAMS database is manually updated. Such manual handling is dependent on the diligence of staff and may be subject to human errors and irregularities without proper protocols or guidelines. However, the upgrade to IRIS will provide some automation. Surface water-groundwater connectivity for individual consented takes is not included in the consents database. Although it is in the GIS database, not being able to see this detail under each consent can lead to oversights when managing consents. However, IRIS will handle this and thus improve the water accounting.
Practical	Yes	Strengths The water accounting system works well for achieving the objectives of the WRP. The system provides technical feasibility to achieve the allocation

Criterion	Evaluation	Comments
		objectives, although a few aspects can only be handled by manual operations. It is expected that upgrading to IRIS will provide the ability to overcome current limitations within RUAMS and add more capabilities for water accounting including real-time data connection between the databases. IRIS will also address and enhance the ability to assign months to a take consent, include irrigation areas, store the hydraulic connection estimate, the version of consent number when it is renewed. The database behind the GIS calculator is updated 3 hourly from RUAMS. This is a timely update but is limited by the timing of updates in RUAMS. Again, IRIS will enhance this feature. There is a consent filing system as well as the electronic database in RUAMS. There are also paper records of many of the metered takes. The accounting performed in the GIS allows for some manual adjustments to account for the spatial location of takes and to deal with things like multiple wells on one consent, or bywash returning downstream of the original take. WISKI and the GIS tool are future-proofed. However, the ability of the whole system to be fully future-proofed is limited due to shortcomings of the RUAMS database, which again will be enhanced with the upgrade to IRIS. GIS links with databases provide spatial analysis. Catchments or subcatchments have common review dates (every 15 years) and typical durations of 15 years (with some exceptions), therefore any future limit revision (minimum flows and allocable flows) can be applied as a blanket change across the catchment when these reviews occur. The reliability of supply (average annual supply reliability of approximately 90%) provides water users a known reliability of supply to develop their business. <u>Potential weaknesses</u> The council has not yet evaluated the benefits or weakness of upgrading to IRIS for water accounting. While it appears that there would be certain enhancements, it is difficult to fully define the practical gains and issues at this stage. Development of IRIS will happen in stages as specialised supplementary software may need to be developed to meet WRC specific needs. Such staged development may have considerable practical constraints during the transitional period. There may be a reasonable amount of other operational issues related to the upgrade and staff training while attending day-to-day operations.
Transparent	Yes	<u>Strengths</u> WRC has conducted/commissioned a considerable amount of investigations/research to identify reasonable water use demands, effect of different supply reliability etc. Most of these studies were carried out in collaboration with communities and stakeholders. Details of these investigations including results are available through the council website. Therefore, the allocation process is highly transparent. Sufficient parts of RUAMS are available online for water users and stakeholders to see. <u>Potential weaknesses</u> The water use database is not available online.
Effective	Yes	<u>Strengths</u> The current system is effective and fit-for-purpose of water accounting. It is expected that upgrade of RUAMS to IRIS will improve the effectiveness. IRIS has been developed for many regional councils. Therefore, the development cost is shared. RUAMS was purchased in 1987 and the GIS

Criterion	Evaluation	Comments
		calculator derived in-house. WISKI was bought from Germany, and is also used to archive other council monitoring information. Thus, the overall accounting system can be seen as cost-effective system to achieve very important task/s at individual water takes, catchment and aquifer level. WRC requires water use of all consented takes to be measured, except for those less than 50 m^3/d. That provides the ability to produce accurate water accounts. <u>Potential weaknesses</u> Only 4% of takes are telemetered. Paper copy water meter returns require considerable staff time to process, and the delay in receiving returns (without telemetry) makes real-time management using accounts difficult. Paper returns of water meter data also allow potential for human error both in water user and council staff handling. Upgrading to IRIS may require additional staff input for data transfer, creating links with WISKI and GIS system, and training. This is necessary, but potentially expensive. The current reliance on manual data input may not be effective in terms of accuracy, timeliness and cost.
Acceptable	Yes	<u>Strengths</u> The allocation framework has gone through a comprehensive public process in the V6 hearing to finalise into the current status. Therefore, the methods now used by the WRC are largely accepted/adopted by Council and stakeholders indicating political and stakeholder acceptance.
Adaptable	Yes	<u>Strengths</u> The water account system is managed through the GIS framework. Therefore, the system can be scalable to any spatial dimension. <u>Potential weaknesses</u> The use of IRIS will ensure some common data collection across the six councils currently in the IRIS group.

Water quality

Description of water quality accounting system

The WRC accounting ‘system’ for water quality aspects is made up of the following components:

1. Consents database RUAMS (Resource Use Authorisation Management System), the purpose of which is to record, track and administer all resource consents, navigational safety by-laws applications, and selected permitted activities for the lifecycle of the activity. RUAMS contains >25,000 records. Fields viewed in the database include Holder details (linked to CONTACTS application), location details, consent type and subtype, application details and dates, consent event dates, ANZSI classification, selected parameters relating to authorisations, annual charges, consent history details. RUAMS will be replaced by IRIS in August 2013.

2. Compliance monitoring database: All compliance monitoring sites and related monitoring activities are recorded in the database. Nearly all consent conditions in the Waikato Region have been entered and classified. Monitoring

programmes have been managed through this database since 2001/2002, site compliance information is accurate however very limited compliance information is available at a consent or condition level. All physical records (i.e. consent compliance reporting/monitoring) are assumed to be part of this consent compliance database.

3. Numerous other databases, models and environmental (State of the Environment) monitoring data including:

- WRC's freshwater State of the Environment (SoE) monitoring network data which include: ground water (pesticides; nitrate-N; *E.coli*); Lake Taupo water quality (water clarity; chlorophyll *a*; total nitrogen (TN); oxygen depletion rate; *E.coli*; clarity); nutrient enrichment in shallow lakes (water clarity; chlorophyll *a*; TN; total phosphorus (TP)); rivers and streams water quality (dissolved oxygen; pH; turbidity; ammonia; temperature; TN; TP; *E.coli*; clarity); and biological monitoring of streams (Average Score Per Metric (ASPM) - comprised of number of sensitive taxa; mayflies + stoneflies + caddisflies (EPT); % of sensitive taxa (%EPT); tolerance of taxa to pollution; and Macroinvertebrate Community Index (MCI)).
- Manual systems that utilise freshwater SoE monitoring data to, for example, estimate/calculate nitrogen losses from land and the sources of nutrients in the region's major river (background vs. point vs. non-point).
- Landuse databases (LiDAR (Light Detection and Ranging) data, Aerial, Agribase, Farms online)
- Soil/topography databases (digital elevation model at 2m resolution, LUC, S-MAP)
- Climate database (CliFlo)
- Regional Ecological Monitoring of Streams (REMS) database (Ecobase)
- Nutrient tracking (NTRACKER database, Taupo catchment only)
- Models, for example OVERSEER for farm nutrient budgets and 'Hicks' sediment model for diffuse catchment sediment loads.

The 'system' incorporating RUAMS has been evaluated here, but as IRIS will be operational at WRC soon this has been included in the evaluation.

At the moment, this system is not developed to the extent that regular accounts can be generated, but WRC has undertaken source analysis exercises (e.g. for the development of policy for Lake Taupo amongst other things) and so the system is assessed here on the basis that this has potential to become an accounting system.

Example of source analysis that could form the basis of an accounting system

An example source analysis for the Waikato region is shown in Table 3-3 below.

Table 3-3: Mass flows of nitrogen and phosphorus in the lower reaches of four Hauraki rivers (Kauaeranga, Piako, Waitoa, Waihou) during 2000–09. Note: The combined mass flows from the various moderate-to-large point source discharges are shown, as are estimates of the pre-development or background mass flows, and the mass flows resulting from catchment land use.

Parameter	Four Hauraki rivers
Nitrogen (t/yr)	
Overall	3360
Point sources	260 (8%)
Background	760 (23%)
Landuse	2340 (70%)
Phosphorus (t/yr)	
Overall	270
Point sources	70 (25%)
Background	75 (28%)
Landuse	125 (46%)

Evaluation of water quality accounting system

Table 3-4: Evaluation of WRC potential water quality accounting system.

Criteria	Evaluation	Comments
Technically robust	Yes	<u>Strengths</u> WRC has a pragmatic approach to identifying the sources of contaminants of concern in some catchments, which for the Waikato region are nutrients, sediment and *E.coli*. The latter two are primarily driven by national guideline values for secondary contact (recreation). With respect to nutrients, the approach taken is to identify any sensitive downstream receiving water bodies (lakes/estuaries) and what contaminants most affect values of that water body. Treaty settlement issues are part of the identification process. Contaminants of concern are referenced in Variation 5 (Taupo), whereas other catchments have limits for clarity and *E.coli* (contact recreation standard), and selected waterway 'classes' have limits imposed for suspended sediment and ammonium (fisheries). Accounting methods appear to be based on sound science (accepting the presence of known knowledge gaps). For example, all environmental indicators have comprehensive 'technical field' explaining derivation and includes relevant citations. There is comprehensive SoE monitoring of freshwater quality in the region. Water quality monitoring includes river sites (114), ground water sites (ca. 80), ecological river monitoring sites (>120), shallow lakes (19) and Lake Taupo. The 'system' has potential to integrate aspects of ground and surface water quality - i.e. extensive groundwater monitoring for contaminants associated with landuse activities (*E.coli*, nitrate and pesticides). With the adoption of IRIS as a consents database, WRC will have improved consent data management. IRIS will also offer the potential to incorporate more data (monitoring/consent/compliance). IRIS would effectively function as a 'conduit' to link many of the council's datasets through a common system. This would effectively move the manually intensive system used to date for source analysis (extracting data from physical records and/or separate databases) to a more automated system for data recovery and analysis, which would greatly facilitate water quality accounting for catchments in the region.

Criteria	Evaluation	Comments
		<u>Potential weaknesses</u> The system used to date for source analysis relies heavily on manual extraction of records and locally developed methods for estimating contaminant loads. This knowledge appears to be held by selected individuals and therefore these methods may not be 'captured' as part of the overall 'system'. Such manually intensive processes mean that catchment budgets, source attribution and nutrient loss estimates are unable to be done routinely. The current consent database (RUAMS) does not store sufficient information about consents to enable routine accounting for sources. For example, it contains consent dates, and discharge location, but not consent history or discharge consent conditions. There is scientific uncertainty regarding groundwater lags - hence the relationship between current landuse and measured river concentrations/loads may be questioned. Estimation of non-point catchment sources rely on estimate values of pre-development (background loads), which are subject to uncertainty. The adoption of IRIS will likely require increased staff effort to configure the systems. The general feeling was that IRIS has the potential to address almost all the water quality accounting limitations identified during workshop discussions, however, when initially released, IRIS will not be configured to address most of these gaps.
Practical	Yes	<u>Strengths</u> Assuming no resource limitations, IRIS has the potential to address some of the current system limitations. It is expected to provide a flexible framework that provides common services used by several types of applications. For instance the current system comprises multiple databases, numerous data sets and physical records, and does not comprise a central or master database 'module' that 'links' the plethora of data into a 'single virtual system'. The understanding is that IRIS provides all the necessary 'plumbing' to address this limitation. <u>Potential Weaknesses</u> The current system, while being technically robust and comprehensive, is not yet practical for the development of accounts outlining the sources of contaminants except in a few catchments. The heavy reliance on manual accounting means that the system is not timely, update-able or future proofed. The current consent database module (RUAMS) is of very limited use for accounting as it does not contain any information on either consent discharge loads or measured discharge loads (i.e. database does not capture any consent monitoring data) - 'system' just stores this information in the form of physical records (requirement manual retrieval). Initially IRIS will be configured only for processing consent applications and ongoing monitoring under the RMA and Biosecurity Act. In relation to IRIS addressing all current water quality accounting limitations within the WRC, the director of IRIS development stated "*Note that IRIS as it currently stands is not the full information management and storage answer to the issues outlined at the Workshop. It is likely to be an integral part of the answer for the IRIS councils, but it is also likely that additional specialist software will be required for data acquisition (for water quantity) and for test result storage analysis and modelling (for water quality).*" It will take time and staff resources to develop and implement new 'environmental accounting' applications for the system.
Transparent	Yes	<u>Strengths</u> WRC publish source analyses for some catchments but these are very limited. However WRC report on a very comprehensive range of freshwater environmental indicators that are updated at intervals. IRIS system has all the 'plumbing' requirements to allow different levels of access

Criteria	Evaluation	Comments
		to users/stake-holders. Initial development is intended for internal use/application only, however IRIS development team already have pilot project looking at various aspects of 'user access' options. Use of IRIS should maximise 'commonality' of data, and enable easy distribution/sharing of and access to data. <u>Potential weaknesses</u> One-off studies at irregular timesteps do not provide useful regional accounting tools.
Effective	Yes	<u>Strengths</u> IRIS is built on the premise of 'multiple users – multiple uses' and therefore, given the resources can permit automated data retrieval for consented and monitored loads – presumably for not only individual properties, but for catchments and/or other water management units specified in the system. <u>Potential weaknesses</u> The current system is heavily reliant (almost exclusively) on manual data retrieval. For example, to retrieve the total load of a contaminant from point source discharges entering a particular water body, while the 'system' contains the data, retrieval is tedious and time-consuming. The only way to compare actual vs consented loads entering water way is via manual data retrieval. Similarly diffuse contaminant loads calculations for catchments take time to generate and require large amounts of resourcing. As these are carried out infrequently, WRC identified the need to move to a more modelling-intensive approach. For more complex data manipulations, it is unclear how exactly IRIS would interface with the required 'specialist software' for data acquisition/storage/analysis/modelling. The understanding is that the 'data warehouse' approach of IRIS would still enable all additional processes to work with IRIS.
Acceptable	Yes	<u>Strengths</u> While there was initial resistance to the messages that Lake Taupo's declining water quality was attributable to landuse, the accounting done to establish sources of nutrients for the catchment has increased acceptance. IRIS has the potential for users to submit data (in agreed format) directly to the 'data warehouse', combined with the potential (and plans) to provide users with access to the selected data. This increased transparency associated with compliance monitoring will (presumably) facilitate uptake (i.e. compliance) <u>Potential weaknesses</u> The V5 development process was lengthy and costly, and is unlikely to be possible to undertake the same level of detailed accounting for all catchments in the region.
Adaptable	Yes	<u>Strengths</u> The current system appears to be relatively adaptable, mainly because it is an ensemble collection of separate (non-linked) databases/data repositories – hence changes can be easily incorporated into the relevant component. <u>Potential weaknesses</u> From the perspective of timely water quality accounting, the current system is not adaptable as it is too reliant on manual data entry/data retrieval. For example, currently it is very manually intensive to undertake nutrient budget loads for a particular catchment.

3.2.2 Results – the costs

The aim of this part of the council workshop interviews was to document the indicative costs of the processes, methodologies and tools regional councils are using (or propose to use) and the identification of any significant capability and capacity issues. The purpose of this was to increase the understanding of the costs that have been (and will be) occasioned by the advent of the National Policy Statement for Freshwater Management 2011 (NPSFM), and any further freshwater Reforms.

As highlighted in the above discussion for WRC, accounting 'systems' may be comprised of several components. Generally, councils were not able to provide costs for the system as a whole, but have provided costs for information systems that play a key role in accounting. We also note that costs that we have dubbed 'limit setting costs' in Section 4 of this report generally include the full costs of policy development, which may be much broader in scope than limit setting for water quantity and water quality.

In the workshop with WRC, we asked specific questions about costs incurred for council to undertake water quantity and quality accounting activities. Following the workshop there were subsequent face-to-face interviews with selected WRC staff. WRC has already progressed some way down this path and were in a realistic position to comment on general level of costs. Where feasible, indicative costs were split into policy development and implementation cost categories for each process identified.

Types of costs and feedback on cost questions

The early discussions with WRC showed that within regional councils, costs tend to be split between science/research, policy development and policy implementation, and so on - falling within different departments according to the organisational structure in place. WRC indicated that this was an easy structure to follow in terms of cost collation and they felt that they could provide costs accordingly given the separate departments of responsibility within their council: resource information (research), policy (development) and resource use (implementation). They suggested that other regional councils are likely to have similar structures in place, and the cost questions were amended accordingly. While we asked questions about costs at the WRC workshop, costs were most easily extracted in one-to-one interviews, which allowed WRC staff to follow up with the financial accountant or group managers for further details on historic and current budgets. This one-on-one process was then used for the other councils.

Examples of types of costs were provided in the questions, and the provision of annual costs was requested. In terms of historic costs, a time horizon of last 3-5 years (or when the policy initiative started) had to be provided. We sought:

- Annual council staff time costs
- Sub-contracting, consultancy fees
- Legal fees incurred by council Hearing processes, Environment Court etc.
- Public consultation costs, iwi and other parties relationships costs
- Benchmarking, monitoring costs etc.

- Transaction costs such as resource consents updates, water trading costs etc.
- Any other costs (e.g. communications, travel, training etc.).

Costs relating to accounting systems are provided in this section, and costs relating to limit-setting processes are provided in section 4.

A summary of the WRC costs relating to information systems that are part of an accounting system is given in Table 3-5, and detailed below.

Table 3-5: Summary of costs related to accounting received from WRC.

System costs related to accounting	
IRIS	$4.7M policy development/implementation costs plus $360k annual operational costs No change in operational costs since the NPSFM

Water quantity and quality accounting

The system at WRC that could be used for accounting systems (amongst other data management functions) for both quantity and quality is IRIS, although as noted at the workshop with WRC, IRIS is only one component of the systems used for accounting and may require some enhancement to better meet accounting needs.

Cost structure of IRIS

The cost of IRIS for the six regional councils has been based on a cost-share basis according to their relative size, e.g. WRC shares 36% of the costs whereas the West Coast Regional Council shares about 8%. In the near future, it may be that Bay of Plenty Regional Council and Hawkes Bay Regional Council will adopt IRIS, and if they join, they will be assigned a joining fee based on the cost-share basis approach so that the existing member councils will get a refund. For those regional councils that already have similar systems in place and are not due to renew their systems currently, it may only be worthwhile for them to consider IRIS when they need to replace their current systems.

The entirety of IRIS costs need to be considered as it is too difficult to separate the different elements of IRIS, for example a new member would need to install at least 50% of the system for it to work. Hence total costs were considered here.

Since the NPSFM came into effect on 1 July 2011, there has been no change in operational costs of implementing IRIS.

Indicative costs of IRIS

The development costs of IRIS have amounted to $5M and have been shared by the six regional councils (this includes sub-contracting costs)[109]. Annual operational costs consist of subscription costs of $1M pa (operational and capital expenditure) total from all IRIS councils starting from 1st June 2013. WRC estimates that an equivalent of $4M from all six regional councils of time and expenses has been spent by regional council staff during development. Implementation costs for WRC for the years 2012/13 and 2013/14 have amounted to around $1M.

[109] Indicative costs have been provided by Derek Postlewaight, Waikato Regional Council, 24th May 2013.

Table 3-6: WRC indicative costs for developing, implementing and operating IRIS.

Development costs	$5M sub-contracting costs shared by six councils – WRC share estimated to be 36%, i.e. $1.9M $4m staff time – WRC contributed more than other councils, WRC share estimated to be $1.8M
Implementation costs	$1M budget for WRC. Other councils have their own implementation budgets.
Operational costs	$1M pa for all 6 councils, spread by cost model. WRC share estimated at $360k pa.
Total WRC costs	**$4.7M plus annual operational costs of $360,000**

As above, it was noted that IRIS would need improvements if it were to be implemented as a single accounting system. Extra costs associated with any enhancement depends of the complexity and scope of the requirements, and from a computer systems perspective these are not yet definite enough to estimate, or even provide an accurate indication of scale. For example, if water quantity was measured by monthly or weekly self-reporting from a site and little further analysis was required, then that could be done within the current capabilities of IRIS. At the other end of the scale, if real-time measuring of water quantity was required, there would be additional costs in the order of $150,000-$250,000 at the councils end, and more costs at each site to install measuring devices.

Issues identified

IRIS as it currently stands is only one component of an 'accounting system' for takes or contaminant sources. It is likely to be an integral part of the answer for the IRIS member councils, but it is also likely that additional specialist software will be required for data acquisition (for water quantity) and for test result storage analysis and modelling (for water quality).

If a separate consent and compliance system was introduced that is specific to water accounting issues, it is likely to introduce significant operational overheads and potential for inconsistencies for council staff that are involved in processing and monitoring consents and other permitted activities for other purposes.

3.3 Horizons Regional Council

The Horizons Regional Council (Horizons) workshop was held at the MfE office in Wellington on Wednesday 5 June 2013. Horizons sent two staff members who were able to work through all of the questions with the project team. The group was not large enough to allow a split into water quantity and water quality groups, and so the questions were worked through end-on end.

3.3.1 Results – the evaluation of accounting systems

Water quantity

Description of water quantity accounting system

The Horizons water accounting 'system' is primarily made up of two components:

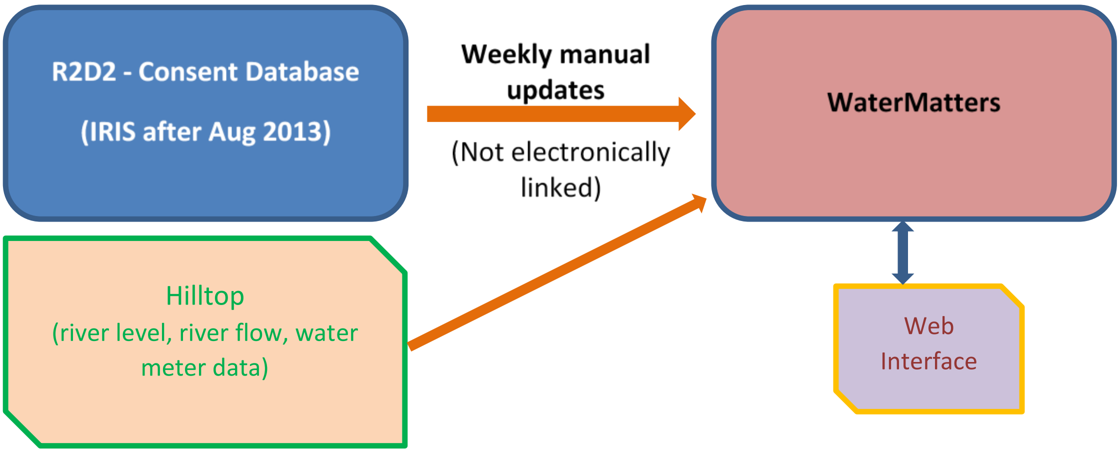


Figure 3-3: Schematic diagram of the Horizons water accounting system.

1. R2D2 is the main consent database, and stores primary consent information such as source type, source description, map grid reference, detailed description of the take, purpose/s, use type/s, take rate and volumes, granted and expiry date, irrigated area etc. However, the database will be replaced by IRIS probably by the end of August.

2. WaterMatters provides a software interface which provides support for compliance staff. WaterMatters was developed using Visual Basic and can handle Hilltop time series data. The database has a web interface, and can inform a range of system outputs including database query reports and spreadsheets. This also includes necessary consent information that is required for compliances such as maximum daily volumes and rates, dates granted, expiry date, all monitoring requirements, and data reporting requirements.

In addition to the above main components, Horizons' water accounting system is supported through other components:

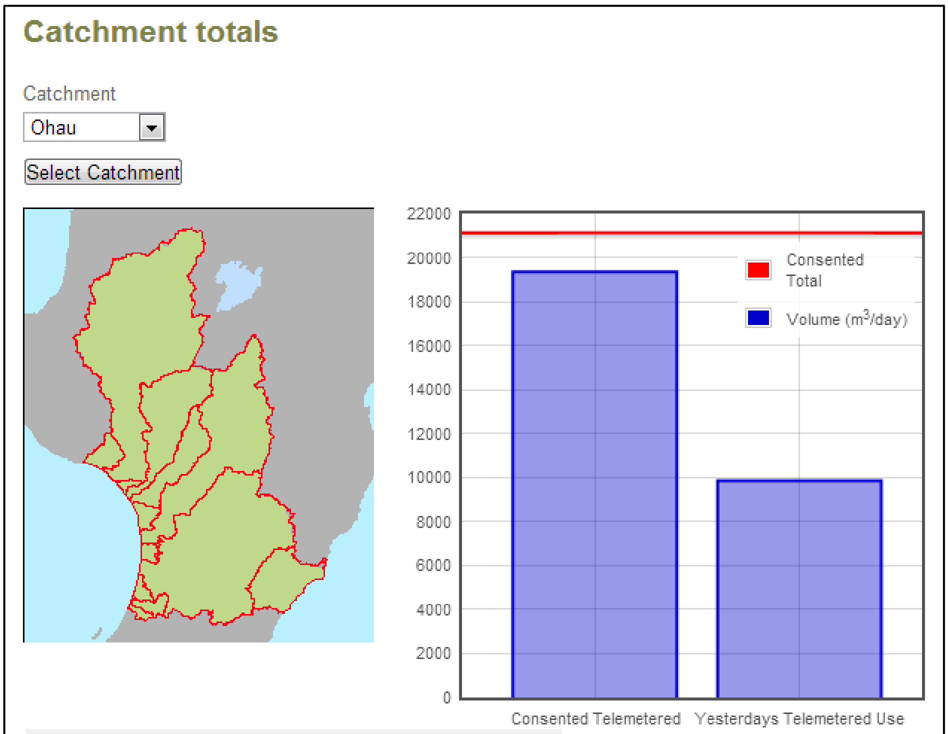
- A GIS system to assess, locate and display spatial location of the water take and use.
- Tools to estimate permitted activity takes.
- Water meters - approximately 70% of the consented volume is measured through telemetered meters.
- A web-based reporting system, fed by data from WaterMatters, to display daily actual water use against consented volumes for individual consents, by catchments or water management zones.
- Paper records of all consents and relevant water meter information.

Horizons' water accounting system is one of the best in New Zealand for metered takes, and includes stockwater takes. Their surface water allocation framework is developed using sound science and extensive hydrological analysis. Whilst current understanding of the groundwater resources is limited, management strategies are sufficient for sustainable resource use. However, they are working on developing better understanding of the groundwater resource through better science such as integrated groundwater-surface water models.

The details of the water accounting system are set out in the Proposed One Plan (or POP; Horizons' Regional Policy Statement and Regional Plan). The POP framework is supported by consenting and water metering programmes, which are in turn supported by R2D2 and WaterMatters. WaterMatters allows near real-time water use status reporting across the region. The reports can be used by both the council (e.g. for compliance checks) and individual users via the web.

Example of water quantity accounts

Figure 3-4 and 3-5 show two examples of water accounts based on telemetered use records. Figure 3-4 illustrates the actual daily use for the reporting date (21 June 2013) and the previous date (marked as Yesterdays) along with the allocated total volume (red bar) for the Ohau catchment. Figure 3-5 shows similar data for the Upper Gorge management zone.



Zone	Consented Total	Consented Telemetered	Yesterdays Telemetered Use
	Volume (m^3/day)		
Ohau	21131	19342	9855
Catchment total	21131	19342	9855

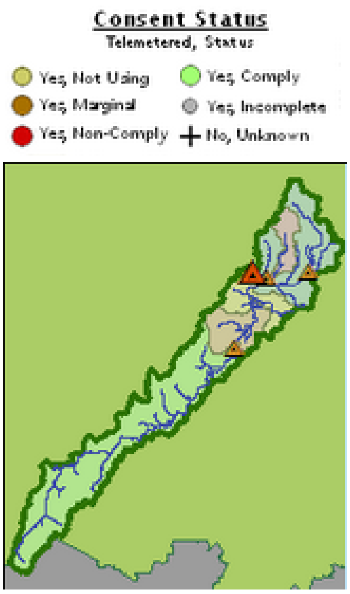
Figure 3-4: The allocated and actual daily use over the last two days for 21 June 2013 for the Ohau catchment.

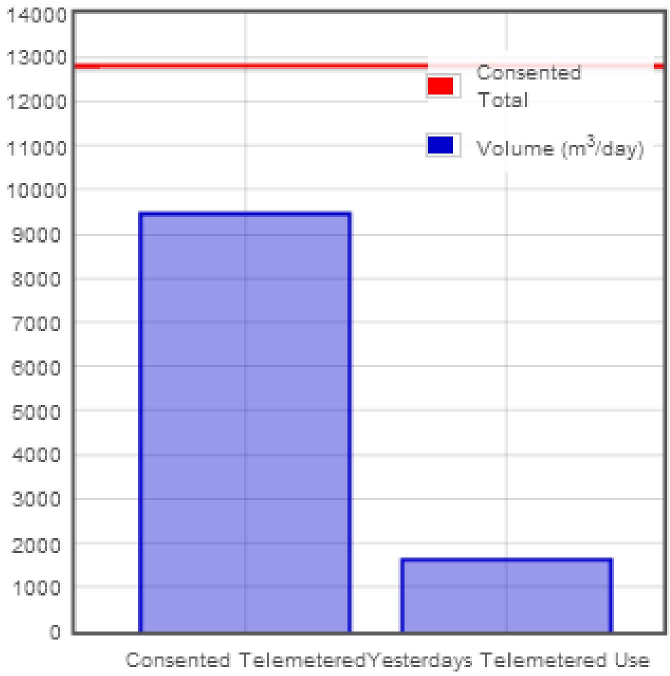
Management zone totals

Zone

Upper Gorge

Select Management Zone





	Volume (m^3/day)		
Subzone	Consented Total	Consented Telemetered	Yesterdays Telemetered Use
Upper Gorge	8802	6520	0
Mangapapa	2968	2940	1630
Mangaatua	347	0	0
Upper Mangahao	472	0	0
Lower Mangahao	224	0	0
Zone total	12813	9460	1630

Figure 3-5: The consented and actual daily use over the last two days for 21 June 2013 for the Upper Gorge management zone.

Evaluation of water quantity accounting system

Table 3-7: Evaluation of Horizons' water quantity accounting system.

Criterion	Evaluation	Comments
Technically robust	Yes	<u>Strengths</u> The two components of the water accounting system, R2D2 (consents) and WaterMatters (water metering) databases, have been set up to obtain daily water accounts at consent, catchment or Water Management Zone (WMZ) scale. The accounts can be obtained at near real-time, if required (individual consents for telemetered takes only). Accounting takes stockwater and non-telemetered takes into account. Sound science and research underpin consented allocation rates and volumes for farming activities, and town and domestic water supplies. Irrigation water demand has been determined using soil-moisture modelling of SPASMO-IR. The council has developed a system to ensure that the water meters are sufficiently calibrated to meet the industry standard. The databases have been developed and tested by skilled staff to ensure accuracy of the water accounts that they produce. The council has developed a comprehensive methodology so that technical components of all consent applications are assessed by the science team prior to decision-making. The consent team checks for accuracy and required consent conditions. A comprehensive water metering program has been developed; approximately 70% of the consented volume can be measured with telemetry. A dedicated staff member quality controls the water meter data. The change to IRIS from R2D2 may facilitate some automated links between two databases and improve the overall accuracy in water accounting. The integration of surface water-groundwater and other hydraulically connected water bodies have been taken into account in developing water accounting. The allocation objectives clearly state that groundwater takes that are hydrologically connected to rivers, lakes or wetlands are managed to protect the life-supporting capacity of those water bodies. A basic range of riparian buffer bands from the surface water bodies are used to account for effect of water abstraction from water bodies on the other, e.g. effect of groundwater abstraction on the stream depletion. The accounts will be further refined using planned integrated surface water-groundwater modelling in the future. <u>Potential weaknesses</u> While there is peer-review of consents and checking at compliance monitoring stage, there is no formal quality assurance (QA) system at end of the consenting process or automated condition checking system built into the system. Accuracy of the data and data integrity is dependent on staff experience and judgement that can vary between people. It is difficult to train new staff to perform at similar accuracy to that of an experienced staff member without a formal QA system. There is no electronic link between the R2D2 and WaterMatters databases. The information from the R2D2 database is manually updated weekly. Such manual handling is dependent on the diligence of staff and may be subject to human errors and irregularities without proper protocols or guidelines. The current system is not fully developed to handle diversions and bywash.
Practical	Yes	<u>Strengths</u> The water accounting system works well for achieving objectives in the POP. Whilst there are a few informal aspects in the handling consent database, R2D2, it technically feasible to achieve the allocation objectives. It is expected that changing to IRIS will provide the ability to overcome current limitations within R2D2 and improve the ability to produce water accounts including real-time data connection between databases. The WaterMatters database works extremely well for the council to accomplish

Criterion	Evaluation	Comments
		many aspects of water accounting such as compliances, efficient water use, protecting ecological flows. Both R2D2 and WaterMatters databases are updatable at required time frames. WaterMatters is mainly fed by telemetered water meter data and therefore updates at near real-time. Both databases are future-proofed up to certain extent, and the change from R2D2 to IRIS will further future-proof the systems capabilities. The council uses two electronic databases and paper records where necessary. In addition to having regular backups of electronic data, paper records will provide an alternative means of records when needed. The council ownership of telemetry is a practical solution to obtaining real-time information on metered takes to enable good water accounting and management <u>Potential weaknesses</u> The council has not yet evaluated the benefits or weakness of changing to IRIS. While management of WaterMatters appears to be well-resourced, procedures/protocols and resources for the current R2D2 database may not be sufficient to implement the new IRIS system. It is vital to maintain both the consent and water meter databases to have efficient water accounts. The dependence of manual accuracy checks and updates of the consent database could potentially be a hindrance to achieving near real-time water management possible with WaterMatters. Installing telemetry at council expense may be impractical in catchments where there are a large number of takes.
Transparent	Yes	<u>Strengths</u> The water accounts are highly transparent and are accessible to all the water users and stakeholders through the Council website at near real-time. Given the accuracy of consent data and limits for the river/catchment/aquifer, the abstractions against the allocation limits can be seen. This transparency enhances the potential for collaborative water management as information is available for all the stakeholders. <u>Potential weaknesses</u> As individual water use records are accessible to others, single water users can be subject to scrutiny and generate the potential for tension between water users in the same catchment/aquifer, primarily during times of low flows/aquifer levels. While Horizons own the telemetry systems in place and thus have greater control over the data, care may still need to be taken over the use of that data. The water account transparency (i.e. daily outputs) is currently available for water users with telemetry only. There is a lack of transparency with respect to non-telemetered takes but these are relatively small.
Effective	Yes	<u>Strengths</u> The current system is effective and fit-for-purpose for water accounting of telemetered takes. It is expected that the change from R2D2 to IRIS will enhance the effectiveness, resulting in Horizons having one of the best water accounting systems in New Zealand. IRIS has been developed for many regional councils, and the development costs have been shared (see section 3.3.3). WaterMatters was developed in-house at very low cost. Thus, the overall accounting system can be seen as cost-effective. Information produced through the system at near real-time is entirely automated. Therefore, it is highly effective for telemetered takes. Having council ownership of telemetry is an effective mechanism to manage metered water accounts. Water user visits to check the council's telemetry equipment has the added benefit of compliance checking the water users water

Criterion	Evaluation	Comments
		meter at the same time. <u>Potential weaknesses</u> The current accounting system is largely focussed on getting quick information for large takes, i.e. most telemetered takes are over 20 l/s. However, some water bodies can have a large number of small takes that add up to a significant cumulative volume and the current system may fail to obtain real-time information for such catchments. However this data can be summed to give annual/seasonal statistics. The change to IRIS may require additional staff input for data transfer, creating links with between the databases, and training. This is necessary, but potentially expensive. The current reliance on manual data input may not be effective in terms of accuracy, timeliness and cost.
Acceptable	Yes	<u>Strengths</u> The methods developed by the council have largely been accepted by water users and other stakeholders. The lack of tensions related to water quantity parts in the POP hearings can be seen as an acceptance of the methods. Political acceptability is inferred from the lack of political challenges to the current system.
Adaptable	Yes	<u>Strengths</u> The current system is adaptable at any spatial scale within the region. The R2D2 and WaterMatters systems have been developed so that accurate information can be available at individual take, catchment or WMZ scale. <u>Potential weaknesses</u> While consent databases are able to be adopted in other regions, some aspects of the WaterMatters approach cannot be repeated in other regions. For example, Horizons have chosen to pay for installation of telemetry systems and thus own the data, which has been possible due to the (relatively) small number of takes in the Horizons region, whereas other regional authorities would likely find this prohibitive, especially without specific regulations to enable this and/or encourage water users to install and maintain such systems.

Water quality

Description of water quality accounting system

For the purposes of this evaluation, Horizons' water quality accounting 'system' is comprised of the following components:

1. The consents database (R2D2) and data accessible from the Hilltop database
2. A compliance monitoring database (Qualarc)
3. Schedule D of the Proposed One Plan (POP) tables of water quality 'targets' [which Horizons note do not meet the NPSFM definition of targets, but are more numeric objectives]
4. Numerous other databases, models and environmental (state of the environment) monitoring data ('Hilltop').

Example of water quality accounts

Horizons has produced accounts for nutrients as part of its State of the Environment 2013 report. Figure 11 from that document, for sources of nitrogen in the Upper Manawatu, is reproduced here as Figure 3-6.

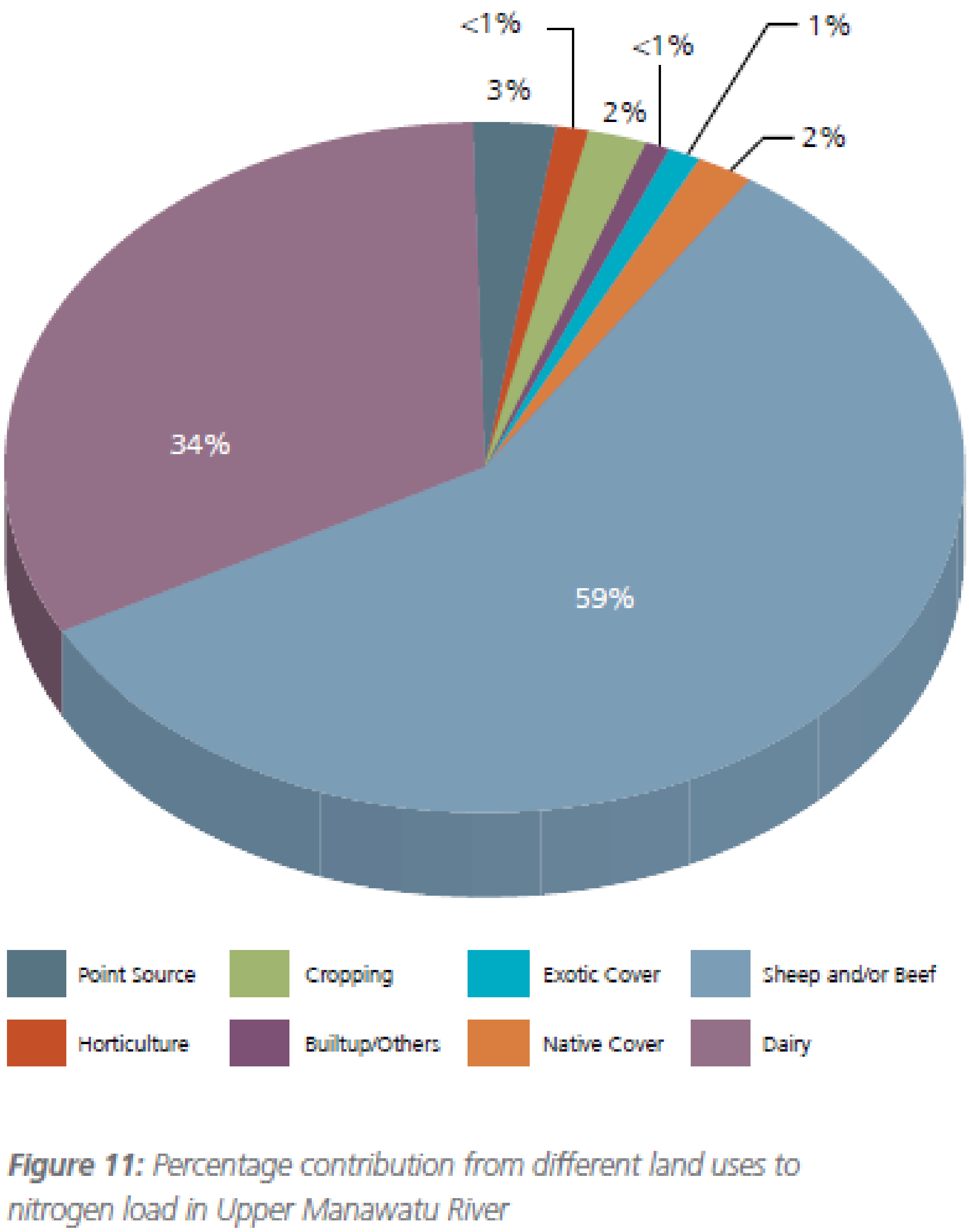


Figure 3-6: Percentage contribution from different land uses to nitrogen load in upper Manawatu River. (From Horizons State of the Environment 2013 report).

Evaluation of water quality accounting system

Table 3-8: Evaluation of Horizons' water quality accounting system.

Criterion	Evaluation	Comments
Technically robust	Yes	<u>Strengths</u> Water quality issues, and the associated ‘contaminants of concern’ are clearly stated in the Proposed One Plan (POP). Robust contaminant source analysis was in the past carried out as one-off exercises for a number of the region’s rivers as part of the development of the POP (for N and P). The general approach was conversion of SoE monitoring concentrations into annual loads. All point source (PS) loads were calculated from compliance and/or SoE monitoring, and then subtracted from measured instream total to determine the diffuse (DF) source contribution. Major point source discharge sites (upstream and downstream of discharge) are included in the SoE monitoring programmes, enabling measured in-stream loads to be calculated, so that the source analysis can carried out. Horizons have a good understanding of how river flows influence water quality outcomes and have therefore approached contaminant load accounts via percentile flow ‘binning’, and use the 80th percentile flow as the upper limit for non-flood flows. The DF load in the WMZ is then apportioned based on land use and using literature and/or modelled (i.e. farm OVERSEER budgets) nutrient loss rates (Roygard and Clark, evidence “Nutrient load scenarios and methodology” 2012). Although manually intensive, this constitutes a bespoke *water quality load calculator* that calculates relative contributions from point sources and non-point sources at different river flows to a reasonable level of accuracy The science used by Horizons is technically robust; they use nationally available science expertise (in-house or externally sources). Technical reports are available for all aspects of the accounting system; for example assignment of WMZ (and subzones or WMSZ), river classification system, optimised periphyton monitoring and N and P loads for WMZs, statistical analysis of river flow data (including frequency of ecosystem disturbance, or FRE3). Horizons change from R2D2 to IRIS should enable automatic data retrieval regarding consent type. The various policies and rules in the POP mean that all intensive dairy farming in the targeted WMSZs and all new dairy conversion in the region will be required to submit farm plans. This data will improve estimates of discharges from various sources, hence improving contaminant accounting. Groundwater is managed by amalgamation of several surface water management subzones (WMSZs), and so in this way it is integrated with surface water quality management. Horizons use quality control on all ‘account reporting’, with a system which involves 2 person teams, with one to prepare the report while another reviews (i.e. internal peer-review). In addition, nutrient management plans (and nutrient budgets) submitted are peer-reviewed by expert (in-house), and the application ‘assessed’ in a similar way to other resource consent applications. <u>Potential weaknesses</u> The current consent database (R2D2) is of limited use for generating contaminant accounts, as it does not capture information on actual measured concentrations or compliance by consent holder. Horizons emphasised that all water quality accounting is based exclusively on measured concentrations/loads, unlike water quantity that is based on consented maxima. However, it is noted that Horizons will soon transition to IRIS which will have the potential to address many of the limitations of the current system. The paucity of comprehensive flow data for point source discharge consent

Criterion	Evaluation	Comments
		holders has been raised as an issue (McArthur and Clark 2007). This limitation has been addressed via Policy 13-4 (POP). To address uncertainty regarding ground water lag times and nutrient attenuation coefficients, Horizons apply a 'blanket' nutrient coefficient of 0.5 (to convert *direct losses* on land to *river losses*) for the whole region (average of typical range 0.3-0.7). This possibly contributes to the variation in loads from 'sheep and beef' when using a 'by difference' (i.e. mass balance) method (Roygard and Clark 2012). For the more general SoE monitoring, nutrients are reported as concentrations and sediments as loads. Need better understanding of loss rates associated with different land use
Practical	Yes	<u>Strengths</u> Nitrogen accounting and scenario testing for targeted WMSZ as per the POP has been accepted by Environment Court. Accounts information is used by Horizons for scenario testing and for education purpose (i.e. public and stakeholders) Horizons' intention is to prepare semi-regular accounts (i.e. sources and loads of accounts) for the region, with an estimated frequency of once every 2 years (e.g. Figure 3-6). The intended 2 yearly timeframe suggests that the system (for at least nitrogen) is practical (technically feasible), timely and updateable. Developing initial accounts for WMSZ is relatively labour intensive (determining landuse, determining nutrient loss rates, calculating measured total and point source contributions), with subsequent iterations/updates being more automated via Horizons' custom-built *water quality load calculator*. Based on the method described, improvements in land use databases, improved understanding of nutrient losses (through OVERSEER nutrient budget), and increased automation of data retrieval from SoE/compliance monitoring databases may enable more automation of WMSZ accounts. <u>Potential weaknesses</u> Previous WMSZ source analyses/accounting was driven by POP need, and it is unclear how easily the WMSZ source accounting will be incorporated into 'business as usual'. Accounts are limited to nitrogen and phosphorus (although these are the key contaminants). Preparation of WMSZ accounts still relies on accessing a lot of data (for measured river loads, and measured point source loads), these data are currently taken from Hilltop, which is a manually intensive process. Horizons emphasised a lack of space and time to work on accounting systems – a key component of doing this is to 'bring together' system components to enable a greater degree of automation - idea is to be able to generate more accounts 'the push of a button' – with the caveat that need the right data in and processing (with associated QC) to get the right data (accounts) out. A general comment from Horizons is that resources are extremely limited – significant increases in resources are required to implement new quantity and quality accounting/limiting setting.
Transparent	Yes	<u>Strengths</u> Users can access a web page called 'Water Quality Matters' where there is limited data available that can be displayed in a graphic format by region, catchment, management zone or consent. Water quality attributes can be selected including BOD, SIN, *E.coli* and DRP. This website allows viewing of consent impacts, as a lot of data is presented about major point source discharges.

Criterion	Evaluation	Comments
		The accounting methods and the science underpinning them (i.e. how the accounts are derived) are transparent. Potential weaknesses The system is not transparent with respect to other stakeholders or users being able to physically access components of the 'system' (within appropriate privacy standards). There may be potential for increased transparency with IRIS.
Effective	Yes	Strengths Horizons have been able to model nitrogen outcomes for all policy scenarios put before the Environment Court for a range of large and small WMSZs (refer Roygard and Clark evidence, 2012). Horizons emphasised that despite the uncertainties, the catchment nutrient loads/scenarios presented in the POP were not challenged in Court. The POP has a comprehensive set of water quality numeric objectives (concentrations) (Schedule D) for 12 water quality attributes for streams in the 124 WMSZ's, and also for additional regional stream/river and lakes (shallow and deep). The accounting system enables delivery on all three of the key criteria, which are: 1) inform decisions on objective and limits 2) inform decisions on how to manage within limits and determining best strategies to reduces discharges) 3) ongoing accounting and report to provide feedback on progress and act as trigger for changes in management Potential weaknesses The development of the POP has been the driver for the catchment accounting - i.e. it has been resourced/prioritised *out of need*. What is unclear is how readily this accounting system will transition into the 'operational routine' of normal catchment accounting and reporting. Horizons currently have catchment budgets/accounts for selected WMZ or WMSZ. Catchment load accounts would need to be done for all priority and over allocated catchments – as this would be needed to inform land use change scenarios, limiting setting and, most importantly, mitigation strategies to address and/or avoid over allocation.
Acceptable	Yes	Strengths To the extent that accounts developed for POP have been tested through the Environment Court, the system is acceptable. Horizons have good relationships with key stakeholders to enhance this acceptability. Potential Weaknesses A major challenge for Horizons has been dealing with concerns surrounding proposed changes to intensive agriculture in targeted zones (and new dairy farming within the region) – however this 'acceptability' is more concerned with nitrogen limits (informed by nutrient accounting) than the source analysis carried out. Some sector groups have argued that they are being unfairly targeted and are not a major source e.g. http://www.stuff.co.nz/dominion-post/comment/8027449/One-Plan-to-have-disastrous-impact
Adaptable	Yes	Strengths The region is divided into 7 parent catchments (note that smaller coastal catchments are combined into either 'West coast' and 'East coast' parent catchments); these 7 parent catchments are split into 43 (or 44) water management zones (WMZ's), which are in-turn split into a total of around 124 sub-zones (or WMSZ's). Because the actual management unit is at the sub-

Criterion	Evaluation	Comments
		zone spatial scale, theoretically the system can be scaled-up by aggregating sub-zones to WMZ scale, and in-turn, aggregating WMZ to give parent catchment scale accounts, and in-turn, aggregating parent catchments to generate regional accounts. <u>Potential weaknesses</u> Catchment accounting is largely limited to nitrogen and to a lesser extent phosphorus. Sediment yields are measured as the amount of sediment carried past a monitoring site per year. While useful for monitoring, it is unclear how these data could be scaled up or down to match different WMZ/catchments. Aggregating of WMSZ loads assumes that load data is available for all 124+ WMSZ's. It seems that in the short term, at least, this WMSZ accounting would be limited to targeted catchments.

3.3.2 Results – the costs

A summary of the costs relating to certain components of Horizons' accounting system are outlined in Table 3-9 and detailed below.

Table 3-9: Summary of costs related to accounting received from Horizons.

System costs related to accounting	
IRIS	$2M policy development/implementation costs plus $170k annual operational costs No change in operational costs since the NPSFM
Telemetry System	$1.14M annual operational costs since 2010
Annual Plan 'WaterMatters' and 'WaterQualityMatters' display software	$9.59M operational costs (2010-13) $20-30,000 per annum since 2005 $4,000 annual upgrade/maintenance costs

A background to IRIS, the general business concept, the scope and cost structure has been provided in section 3.2.3 for WRC and in Appendix C. IRIS is an information system that, once implemented, will be used much more broadly than for purely accounting purposes.

Indicative costs of IRIS for Horizons

The cost of IRIS for the six regional councils has been based on a cost-share basis according to their relative size and Horizons shares 15.5% of the costs. Since the NPSFM came into effect on 1 July 2011, there has been no change in operational costs of implementing IRIS.

Table 3-10: Horizons indicative costs for developing, implementing and operating IRIS.

Development costs	$5M sub-contracting costs shared by six councils – Horizons share estimated to be 15.5%, i.e. $0.8M $4M staff time – Horizons' share estimated to be $0.5M
Implementation costs	$0.7M budget for Horizons. Other councils have their own implementation budgets.
Operational costs	$1M pa for all 6 councils, spread by cost model. Horizons' share estimated at $170k pa.
Total costs	**$2M plus annual operational costs of $170k pa.**

Telemetry system

Background

Horizons has had a telemetry system for around 20 years. During that time it has evolved from a flood warning system to a real-time data capture system. This occurred as the benefits of improved technology made real-time data collection increasingly easy. There is bolt-on software called WaterMatters in which telemetered take volumes are evaluated against resource consent conditions (allowable water taken/day based on how high or low the river is), operating well before the NPSFM came into force. The software allows resource users to monitor river flow and their own water use and warns users and Horizons when resource consent conditions are not complied with. Resource consents for water takes are restricted to ensure the cumulative core allocation of water (the equivalent of a limit in the NPSFM) for a sub-catchment is not exceeded, so in its broadest sense, WaterMatters is monitoring whether the cumulative core allocation (i.e. the limit) of water is being complied with on a real-time basis.

Indicative costs

The operating costs of telemetry and database management are all done by the same department in Horizons. The operating costs of the telemetry system are incorporated into the costs set out in the Horizons Annual Plan, i.e. $9.59M. On further analysis, the on-going operating costs of telemetry are about 35% of the annual total. That would mean that roughly $3.4M of the $9.59M covers the operating cost of the telemetry system, including field sites, maintenance, data quality control and database management for the period 2010-13. Essentially operating costs averaged $1.14M per annum for the period 2010-13.

3.4 Tasman District Council

The workshop with Tasman District Council (TDC) was held at the TDC offices in Richmond on Friday 7 June 2013. Altogether approximately 10 TDC staff attended, and they covered areas of science, planning, monitoring and administration. TDC preferred not to split into two groups (quantity and quality), primarily because the expertise of some staff members covered both areas. The limits questions were addressed first, and then the accounting systems questions. The TDC team had already met and populated the answers to the questions for this review, which helped considerably in managing time to go over all the questions within the day.

3.4.1 Results – the evaluation of accounting systems

Water quantity

Description of water quantity accounting system

The Tasman District Council (TDC) water accounting 'system' is primarily made up of two components:

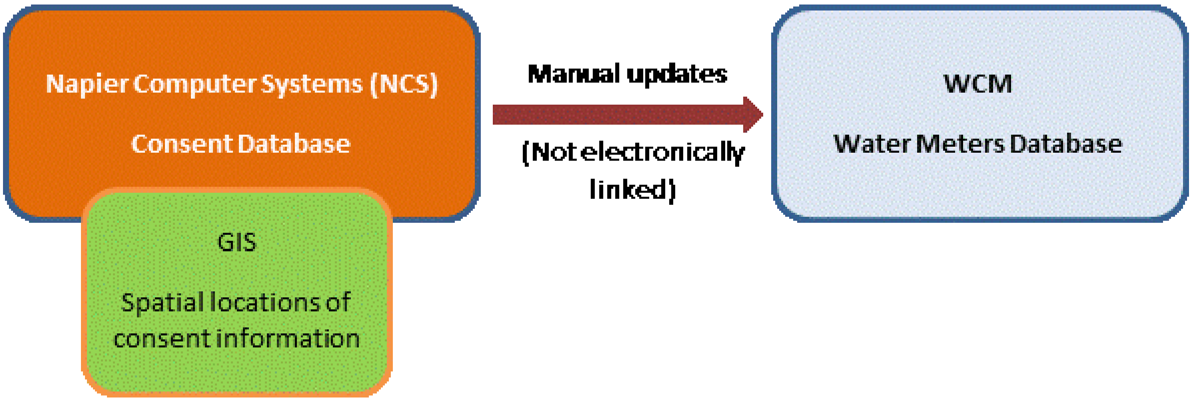


Figure 3-7: Schematic diagram of the TDC water accounting system.

- Napier Computer Systems (NCS) is the main consent database. The database also holds variety of other council information such as relating to Building Act requirements or dog licensing. NCS is commonly used by Territorial Authorities.
- The Water consent monitoring (WCM) database holds water metering data of the consented takes. WCM is an in-house, custom built and maintained database. WCM handles time series data using Hilltop.

NCS is not electronically linked to the WCM database. However, regular manual checks and reconciliations are carried out.

In addition to the above main components, the TDC water accounting system is supported through other components:

- TDC's GIS system enables spatial analysis of the consents.
- Estimates of permitted activity water use. Detailed studies have been conducted for some high water use catchments.
- Water meters; approximately 80% of the consented takes are metered.
- Monitoring network of river flows, groundwater levels, rainfall and climate.
- Paper records of all consents and relevant water meter information.

The TDC water accounting system has been developed over the last three decades and over that time has evolved to fit TDC's needs. The details of the water accounting system along with fresh water objectives are set out in the Tasman Resource Management Plan (TRMP). TDC water management is tied to three key issues:

1. Reduced water body flows or levels;
2. Allocation of fresh water between competing water users; and
3. Freshwater augmentation.

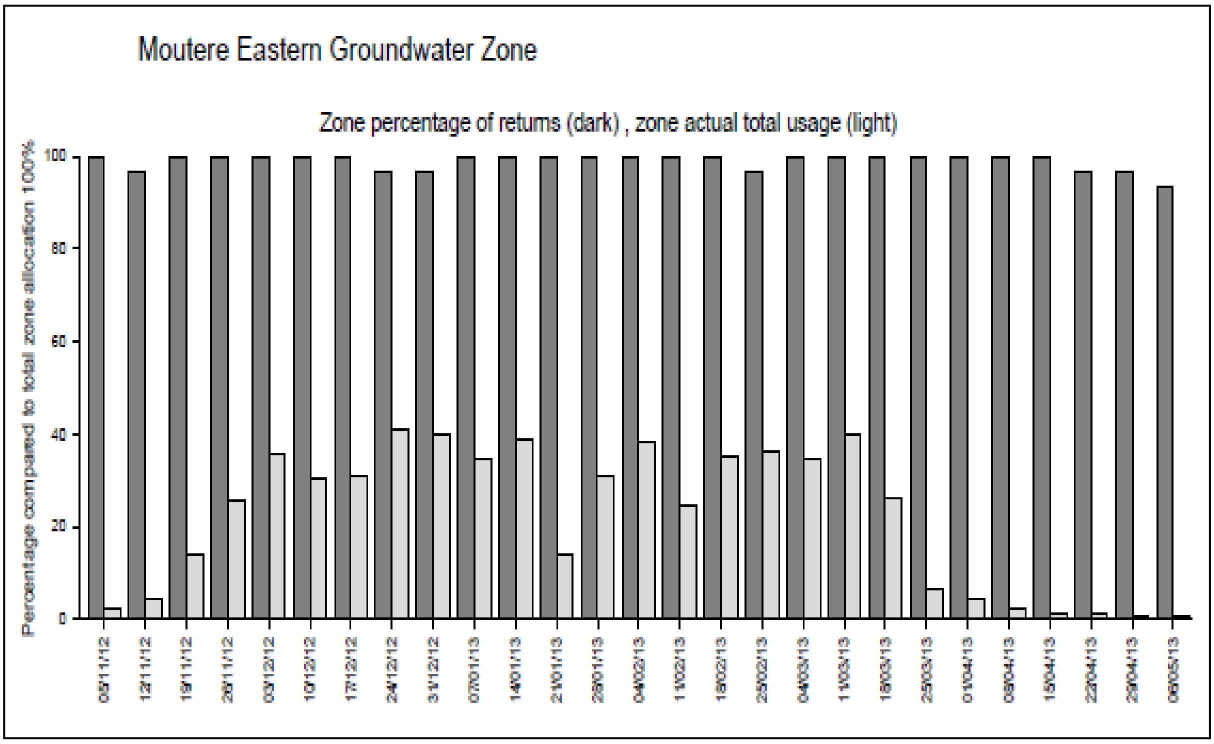


Figure 3-8: The returns received and actual weekly use for the Moutere Eastern Groundwater Zone, November 2012 to May 2013.

Example of water accounts

Figure 3-8 shows an example of a water account from the Tasman region. The figure illustrates the percentage of returns received from each zone, and the weekly actual use for the Moutere Eastern Groundwater Zone between November 2012 and May 2013.

Evaluation of water quantity accounting system

Table 3-11: Evaluation of TDC's water quantity accounting system.

Criterion	Evaluation	Comments
Technically robust	Yes	Strengths TDC's water accounting system comprises of two main components: the NCS (consents) and WCM database (water metering monitoring). These two databases are set up to provide comprehensive water accounting for the district. Water accounts from those that require water meters are generally produced at weekly intervals using data from NCS and WCM. However, the system is capable of producing accounts at daily, monthly or annual periods. Metered takes account for 80% of the consented takes, and some stockwater takes may

Criterion	Evaluation	Comments
		be included where community schemes are consented Consent applications are accessed by science/technical staff to ensure that allocated rate/volume is reasonable. The accuracy of consent information is manually checked by the consent staff. Irrigation application rates are generally determined based on soil type as specified in plan. TDC's security of supply assumptions account for climate variability and soil based application rates, and also account for basic irrigation efficiency. However they are blind to crop type because that can change within the term of consent. Other water users such as industrial and commercial users are required to demonstrate that applied volume is reasonable. In addition there are provisions in the plan to review the allocation volumes based on actual use. Users need to demonstrate that the water meters are sufficiently calibrated to meet the industry standard at the installation and then every fifth year. There is a dedicated quality controller auditing weekly water use data. Surface water-groundwater integration is high within most WMZ in the district. Therefore, water allocation and use is assessed/treated as a hydraulically connected resource to ensure that the life-supporting capacity and other values (e.g. recreational, cultural) of surface waters are not adversely affected. Resource availability for most WMZs is assessed through integrated surface water-groundwater models. There is a comprehensive system in place to handle expired and renew consents. <u>Potential weaknesses</u> The ability to properly account for water takes can be affected by the conditions (limits) set on consents. TDCs consent conditions in general include instantaneous rate (l/s) for both surface water and groundwater takes (an annual allocation limit is defined for some groundwater takes). Without returns indicating longer term use (seasonal or annual) it may be hard for TDC to build a picture of water demand. However TDCs l/sec rate is linked to area irrigated and amount used per week, which provides water demand trend information. In addition, a l/s rate alone technically allows continuous water use, i.e. 24 hour abstraction throughout the year. While use of l/s rate may be sufficient for surface water takes, such continuous pumping could reduce the groundwater level and thus adversely affect the resource sustainability. However TDC states that consent holders do not use water in this way. The allocation rate is linked to (summer) allocation limit when the resource is under most stress. There is no formal quality control system or automated checking built into the consent database, other than manual checking. Accuracy and integrity of the data is therefore dependent on the experience and judgement of staff, which may be variable. It is difficult to train new staff to perform at similar accuracy that of an experience staff member without a formal QC system. There is no electronic link between the NCS and WCM databases. The information from NCS is manually updated as required. Such manual handling is dependent on the diligence of staff and may be subject to human errors and irregularities without proper protocols or guidelines. Historic consented data at any given time can only be extracted manually. There are only 8 telemetered takes out of 1050 metered takes. 71% of meter returns are submitted electronically and of this 83% are inputted through Council's website. The reliance on manual data input from water users may not be effective in terms of accuracy, timeliness and cost.
Practical	Yes	<u>Strengths</u> TDC was one of the first regions in New Zealand to streamline water allocation. Through time they have developed a system which meets their needs, and as such the system is practical.

Criterion	Evaluation	Comments
		Both the NCS and WCM databases can be updated on an as required basis. However, data availability for WCM is dependent on timing of water meter returns. Both databases appear to be future-proofed; however, some upgrades may be needed to improve efficiencies. In addition to electronic databases, paper records are kept where necessary. Therefore, main data can be extracted from more than one physical source. A GIS linked with the databases provides spatial analysis. <u>Potential weaknesses</u> While most of TDC water accounting system is practical, there are limitations to achieve full practical potential. Some of the issues are: - Little telemetry and therefore no facility to obtain data in real-time (although it can be argued that the current responses have not been disadvantaged by this lack of telemetered data); - Difficult to search fields, collate and report on data across various fields; - Difficult to achieve real time data management and link allocation data to use records without manual processing; and - Difficult to integrate water meter data with rainfall and river flow, consent information, property information without manual processing.
Transparent	Yes	<u>Strengths</u> Water accounts are accessible to water users and stakeholders through the council. Water users receive an annual water use summary. <u>Potential weaknesses</u> Neither consent nor water use data are available via a website. There are only 8 telemetered takes. Therefore, total water use within a WMZ is not easily transparent without going through paperwork.
Effective	Yes	<u>Strengths</u> TDC's current system is effective, and the weekly accounts that they can produce meets the district's objectives for water management. The NCS database handles many other data types than water take consents. Therefore, development and maintenance costs are shared across council activities. The WCM is custom built to meet water meter data storage and reporting needs. <u>Potential weaknesses</u> The system relies on returns from water users which are audited. Collating and recording the data is labour intensive and may not be effective in terms of accuracy, timeliness and cost. It is difficult to manage surface water in real-time without telemetered water use data (primarily for large takes and heavily allocated streams). There is no database for storing s14 (3)(b) takes. There is a lack of electronic features in the database system (e.g. search, collate and report on data across various fields, real time data management, no quick and easy way to insert/record data/change details) that reduces the effective use of the system.
Acceptable	Yes	<u>Strengths</u> There are no apparent political or stakeholder tensions with regard to the water accounting system, suggesting that the system is acceptable.

Criterion	Evaluation	Comments
		Use of water meters is seen by water users as a positive measure to manage their resource use.
Adaptable	Yes	Strengths The current system is adaptable at any spatial scale within the district (using GIS). Potential weaknesses The system is developed to meet local TDC issues. Therefore, it could potentially be difficult to use the system in other regions. However, there may some adaptable parts of the system, such as the way allocation is assessed against weekly actual use.

Water quality

Description of water quality accounting system

TDC describe themselves as 'fast followers' when it comes to giving effect to water quality aspects of the NPSFM. TDC have not yet started the process of limit setting (for quality), and as a consequence, there has been limited progress in developing water quality accounts for catchments/WMZs in the region. TDC do not routinely use a system to generate accounts however, components of a system are present, such as identification of contaminants of concern, good SoE monitoring programme, and nutrient accounts undertaken for selected 'at risk' catchments in the region. Some one-off source analyses have been undertaken.

For the purposes of this evaluation, TDC's water quality accounting 'system' is comprised of the following components:

1. Consents database (NCS)
2. Tasman Regional Management Plan (TRMP) – Chapter 33
3. Data from TDC's state of the environment (SoE) monitoring programmes including:
   A. Quarterly sampling of 55 water quality monitoring sites for 13 indicators including DO, temperature, conductivity, clarity, colour/appearance, faecals/*E.coli*, filamentous algae, MCI, fine sediment, substrate size, turbidity and nutrients
   B. 18 ecological monitoring sites monitored annually
   C. Bathing water surveys monitored weekly/fortnightly over the swimming season (Nov-Mar)
4. Water quality guideline values (Table 1, River Water Quality in Tasman District 2010 – Cawthron Report)
5. Other databases (soil, LCDB, weather, topography).

At the moment, this system is not developed to the extent that regular accounts can be generated, but TDC has undertaken source analysis exercises (e.g. for the Motupipi below) and so the system is assessed here on the basis that this has potential to become an accounting system.

Example of source analysis that could form the basis of an accounting system

Diffuse source load estimates have been modelled for the Waimea catchment using SPASMO and the Motupipi catchment using OVERSEER and other inventories. For the Motupipi catchment, pasture land use accounted for 80% of total N and P losses. An example of accounts is shown below (Table 3 taken from p20 of Motupipi Catchment nutrient management report[110]).

Table 3-12: Estimated N and P losses from the Motupipi catchment.

Table 3 Estimated N and P losses for the Motupipi Catchment from all known inputs

Land Use/ point discharge	Area in Catchment (ha) (% of catchment)	Estimated Nitrogen loss kgN/yr (% total loss)	Estimated Phosphorous loss kgP/yr (% total loss)
Pasture	1517 (55%)	49 147 (80%)	1829 (81%)
Gorse & Broom	88 (3%)	4402 (7%)	9 (<1%)
Silage pits (7 @ 100 tonnes DM/pit) – estimate of loss from base of pits in catchment		2000 (3%)	80 (3.5%)
Native Vegetation	1100 (40%)	1938 (3%)	97 (4.3%)
Septic Tank discharge to land		1800 (3%)	70 (3.1%)
Dairy Shed discharge to Motupipi R		1300 (2%)	150 (6.7%)
Cropping	9.2 (<1%)	367(<1%)	7 (<1%)
Exotic forest	54 (2%)	168 (<1%)	6 (<1%)
Sewer overflows		2.4 (<1%)	0.6 (<1%)
ROUNDED TOTAL	2768 ha	61 124 kgN/yr	2249 kgP/yr

[110] http://www.tasman.govt.nz/environment/water/rivers/river-water-quality/state-of-river-water-quality-in-tasman/river-water-quality-investigations-in-specific-catchments/motupipi-river-takaka/

Evaluation of water quality accounting system

Table 3-13: Evaluation of TDC's potential water quality accounting system.

Criterion	Evaluation	Comments
Technically robust	Yes	<u>Strengths</u> The TRMP lists contaminants of concern (33.1.1 – Issues), namely nutrients, pathogens, chemicals (urban) and sediment, with diffuse sources being more important (due to relatively low number of major points source discharges to freshwater in the region). TDC have good SoE monitoring programmes - 55 core sites, with the total number of sites between 1999 and 2009 being 75. The monitoring programmes targets areas where water quality pressures are greatest, with only around 10% of sites in pristine areas. TDC have a comprehensive consent database (NCS) that contains all the necessary relevant information for managing consent discharges to water. The absence of major point source discharges in many catchments/sub-catchments could mean that TDC has the potential to look at 100% modelling approaches (i.e. combination of modelling and literature loss rates and standard effluent concentrations) to generate accounts on catchment/sub-catchment scales. TDC benefitted from a large, well-resourced research project for producing an integrated catchment model (ICM) for the Motueka catchment. A similar approach was used for the Motupipi work described earlier. <u>Potential weaknesses</u> The system is not yet able to be used to produce regular accounts. Hence TDC currently has no systematic way of determining if and by how much the water quality of a catchment/sub-catchment is over allocated. However TDC note that by and large their water quality is good and conclude that its assimilative capacity is not over-allocated. SoE water quality monitoring is only done at quarterly frequency, which has the disadvantage of requiring 10-15 years of data to get sufficient statistical power to detect subtle trends. It is also only undertaken at low flow conditions so there is no information on concentrations/loads during higher/flood flows. TDC are yet to decide on what water quality management zones will be established for the region. TDC has a lot of small point source discharges and only a few major ones to freshwater As a result the effects from point sources are small. They have some discrete measurements for points sources (e.g. wastewater treatment) to differentiate between consented and actual discharge loads, but it seems the amount of data they have on point source discharges is limited (which indicates the calculated load and difference method is less likely to be useful to TDC).
Practical	Yes	<u>Strengths</u> TDC has completed source analyses for the Waimea and Motupipi catchments. A modelling approach to nutrient loss budgets may have strengths over manually intensives methods of calculating load totals, subtracting point source totals, determine diffuse sources components, then applying nutrient coefficient to generate a catchment load. If using a modelled approach like Motupipi, then it should be very timely and updatable, and conducive to scenario testing. If accounts were created using model nutrient studies, then that approach

Criterion	Evaluation	Comments
		would be future proofed as new versions of models are used as they become available, and similarly new models that deal with other land use activities could be used instead of relying on standard/literature values. <u>Potential weaknesses</u> No ongoing accounting system employed yet. Although other nutrient loss accounts have been prepared as separate case-studies for priority catchments it appears these accounting processes (i.e. for Waimea and Motupipi catchments) have not been repeated by TDC in line with their risk-based approach. It is not immediately clear how the nutrient loss budgets for the Waimea/Motupipi catchments have been utilised by TDC. There are uncertainties around validating modelled budgets – i.e. reconciling modelled inputs with river/catchment outputs (i.e. actual measured loads). Modelling approaches may have weaknesses if they have to apply attenuation factors or rely on quarterly monitoring to derive them. Models need to be validated for the region.
Transparent	Yes	<u>Strengths</u> The example Motupipi work was done in a collaborative way and thus catchment landowners would have been fully aware of the work. Technical reports can be found on the TDC website <u>Potential weaknesses</u> This isn't yet a fully developed system with regular (e.g. annual) accounts made available for the region, instead using cyclical SoE reports
Effective	Yes	<u>Strengths</u> TDC have surface water management boundaries, they have SoE monitoring at a lot of sites, with about 90% of these concentrated in 'hot spots' of the region (is lowland plains where pressures from land use intensification are greatest), they have a table of WQ criteria. These components have allowed them to identify contaminants of concern, and catchments where water quality is either under pressure or degraded in relation to community values placed on those water bodies (e.g. ecology/contact recreation/stock watering). For catchments identified as priority catchments, they have undertaken nutrient-loss budgets (source analyses). However TDC are not using 'accounting' in a formal sense. <u>Potential weaknesses</u> No regular accounting is undertaken. It is unclear how catchment nutrient-loss accounts are currently used by TDC. Proposed policy changes in the TRMP do not appear to make any reference to catchment load limits or nutrient-loss accounting undertaken for impacted catchments.
Acceptable	Yes	<u>Strengths</u> The Motupipi catchment nutrient work included a fundamentally collaborative approach and works on the premise that understanding each other's property contribution to catchment water quality will help land-users to work together to improve catchment water quality. Each participating farmer received a summary for each block on their property. If similar approaches were used in other catchments, there would likely be a high level of acceptance of accounts produced. <u>Potential weaknesses</u> This collaborative approach may not always be practical, depending on the size of catchment and the issues it faces.

Criterion	Evaluation	Comments
Adaptable	Yes	Strengths Although TDC do not generate catchment accounts on a regular basis, they have at least completed catchment nutrient loss budgets for Waimea and Motupipi catchments. This modelling approach could be applied to a number of spatial scales. Potential weaknesses Only lowland plains area of catchments have issues with water quality, and therefore it is unlikely that the level of detail applied for contaminant accounting in target/priority catchments would be applied to 'low priority' parts of the catchments. This will make it challenging to develop a framework that enables aggregation of accounts of varying levels of detail into a regional picture.

3.4.2 Results – the costs

Detailed cost information from TDC is outlined below, split between TDC's water policy costs, water monitoring, water permit processing, and compliance effort. Except for 'compliance monitoring' which is quantity only (effectively water metering costs), it was too difficult for TDC to differentiate between what is water quality and what is quantity related. It was also too difficult to differentiate costs for systems used in accounting costs related to limit setting, so the split between this section and section 4.5.3 is somewhat arbitrary - however as much detail as possible has been provided. A summary of costs for systems used by TDC in accounting are given in Table 3-14 and detailed below.

Table 3-14: Summary of TDC costs related to accounting systems[111].

System costs related to accounting	
SoE monitoring	$1.45M operational costs (2010-12). Annual costs fairly constant since 1992 allowing for inflation and two FTE increase in team membership No change in operational costs at present since the NPSFM
Water and discharge permits *Water quantity* *Water quality*	Policy implementation costs (2010-12). Annual costs fairly constant since 1992 allowing for inflation $303,171 $193,344 No change in operational costs at present since the NPSFM
Compliance monitoring *Water quantity* *Water quality*	Policy implementation costs (2010-12). Annual costs of compliance work fairly constant since 1992 allowing for inflation and two FTE increase in team membership, and the increased effort following introduction of water metering regulations $256,524 $371,607 No change in operational costs at present since the NPSFM

[111] Discussions with Dennis Bush-King, Tasman District Council, 13th June 2013.

State of the Environment (SoE) Monitoring

Information from SoE monitoring on both water quality and quantity feeds into policies and assesses pressures in catchments, e.g. TDC's Recreational Water Bathing Survey, groundwater quality investigation. Costs have been compiled for the last two financial years to give an indication of their magnitude (Table 3-15). Total costs amount to $704,303 for 2010/11 and $749,442 for 2011/12 respectively and have remained relatively constant since 1992.

Table 3-15: TDC's SoE monitoring costs.

Cost type	YTD Actual 2010/11	YTD Actual 2011/12
SoE monitoring (water quantity and quality)		
ENV MTG WATER GENERAL WAGES	$ 466,532	$ 540,678
ENV MTG GROUND WATER SoE WAGES	$ 80,313	$ 67
R/I Enviro Mtg Water Consultan	$ 17,775	$ 20,559
Fish Survey		$ 26,080
R/I Enviro Mtg Water Equip Mtc	$ 13,954	$ 12,438
Postage and Freight	$ 9	$ 154
R/I Env Mtg Wat Telephone	$ 344	$ 7,154
Electricity	-$ 134	$ 248
R/I Env Mtg Water Advertising	$ 1,549	$ 340
R/I Enviro Mtg Water Travel	$ 9,030	$ 4,217
R/I Enviro Mtg Water Information	$ 1,741	$ 9,813
R/I Enviro Mtg Water Materials	$ 30,597	$ 24,836
R/I Enviro Mtg Wter Accommodat	$ 4,867	$ 9,097
R/I Enviro Mtg Water Training	$ 3,457	$ 4,382
Cellphone/Telemetry/GPRS	$ 4,217	$ 2,422
R/I Enviro Mtg Water Lab Costs	$ 39,754	$ 53,800
OVERHEAD ALLOCATION-FCSC	$ 24,509	$ 26,510
Service Centre Oncharge-RESOUR	$ 3,416	$ 3,732
R/I ENVIRO MTG BAD DEBTS EXP		$ 252
STAT COMPLIANCE ONCHARGE-RESOU	$ 792	$ 258
DEPRECIATION	$ 1,581	$ 2,405
Catchment based research and investigation*	$ 516,000	$ 550,000
Total Operating	**$ 704,303**	**$ 749,442**

* Relates to other catchment specifics budgets, e.g. flood monitoring system, telemetry system maintenance, targeted investigation for catchment specifics, staff time etc.

Water permits

Policy implementation costs for water permits (water quantity) and discharges (water quality) are represented below. No specific budget distinction is made for discharge permits of different 'jurisdiction' (e.g. land, air, water), however a water quality estimate has been given (%). Costs have been compiled for the last two financial years to give an indication of their magnitude (Table 3-16).

Table 3-16: TDC's water permits costs.

Cost type	YTD Actual 2010/11	YTD Actual 2011/12
Water permits (water quantity)		
SAL and WAGES	$ 150,904	$ 122,462
Pl Water Permits Legal Fees	$ 156	$ -
Pl Water Permits Consultancy	$ 1,650	$ -
Pl Water Permits Travel	$ 364	$ 636
Pl Water Permits Information	$ 680	$ -
Pl Water Permits Accommodation	$ -	$ -
Pl Water Permits Training Fe	$ -	$ -
OVERHEAD ALLOCATION-FCSC	$ 10,892	$ 11,782
Service Centre Oncharge-RESOUR	$ 1,519	$ 1,659
STAT COMPLIANCE ONCHARGE-RESOU	$ 352	$ 115
Total Operating	**$ 166,517**	**$ 136,654**
Discharge permits (water quality)		
Discharge permits (estimated water quality component 50%)	$ 77,104	$ 116,240
Total Operating	**$ 77,104**	**$ 116,240**

Compliance monitoring

TDC's policy implementation costs for compliance and enforcement of water use have been compiled below. Compliance discharges relating to water quality have been estimated (% of expenditure) and cover water metering monitoring, annual dairy shed monitoring etc. No specific budget distinction is made between discharges to water, land, or air. Costs have been compiled for the last two financial years to give an indication of their magnitude (Table 3-17). They have remained relatively constant over the past few years.

TDC remains to be convinced that any national systems will lead to costs being minimised – in fact as more takes become metered council costs in water are going to increase.

TDC's water metering database is 'home grown' and is likely to require more attention over time. A national platform that can work in with TDC's current information system and that will allow historical data to be migrated may be a benefit, but there is not enough information to know at present. Benefits and costs of national systems or guidance will depend on what the Government expects TDC to collect that they do not already capture. Intuitively national consistency should be beneficial but it depends on many other factors. Councils all start off with different levels of issues, capacities, and systems. The costs of changes will be distributed differently and, until TDC can envisage what may be expected, can't comment further.

Table 3-17: TDC's compliance monitoring and discharge costs.

Cost type	YTD Actual 2010/11	YTD Actual 2011/12
Compliance monitoring (water quantity)		
SALARIES MISSING READINGS	$ -	$ 876
SAL and WAGE (PERMITTED ACTIVTY)	$ 37,522	$ 49,899
SALARIES OVERTAKES	$ 22,341	$ 14,209
SALARIES DATABASE	$ 24,436	$ 25,013
SALARIES AUDITS	$ 22,500	$ 14,950
SALARIES PRESEASON	$ 11,991	$ 15,068
Comp Monit Legal Costs	$ 2,041	$ -
PI Comp Mntg Water Consultancy	$ -	$ -
PI Comp Mntg Water Travel	$ 1,380	$ -
PI Comp Mntg Water Information	$ 1,373	$ -
PI Comp Mntg Water Materials	$ -	$ 1,165
PI Comp Mntg Water Accommodati	$ 821	$ 150
PI Comp Mntg Water Lab Costs	$ 262	$ -
OVERHEAD ALLOCATION-FCSC	$ -	$ 4,713
Service Centre Oncharge-RESOUR	$ 4,357	$ 663
STAT COMPLIANCE ONCHARGE-RESOU	$ 607	$ 46
Total Operating	**$ 129,772**	**$ 126,752**
Compliance monitoring - discharges (water quality)		
Discharge permits (estimated water quality component 60%)	$ 208,283	$163,324
Total Operating	**$ 208,283**	**$163,324**

3.5 Auckland Council

The Auckland Council (AC) workshop was held in two AC venues (Takapuna for limit setting, and City for accounting systems discussions) on Tuesday 11 June 2013. AC sent along up to 22 staff at various stages of the day. The limit setting questions were discussed in one large group whereas the accounting systems questions were able to be split into water quantity and water quality groups.

3.5.1 Results – the evaluation of accounting systems

Water quantity

Description of water quantity accounting system

The Auckland Council (AC) water accounting 'system' is primarily made up of two components:

- A consents database, built in-house within Oracle software.
- A water use database holds water metering data from consented takes, and a water use database was custom built and handles time series data using Hydrotel.

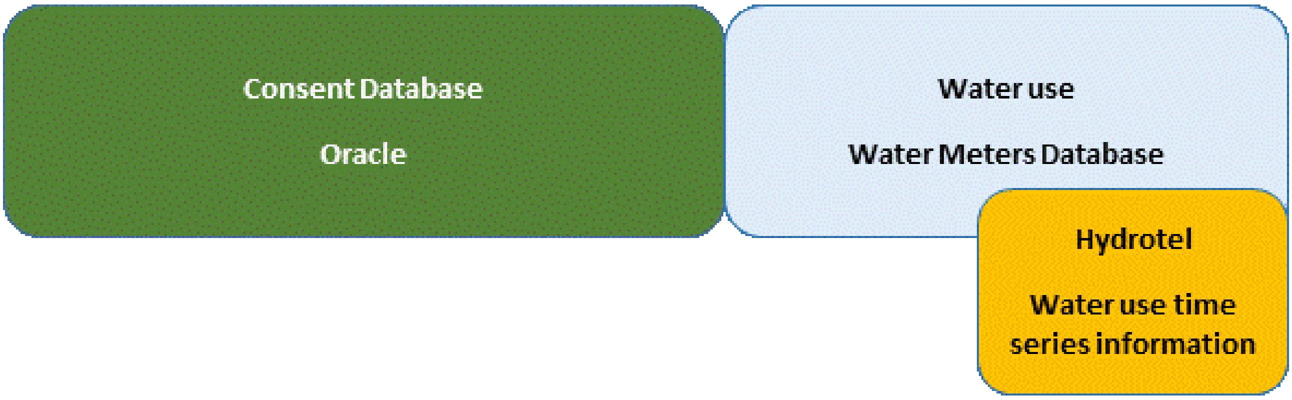


Figure 3-9: Schematic diagram of the AC water accounting system.

The water use database is partially linked to the consents database so water use information is contained in the consent fields. Basic information such as the first and last meter reading of quarterly returns is entered into the consents database, and thus average daily water use for the quarter and annual water use can be determined.

In addition to the above main components, AC's water accounting system is supported through other components:

- 100% of the consented takes are metered.
- 9 out of 1100 take consents are telemetered.s14 takes are accounted for in highly allocated areas, but not accounted for in the majority of the region.
- Water meter information is updated quarterly with 60% of consent holders self-entering online and rest of the paper data manually entered online by Council staff.

The former Auckland Regional Council had an accounting system for decades that AC has inherited and the system has been reviewed regularly.

Example of water quantity accounts

Table 3-18 shows an example of an annual water account, and compares the 2004-2005 and 2005-2006 water years' key water use statistics.

Table 3-18: Key water use and allocation statistics for Auckland Region.

Key Water Statistics	2004-2005	2005-2006
Number of consents	1,499	1,439
Groundwater take consents	1,172	1,132
Surface water take consents	327	307
Water allocated	152 Mm^3	138 Mm^3
Water Used	118 Mm^3	104 Mm^3
Inactive consents	22%	21%
Quarterly meter returns	90%	91%
Failed quarterly returns	4%	9%
Consents with use exceeding water allocation	12%	14.50%

Figure 3-10 shows the water allocated and used for 2005-2006 for five categories of use.

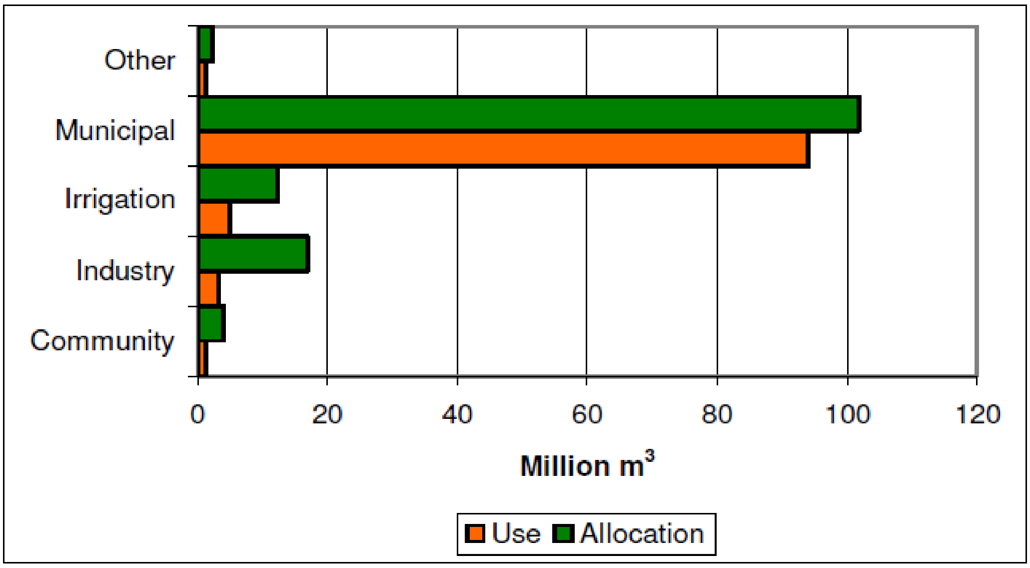


Figure 3-10:Total allocation and use for five categories of use, 2005-2006.

Evaluation of water quantity accounting system

Table 3-19: Evaluation of AC's water quantity accounting system.

Criterion	Evaluation	Comments
Technically robust	Yes	Strengths AC's water accounting system comprises of two main components: a consents database and water use database (water metering). These two databases are set up to provide comprehensive water accounting for the Council. Water accounts are generally produced at quarterly intervals using data from the consents and water use databases. However, the system is capable of producing accounts at daily, monthly or annual periods. 100% of consented takes are water metered. All meter readings are entered into a database on a quarterly basis and reports can be generated to calculate the total water use within a catchment or aquifer. This data though will need to be quality checked to remove manual data entry errors and other checks like separating combined use and allocation recorded against one consent. Consent applications are accessed by science/technical staff to ensure that the allocated rate/volume is reasonable. Industrial and municipal water use must be justified on the application and maybe subjected to further auditing. The accuracy of consent information is manually checked by the consent staff. Irrigation water requirements are based on crop type and area. There is consideration of crop water requirements for different crop types based on some ET, rainfall, and measurements of soil moisture holding capacity. Council has reports on these matters by Hort Research for the major growing locations in the region. There is also consideration of irrigation methods and efficiency. Users need to demonstrate that their water meters are accurate to +/- 5%, provide a photo of the site setup and provide a renewed certificate of accuracy every fifth year. Team leaders check for accuracy of the accounting systems. There is a comprehensive system in place to handle expired and renewed consents.

Criterion	Evaluation	Comments
		<u>Potential weaknesses</u> There is no formal quality assurance system or automated conditional checking system built into the consent database, other than manual checking. There is no two way electronic link between the consent database and water use database. Historic consented data at any given time can only be extracted manually. There are 1,100 take consents. Water use records are largely (60%) self-submitted online by consent holders. The rest are manually entered online by admin staff. The current reliance on manual data input is around 40% and adds to Council's timeliness and costs.
Practical	Yes	<u>Strengths</u> Both consent and water use databases can be updated on an as required basis. However, data availability for water use is dependent on the quarterly water meter returns. In addition to electronic databases, paper records are kept where necessary. Therefore, main data can be extracted from more than one physical source. <u>Potential weaknesses</u> Both databases appear to be future-proofed; however, some upgrades may be needed to provide efficient practical use. While most of the Auckland water account system is practical, there are limitations to achieve full practical potential. Some of the issues are: - While the GIS system does link to the consent data base, the water use fields are not currently linked.Little telemetry and thus no facility to obtain data at real-time for online consent monitoring. - Difficult to search fields, collate and report on data across various fields - Difficult to achieve real-time data management and link allocation data to use records without manual processing. The two databases should be more interconnected.
Transparent	Yes	<u>Strengths</u> Water use data and compliance information is available online via a website to consent holders. The water use database is an online website and also available for stake holders.<u>Potential weaknesses</u> There are only 9 telemetered takes. Therefore, total water use within a catchment or aquifer is not easily transparent without going through paperwork.
Effective	Yes	<u>Strengths</u> The AC current system is effective and meets the council's objectives for water management. The accounting system is custom built to meet water meter data storage and reporting, so any improvements will be in-house and cost effective. <u>Potential weaknesses</u> 60% of water use records are self-submitted online by consent holders, leaving 40% to be handled manually. . The current reliance on manual data input may not be effective in terms of accuracy, timeliness and cost. It is difficult to manage surface water in real-time without telemetered water use data (primarily for large takes and heavily allocated streams). Paper returns of water meter data also allow potential for human error both in water user and council staff handling.

Criterion	Evaluation	Comments
		AC has no database for storing s14 takes. The database can be queried to report on historic records but the report will need to be quality checked which can be time consuming.
Acceptable	Yes	Strengths 100% of water takes are metered, and the system is accepted and is seen by water users as a positive measure to manage their resource use.
Adaptable	Yes	Strengths The current system was developed in-house and so can be easily upgraded. Potential weaknesses The system is developed to meet local Auckland issues. Therefore, it can potentially be difficult to use the system in other regions. However, there may be some adaptable parts of the system, and with minor changes several other regional councils have adopted this system, namely: Marlborough, Hawkes Bay and Wellington.

Water quality

Description of water quality accounting system

For the purposes of this evaluation, Auckland Council's (AC) water quality accounting 'system' is comprised of the following components:

1. Consents database
2. Data from AC's SoE monitoring programmes (freshwater) which are stored in a water quality archiving database called HYDSTRA. Stream ecological monitoring data is stored in an SEV database. Monitoring programmes include:

   A. Stream water quality programme: monthly sampling of 31 sites (as of 2009[112]) for around 20 water quality indicators, including dissolved and total heavy metals (zinc, copper and lead). Other variables include: DO, temperature, conductivity, salinity, pH, Total Suspended Solids (TSS), turbidity, NH_4-N, NO_x-N, Kjeldahl-N, TN, DRP, TP, and *E.coli*.

   B. Stream ecological quality programme: type and number of invertebrates monitored at up to 64 sites every year. Data used to generate macroinvertebrate index (MCI) as modified for soft-bottomed streams.

   C. Lake water quality programme: 7 lakes sampled 6-times per year for nutrients (TN and TP), chlorophyll *a*, clarity and *E.coli*, which are used to produce the Trophic Level Index (TLI).

   D. Lake ecological quality programme – evaluates the biological community in 29 lakes in 2 sub-programmes (rotifers (zooplankton) and macrophytes).

   E. Ground water quality programme: monitors 24 boreholes quarterly of high use and sensitive aquifers in region. Parameters measured include:

[112] Some comments here with regard to AC's monitoring may hence be a bit out-of-date.

temperature, pH, conductivity, DO, redox, turbidity, TSS, total dissolved solids, alkalinity, hardness, nutrients, pesticides, cations/anions, silicate faecal coliforms, *E.coli*.

3. Water quality assessment criteria: Canadian Council of Ministers of the Environment (2001) system used to derive four water quality indices: Scope, Frequency, Magnitude and overall Water Quality Index (WQI).

4. Other databases (soil, landuse, weather, topography).

AC have done a great deal of work in relation to stormwater contaminant sources and loads, and have a wealth of scientific technical reports relating to water quality issues in the region, which underpin SoE monitoring and inform policy. At the moment, this system is not developed to the extent that regular accounts can be generated, but AC has undertaken source analysis exercises (e.g. using CLM as below) and so the system is assessed here on the basis that this has potential to become an accounting system.

Example of a source analysis that could form the basis of an accounting system

The Catchment Load Model or CLM was developed to enable estimation of stormwater contaminant loads on an annual basis. The CLM is very simple, and takes the area of a particular land use (source) within the area being studied (the catchment) and multiplies it by the quantity of contaminants discharged from that land use (source yield) to provide an annual load from that source. The loads from each source within the catchment are then added together to provide an annual contaminant load for the catchment of interest. Source yields from the different source areas are provided for Total Suspended Solids (TSS), zinc (Zn), copper (Cu) and Total Petroleum Hydrocarbons (TPH).

The six urban land use types (sources) used by CLM are: roofs (divided into nine different types of material); roads (divided into six different vehicles/day categories); paved surfaces, other than roads and roadside footpaths (divided into residential, commercial and industrial); urban grasslands and trees (divided into three different slope categories); urban streams; and construction sites (considered to be 100% bare earth for the purposes of estimating contaminant loads). Although it has been developed for urban stormwater discharges, the CLM also incorporates five rural land uses, each subdivided into three categories, to enable mixed land use catchments around the fringes of the Auckland urban area to be modelled. A calibration of the CLM produced results for three catchments in the Auckland region, as shown in Figure 3-11.

Table 12

Comparison of measured and modelled contaminant loads (kg year-1) for the selected catchments (monitoring loads from Timperley et al, 2005)

	Residential (Mission Bay)		Commercial (Central Business District)		Industrial (Mt Wellington)	
	CLM	Monitoring	CLM	Monitoring	CLM	Monitoring
TSS	28,011	28,000	9,381	9,330	8,575	8,570
Total zinc	26.0	26.0	50.5	47.0	176	176
Total copper	3.60	3.6	4.20	4.2	4.6	4.6

Figure 3-11: Annual loads modelled by CLM for 3 contaminants and 3 catchments.

Evaluation of water quality accounting system

Table 3-20: Evaluation of AC's potential water quality accounting system.

Criterion	Evaluation	Comments
Technically robust	Yes	<u>Strengths</u> AC have a comprehensive consents database that contains all the necessary relevant information for managing consented discharges to water. There are numerous technical publications, which ensure that the monitoring design, methods, models, protocols, and data/trend analysis are robust and benefit from outside knowledge and external peer-review. AC has comprehensive SoE monitoring programmes for fresh water quality that includes rivers, lakes and ground water components. Within the rivers and lakes programmes, there are physicochemical, microbial and ecological components. International methods are used to analyse/aggregate water quality data into a single water quality index or WQI. Monitoring data for the Auckland region shows a strong relationship with WQI, with water quality decreasing in the order forestry>rural>urban. Ecological monitoring yields MCI/QMCI values and also a stream ecological value (SEV). AC has determined sediment yields from various catchments, with a strong relationship between sediment yield and the percentage of pasture, forestry and urban land use in the catchment (relationship explained >90% of the variance). Contaminant accounts at a catchment/subcatchment scale are produced for some catchments using a locally developed stormwater contaminant load model called CLM. The CLM produces annual contaminant (i.e. TSS, total zinc, total copper and total petroleum hydrocarbons, TPH) yields for catchment greater than 20 hectare. CLM deals best with urban catchments but can cope with up to 20% rural catchments. Through SoE monitoring, regular reporting and 5 yearly trend analysis, AC have a good 'science-based' understanding of the main issues. For the region's streams, the biggest issue is physical loss of stream habitat, not nutrients. In urban catchments, there is concern regarding heavy metal and TPH toxicants, but again, physical loss of stream habitat is considered the biggest issue with respect to WQ degradation. Presumably this reflects AC's strong emphasis on biological stream monitoring. Modelling of rural diffuse sources using CLUES has recently commenced (however, no contaminant/nutrient-loss account as yet). <u>Potential weaknesses</u> 31 river SoE water quality sites cover 230-odd catchments in the Auckland region seems insufficient to provide the necessary spatial coverage of the region, and any future WMZ's. In comparison TDC have 55 sites, Horizons 130 sites and WRC 114 sites. AC have yet to set WMZs for water quality management. The calculation of the WQI uses a rolling 5 year 98%ile value of two control sites as the standard by which water quality parameters are assessed for compliance. 98%ile values most likely represents a small number of events sampled at relatively high flows over winter months (i.e high turbidity and high nutrients). These reference compliance standards can be quite variable, and can be significantly higher than the corresponding ANZECC (2000) value. AC stated that ANZECC or national standards were not used because these targets/guidelines were not being met even at Auckland reference sites. Such an approach is consistent with the use of the ANZECC guidelines, where it is stated that locally derived guidelines are preferable where they exist. With respect to *E.coli*, AC do not have a good handle on volumes/frequencies of combined sewer overflows. Improvement would require better data-sharing with Watercare. Auckland has a large number (>40,000) of septic tanks and AC do not have a

Criterion	Evaluation	Comments
		good handle of nutrient losses from this diffuse source. With the exception of STP discharges (which routinely monitor TN, NH_4-N and pathogens), AC do not appear to have a good handle on the regions point source discharges to freshwater, and the loads of contaminants associated with them. The consents database only has information on consented maximum discharge rates and associated contaminant loads – it does not contain measured concentrations (i.e. as part of consent compliance). These are collected by the 'system' in the form of archived compliance reports and can only be retrieved manually (i.e. no automation). AC have a ground water monitoring programme, but it was unclear how, or whether it was integrated with surface water quality programmes. Presently AC do not have a system that enables them to understand changes in loads associated with significant changes in land use. Note the Auckland does not appear to have the same dairy intensification pressure as other areas – for example, the area of dairy farming in the region decreased 24% from 61,400 ha in 2002 to 46,400 ha in 2008.
Practical	Yes	<u>Strengths</u> AC is in the process of developing a system for producing regular accounts, and is currently looking at methods for generating accounts, for example, starting to investigate the feasibility of using CLUES to determine catchment nutrient losses. If building a system from scratch, AC indicated they would like nutrient information on a catchment/WMZ scale, and system automation to enable more contaminant account generation 'at the push of a button.' <u>Potential weaknesses</u> It seems unlikely that AC could proceed down the calculation method used by other councils due to the lack of information regarding point source discharges and associated contaminant loads. It seems more likely that AC will go down a modelling path for contaminant accounting.
Transparent	Yes	<u>Strengths</u> While there is no system for regular accounting as such, some one-off source analyses have been carried out. AC produce regular (annual) technical reports summarising the all the SoE water quality monitoring programmes, and also produces more 'consumer' friendly environmental report cards on stream water quality where each site is given an A to E rating (A = excellent, E =poor). In additional to regularly reporting of SoE data, normally every 5 years the data is analysed for any significant trends in the region's water quality. All environmental report cards, and technical publications are available on the AC website.
Effective	Yes	<u>Strengths</u> AC are in the process of investigating ways to model WMZ / catchment loads of contaminants to enable regular accounting. <u>Potential weaknesses</u> AC acknowledge a lot of 'gaps' and that they are waiting to see what happens with respect to specific guidance/direction from central government in giving effect to the NPSFM. That is, they are aware of not wanting to start implementing strategy that is then found to be inconsistent with future directives from central government.

Criterion	Evaluation	Comments
Acceptable	Yes	<u>Strengths</u> Understanding of sources for urban contaminants is well developed and methods have been tested. On this basis it is assumed a regular accounting systems would be relatively easily accepted for many catchments in the region. <u>Potential weaknesses</u> The proposed Unitary Plan includes rules for dairy farm effluent which will require the provision of a nutrient budget, undertaken with the OVERSEER model, and this requirement may be perceived as onerous to end-users at first. Pressures in the Auckland region for further urban growth may provide challenges.
Adaptable	Yes	<u>Strengths</u> Assuming a modelling approach is taken and sufficient data (i.e. land use and other parameters) are available then it should be adaptable to a range of WMZ scales. AC WMZ's will comprise numerous individual catchments, so presumably down-scaling to catchment scale would be no issue, and up-scaling to regional level would be down by simply summing the number of WMZ's.

3.5.2 Results – the costs

Costs received from AC with regard to accounting systems are summarised in Table 3-21 and detailed below.

Table 3-21: Summary of costs relating to AC's accounting systems.

System costs related to accounting	
Consented water takes	$140,551-$141,751 (2010-12)
Contaminant Load Model (CLM)	$60,000 set-up costs (2013/14) $10,000 to run model for each catchment and analysis of options
SoE water quality and quantity monitoring	$1.3M total costs (2011/12) $1.2M total costs (2012/13)

SoE monitoring costs

The costs of freshwater monitoring (quantity and quality) for AC's SoE (State of the Environment) programme are as shown in Table 3-22. For the year 2011/12, total capital and operational costs including FTE time amount to $1,321,000, whereas for the year 2012/13, total costs amount to $1,224,500.

Consented water takes

In terms of water accounting systems for AC, resource dedicated to accounting of consented takes is 1 FTE, however, additional resources from the consents the also undertake this work on an ad hoc basis. The compliance monitoring advisor undertakes all the accounting for takes, and runs monitoring programs for requesting compliance records, chasing up overdue records, following up with non-compliance, compliance site visits etc.

Table 3-22: AC's SoE monitoring capital and operational expenditure (2011-13).

Freshwater 2011/2012 Annual Costs Opex /Capex	
Opex - Freshwater Quality (Ground, Streams etc.)	$134,500
Opex - Surface Water Hydrology	$63,500
Opex - Ground Water Hydrology	$19,000
Capex - Freshwater Capex expenditure	$224,000
FTE's ~	$880,000
Total costs	**$1,321,000**

Freshwater 2012/2013 Annual Costs Opex /Capex	
Opex - Freshwater Quality (Ground, Streams etc.)	$134,500
Opex - Surface Water Hydrology	$90,000
Opex - Ground Water Hydrology	$20,000
Capex - Freshwater Capex expenditure	$100,000
FTE's ~	$880,000
Total costs	**$1,224,500**

Contaminant Load Model

Background

AC's Contaminant Load Model (CLM) is a spreadsheet-based model which has been developed to enable estimation of stormwater contaminant loads on an annual basis[113]. The model is set up so that the area of a particular land use (source) within the area being studied (the catchment) is multiplied by the quantity of contaminants discharged from that land use (source yield) to provide an annual load from that source. The loads from each source within the catchment are then added together to provide an annual contaminant load for the catchment of interest.

Indicative costs

The CLM set up costs are for the year 2013/14, and the run per catchment will occur as each catchment enters the planning process. These are indicative costs only, for a largely one-off exercise:

- $60,000 for model setup.
- $10,000 per catchment to run model and undertake some analysis of options.

In terms of costs around the implementation of the NPSFM, AC envisages it will overall reduce costs versus doing quality assessment at each local scale, however were unable to tell to what scale[114].

[113] Contaminant Load Model User Manual, Auckland Regional Council, September TR 2010/003.
[114] Correspondence with Judy-Ann Ansen, Auckland Council, 24th June 2013.

3.6 Environment Canterbury

The workshop with Environment Canterbury was held at the NIWA offices in Christchurch on Friday 14 June 2013. Environment Canterbury sent three staff to the workshop, who were able to work through all of the questions with the project team. The group was not large enough to allow a split into water quantity and water quality groups, and so the questions were worked through end-on end.

3.6.1 Results – the evaluation of accounting systems

Water quantity

Description of water quantity accounting system

The Environment Canterbury water accounting 'system' is primarily made up of two components:

- CoCoA is the main consent database. This database was custom built with Otago Regional Council. The CoCoA stores primary consent information such as source type, source description, map grid reference, detailed description of the take, purpose/s, use type/s, take rate and volumes, granted and expiry date, irrigated area etc.

- Water Users Database is water meters database. This sequel database links with CoCoA to obtain the necessary consent information that is required for compliance such as maximum daily volumes and rates, dates granted, expiry date, all monitoring requirements, data reporting requirements. The time series data is stored in TIDEDA. The database provides software and produce support for compliance staff.

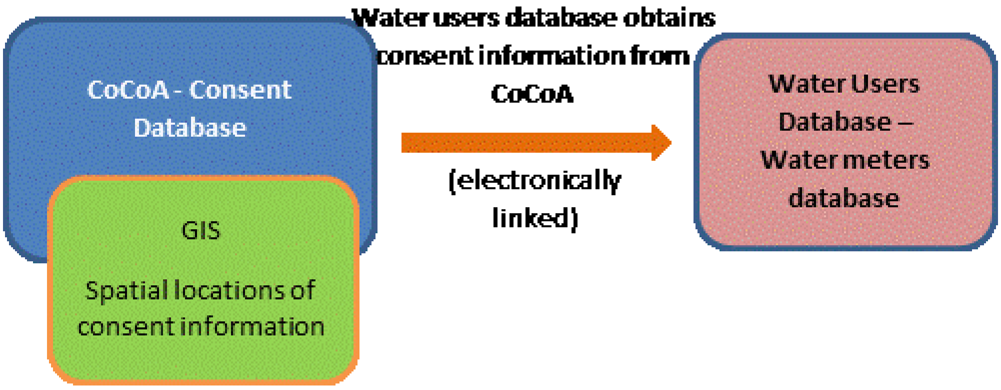


Figure 3-12:Schematic diagram of the Environment Canterbury water accounting system.

In addition Environment Canterbury has a GIS system to assess, locate and display spatial location of the water takes. Other attributes of the Environment Canterbury system include:

- 66% of water takes over 20 l/s have water meters and 80% of these are telemetered.

- Water users pay for water meters and telemetry.

- Preferred third party providers install and calibrate water meters and the telemetry.
- s14 takes are not accounted for except for specific studies (e.g. Banks Peninsula which is the only zone where this is a significant issue).

Environment Canterbury's water use accounting system is only a few years old, however, water use of a few large surface water takes have been monitored for many years.

Example of water quantity accounts

The following is taken from a Canterbury Region water use report for the 2011/2012 water year.

The surface water use data collected for the 2011/12 water year are presented in Figure 3-13 (below) as a monthly allocation. The allocated volume associated with each month is shown by the green outlined portion of the bar, and the actual water use volumes are shown by the solid green portion. The percentage of allocation used is represented in text at the top of the monthly bars. The figure shows that the greatest proportion of use occurred during October through to February where over 40% of the monthly allocated volume was utilised. This reflects the fact the 2011/12 water year returned an average rainfall. In drier years it would be expected that actual water use would be greater.

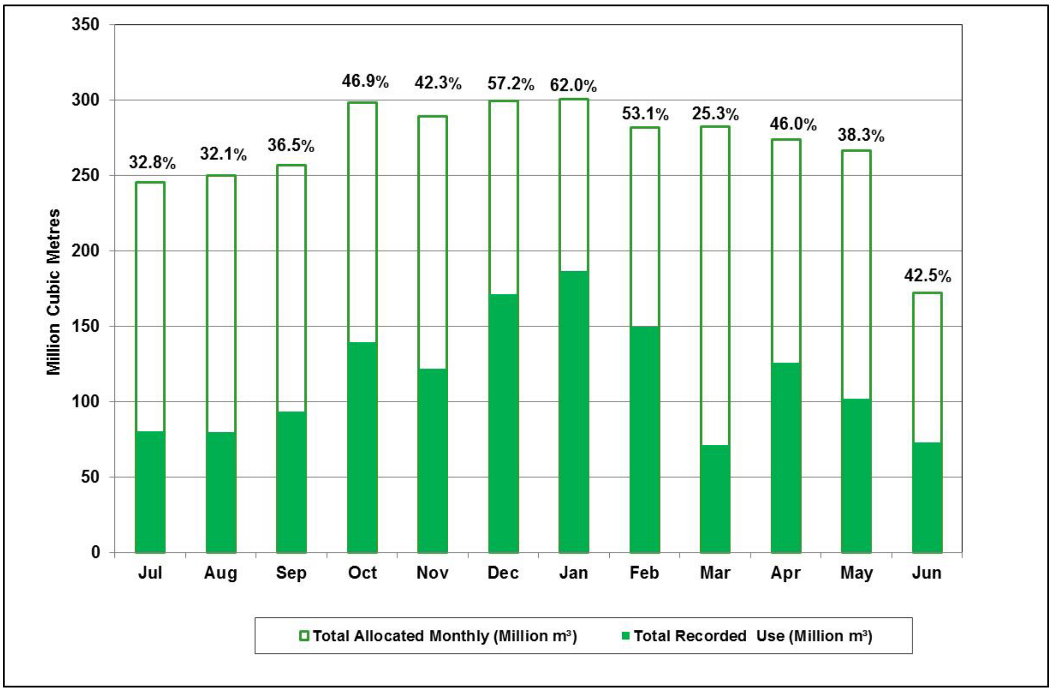


Figure 3-13: Allocated surface water volume in the Canterbury region and the proportion of metered surface water abstraction points (SWAP) that provided information.

The 1,346 surface water abstraction points accounted for 15,657,779,146 cubic metres of water allocated within the region. Of these consented takes, 28.4% (382) were equipped with water measuring devices. These 382 surface water abstraction points represented

3,215,685,080 cubic metres of allocated surface water, of which 1,395,935,797 cubic metres (43.4%) was used during the 2011/12 water year.

Evaluation of water quantity accounting system

Table 3-23: Evaluation of Environment Canterbury's water quantity accounting system.

Criterion	Evaluation	Comments
Technically robust	Yes	Strengths The water users database stores 66% of takes greater than 20 l/s with 80% of these telemetered, which will greatly assist real-time management in the future. Sound science and research underpin consented allocation rates and volumes for farming activities. Irrigation water demand has been determined using soil-moisture modelling of IRRICALC. Council has developed a unique third party installers system to ensure that the water meters are sufficiently calibrated and installed to meet Environment Canterbury's standards. Potential weaknesses The two components of the water accounting system, CoCoA (consents) and the Water Users database (water metering), are only partially connected, also they cannot produce real time daily water accounts at consent or Sub Regional Plan (SRP) scale. The management of consented groundwater takes in aquifers within sub regional plans is complicated when some of the 10 management zone boundaries cross over aquifers. Environment Canterbury does not have a dedicated person to quality assure (QA) the water metering data. There is no formal QA system at the end of the consenting process or automated conditional checking system built into the system, which may result in water allocation lacking data integrity.
Practical	Yes	Strengths The water accounting system works well for achieving the objectives of the regional plan. It is technically feasible to achieve the allocation objectives. The Water Users database follows the requirements set by the Government. It is working well and enables Environment Canterbury to accomplish many aspects of water accounting including: use in naturalising flows from water resource investigations in preparation of SRPs, compliance, efficient water use, and protecting ecological flows. The council use two electronic databases and paper records where necessary. In addition to having regular backups of electronic data, paper records will provide an alternative means of records when needed. Potential weaknesses Environment Canterbury's relatively recent start with water metering has resulted in the ability to produce only short records of naturalised flow, when long records are required to model the water resource in the development of minimum flows, allocation caps, stakeholders reliability of supply, the key requirements for limit setting in sub regional plans. There are delays in updating the water users database, due to previous irrigation season water use not being loaded until the following winter (i.e. not real time).
Transparent	Yes	Strengths Stakeholders can gain access to CoCoA via the Environment Canterbury

Criterion	Evaluation	Comments
		website. <u>Potential weaknesses</u> The water use accounts are not accessible via a website to the water users and stakeholders. No historic records of the total consented takes at regular intervals are available to assess total allocation over time.
Effective	Yes	<u>Strengths</u> The current water use system is effective and improving as smaller takes are requiring water meters. CoCoA contains many of the fields crucial to a consents database. <u>Potential weaknesses</u> The current accounting system is largely focused on getting water use information based on the size of the take, i.e., takes over 20 l/s. However, some water bodies can have a large number of small takes (less than 5 l/s) that add up to a significant cumulative volume; the current system may fail to provide information for such catchments. There is no database for storing the s14 takes. The current reliance on human input of data may not be effective in terms of accuracy and cost. CoCoA requires upgrades to standardise consent conditions e.g. take volumes over various time periods of groundwater, and various time periods for the maximum rate of surface water.
Acceptable	Yes	<u>Strengths</u> The methods developed by Environment Canterbury have largely been accepted by water users and other stakeholders as a high number of meters have been installed. Irrigators in sensitive water resource areas suggested water metering prior to the government regulations, an indication of the future acceptance. There have been no or few political challenges to water metering requirements as the government established national regulations.
Adaptable	Yes	<u>Strengths</u> The system is sufficiently flexible so that it can be adapted for a range of management units. It can be adapted to be scalable from SRP to WMZ to the Canterbury region.

Water quality

Description of water quality accounting system

For the purposes of this evaluation, Environment Canterbury's water quality accounting 'system' is comprised of the following components:

1. Consents and compliance database (CoCoA);
2. Table of numeric 'outcomes' for Canterbury rivers, lakes and groundwater (Tables 1a, 1b and 1c, respectively from the proposed Land and Water Regional Plan, pLWRP). For example, the river outcome table (Table 1c from

pg 4-2 of pLWRP) provide numerics for the following water quality indicators: ecological health, macrophytes, periphyton, siltation and microbiological. Note that outcomes do not relate to water management zones, but rather river management units (i.e. spring-fed, hill-fed lower, hill-fed upland etc, developed using the REC).

3. 'Look up' tables for nutrient losses from non-point sources (Schedule 8) based on good management practice, and represent maximum limits for the region. Currently Schedule 8 empty, but values are based on Lilburne et al. (2010 - R10/127).

4. Numerous other databases, models and environmental ('state of the environment') monitoring data including:

- Environment Canterbury's freshwater state of the environment (SoE) monitoring network data (mainly held in SQUALARC database) which consists of the following:
  - Quarterly monitoring of 14/15 indicators of water quality at 39 river sites (for plan and policy effectiveness) Monthly monitoring at 96 water quality sites (SoE)
  - Weekly monitoring of swimming spots (100 in total) weekly between mid Nov and Feb/Mar.
  - Over 300 ground water wells sampled annually for temperature, conductivity, major ion chemistry, NH_4-N, NO_x-N, iron, manganese, silica, *E.coli* and total coliforms.
  - 22 sites from 21 high country lake monitored monthly during summer months. Main water quality indicators related to calculation of Trophic Level Index (TLI) - TP, TN, clarity and chlorophyll *a* (refer to Environment Canterbury report U06/34).
  - SQUALARC also contains water quality monitoring from 25 marine (near shore sites) sampled monthly.
- A customised water quality load calculator that calculates relative contributions from point sources and non-point sources at different river flows.
- Numerous databases including: land use databases (Agribase LUCB, remote sensing from landcare); soil databases (e.g. S-Map); topography (DEM); and climate (rainfall).
- Complete inventories of N and P from consented discharge (point source) in all of the 38 nutrient management zones in the region (refer to Environment Canterbury technical Report R12/18, 2012). Inventory of the region shown below (Table ES1 from R12/18 2012).
- OVERSEER budgets for modelling diffuse nutrient losses.

Example of water quality accounting

Environment Canterbury has a good understanding of point source contaminants loads, namely nitrogen and phosphorus, with point source accounts completed for all 38 nutrient management zones (Technical Report R12/18 2012). As an example, N-loads from the top 5 nutrient management zones is given in Table 3-24 below.

Table 3-24: N-loads from the top 5 nutrient management zones.

Nutrient Management Allocation Zone	N (t/yr)
Ashburton-Rakaia	1078
Ashburton	630
Selwyn-Waihora	472
Rangitata-Orari	306
Orari	208

Evaluation of water quality accounting system

Table 3-25: Evaluation of Environment Canterbury's water quality accounting system.

Criterion	Evaluation	Comments
Technically robust	Yes	Strengths Environment Canterbury's system is underpinned by a lot of science (in-house and externally sourced) which is available on the Environment Canterbury website. For example, catchment nitrogen accounts for the Hurunui catchment (Report R10/66) references peer-reviewed methods used to estimate current nutrient loads. Environment Canterbury uses spatially comprehensive SoE water quality monitoring programmes and numeric objective/outcomes to enable a good understanding of current water quality allocation status (and region hot spots/priority WMZ). This good point source load data will help towards a more automated (or at least less manually intensive) catchment accounting of nutrients. Current catchment loads have been determined for selected catchments, for example the Hurunui. This involves calculating the load from flow x concentration, thus diffuse loads are readily determined by using the point source loads that have been determined for the nutrient management zones. Environment Canterbury's approach uses good integration of ground water and surface water as they are linked with the relationship between water quality in groundwater recharge and of the surface water body representing the nutrient attenuation coefficient for that particular zone/catchment/reach. This is different to the Horizons approach that uses a blanket nutrient attenuation coefficient of 0.5 to translate river loads to catchment loads (and vice versa). Environment Canterbury has a good awareness of the complex interplay between different water quality/quantity parameters and how they influence water quality outcomes. These need to be incorporated into the setting of numeric objectives that relate to the specific values/outcomes/narrative objectives for the catchment/WMZ. In the Hurunui catchment, Environment Canterbury explored the relative merits of different approaches for meeting the nitrogen objective (related to periphyton for that WMZ). The potential basis for numeric limits include ANZECC guidelines, Environment Canterbury percentile data from SoE monitoring and NZ periphyton guidelines. Potential weaknesses The manual system of retrieving data from consent monitoring and SoE monitoring databases is resource intensive. Environment Canterbury recognise the need for increased automation, as currently they have to 'triple handle' which

Criterion	Evaluation	Comments
		has major issues for resourcing. The quarterly monitoring frequency of the river quality programme is not ideal for trend detection and determining annual contaminant loads. Environment Canterbury acknowledge this and are implementing monthly sampling (at the expense of spatial coverage). There is uncertainty in diffuse nutrient losses – i.e. current schedule 8 is vacant as the look-up values for nutrient losses for different pastoral land use are being re-calculated. Environment Canterbury perceive a current disconnect between environmental compliance monitoring data and SoE monitoring data. The former can be a much reduced set of parameters, lower precision, and therefore of limited value for SoE monitoring. Issues may arise as the 10 WMZs boundaries do not line-up with catchment and aquifer boundaries.
Practical	Yes	<u>Strengths</u> The system works well, and is relatively straight forward. Point sources are calculated by measured inputs (consent compliance), SoE monitoring provides totals and so by subtraction of point sources (which have been calculated for all 38 nutrient zones), allow the mass of diffuse source of contaminants (i.e. nutrients). Diffuse sources are then ‘apportioned’ by modelling (mainly OVERSEER). <u>Potential weaknesses</u> There are approximately 17,000 farms in the Canterbury region. While many of these life style blocks, there are around 9,000 ‘real farms’. The ‘system’ for dealing with the submission of literally 1000’s of farm management plans is yet to be developed. Environment Canterbury envisage automated submission (analogous to tax returns) and probably have QC in the form of random audits. Current accounting systems are still labour intensive - already serious resourcing issues in the process of giving effect to the NPSFM, and the implementation and management of the system will further add to stretched resources. Environment Canterbury noted: all of this costs money - who is going to pay, rate payer/consent holder?
Transparent	Yes	<u>Strengths</u> The high level of community consultation ensures transparency of processes generally. SRPs are developed with Zone Committees and a lot of community and stakeholder input. All technical documents (including court evidence) are available from the website. <u>Potential weaknesses</u> A potential issue with transparency is that Environment Canterbury have not addressed potential privacy issues around submitted farm/nutrient plans. Ideally, Environment Canterbury would have the potential to use nutrient loss budgets and make results accessible to other stakeholders – a form of ‘peer pressure’ within catchment to attain best possible farm management practices with respect to environmental compliance.
Effective	Yes	<u>Strengths</u> With respect to contaminant accounting outputs, the Environment Canterbury system is fit for purpose in that it is capable of generating a full range of relevant contaminant accounts at a number of scales – i.e. from catchment to WMZ to

Criterion	Evaluation	Comments
		regional. Potential weaknesses The system is data intensive with a combination of manually calculated loads (from SoE/compliance data) for actual and point sources, and modelled for diffuse. To address this Environment Canterbury are looking towards more modelled approaches to make the accounting process less resource 'thirsty' – which would also enable more timely updating of accounts.
Acceptable	Yes	Strengths Environment Canterbury's process of water management generally is collaborative so there should be greater stakeholder and community 'buy-in' to the accounting processes set in place. Potential weakness Contaminant accounting of diffuse sources will require farmers to submit nutrient budgets - this will be a consent condition and compliance monitoring will be required to obtain this information.
Adaptable	Yes	Strengths Assuming the 38 nutrient management zones align with the 10 main water management zones, the N and P accounts data for point source can be readily scaled up to WMZs. The 10 WMZs are comprised of multiple catchments – accordingly water quality will actually be managed at the catchment scale, with these result being aggregated to WMZ level and obviously WMZ account could be scaled to regional level. In addition to determining accounts for point sources, diffuses sources and totals, Environment Canterbury also report load accounts by land use, intensity, soil type, climate and by irrigation (coarsely).

3.6.2 Results – the costs

Environment Canterbury's costs of systems related to accounting processes are summarised in Table 3-26 and detailed below.

Table 3-26: Summary of Environment Canterbury's costs related to accounting systems.

System costs related to accounting	
Water user database	$340-380,000 (2008-9), on-going annual costs of $210-220,000
CoCoA database	$570,000 (2012/13)

Water User Database

Background

Before 2008, water usage data at Environment Canterbury was stored in two different ways for two different purposes (compliance and resource investigations). With the national regulations for water metering on the horizon, a new system that would cater for both purposes was designed and implemented. As Environment Canterbury was not going to (be able to) retrieve water usage data for all 5,000 consents, the database was simply set-up to store the data received from third parties. It is set-up in a way that allows reporting on consent compliance as well as reporting on totals for catchments and zones, as well as (consented) water usage type.

Indicative costs

Environment Canterbury's Water User Database was set up in 2008/9 and costs consisted of $50-80,000 contractor costs. In the financial year 2008/9, management and design costs amounted to 50% of one FTE, equivalent to $160,000 including overheads. For the following years, FTE time drops to 25%, i.e. $80,000. Other annual costs include contracting and maintenance of the database system of $20-30,000. Additional costs of data handling and entry consists of $100,000 annually since 2009/10 but these costs are predicted to rise given a growing database. Total set-up costs amounted to $340-380,000 in 2008/9 with on-going annual costs of $210-220,000, which are likely to grow as the database expands.

Table 3-27: Indicative costs of Environment Canterbury's Water User Database.

Water User Database costs since 2008/9	
Set-up costs Managing and design costs Contracting and maintenance costs Data handling and entry	$50-80,000 contractor costs $160,000 and then $80,000 annually $20-30,000 annual costs $110,000 annual costs No additional costs since the NPSFWM? Maybe some costs savings if there had been a national accounting scheme in place?
Total costs	**$340-380,000 with on-going annual costs of $210-220,000 likely to grow**

CoCoA database

Background

The CoCoA database is effectively a repository for all information associated with RMA authorisations within the Canterbury region. It holds the details of authorisation, provides a prioritisation framework and scheduling system to guide compliance. It also allows Environment Canterbury to manage all transfers, surrenders, expiries, and processing of authorisations.

Indicative costs

Costs are a very rough estimate as the database Environment Canterbury are using has not been 'live' for a full year yet. Notwithstanding that, costs have been broken down as of 2012/13:

- Software licencing $100,000
- Depreciation of the software asset $120,000
- IT staff for updating Accela software, fixes $50,000
- Labour cost $200,000 (including overheads)
- TOTAL COSTS $570,000 (2012-13)

Environment Canterbury does not anticipate the costs will increase significantly as a result of the NPSFM[115].

Environment Canterbury does not believe that costs would be minimised if standardised processes or accounting systems are used. In fact the later any standardisation is left the more likely it will be to increase costs as Environment Canterbury would have to adjust what is already developed.

3.7 Summary of challenges and information requirements

When the project team visited councils, we asked a number of questions relating to the challenges and information requirements of accounting for all water takes and sources of contaminants. Analysis of the answers has identified commonly occurring themes for water quantity and water quality topics, which are discussed below.

3.7.1 Challenges

Councils have either faced, or anticipate facing, a number of challenges in establishing and maintaining accounting systems. For example:

- Finances/resources to upgrade systems to collect data, review consents or plans to impose reporting requirements, and resource staff for data entry/QA (particularly as systems as they stand may be a combination of 2-3 databases that have to be manually linked)
- Quality assurance of data – need to develop input protocols
- IT/database management challenges
- Developing a system that aligns water quantity and quality
- Political buy-in of accounting need, which precedes financial commitment to this
- Clarification of data ownership/privacy issues, what will the data be used for, and who should pay for its collection
- Changing of predictions used in accounting due to model versions/updates
- Educating the community about the needs for limits, especially farmers with regard to nutrient limits
- Dealing with scientific uncertainties
- Increased requirement for monitoring to account for contaminants in particular
- Low priority of water issues (compared to housing/economic growth)
- ‘Short-termism’ due to 3 year political cycle can hamper long-term strategic planning, and
- Time for staff to work on this issue, when the current focus is on the planning process (i.e. setting limits).

[115] Correspondence with Brett Aldridge, Environment Canterbury, 21st June 2013.

Councils identified a number of potential uncertainties that may arise, and in some cases were able to offer ways to manage these uncertainties. These are summarised in Table 3-28 below for water quantity and quality, and broadly include process, logistics and technical issues. There is overlap between the uncertainties identified in this table and the list of challenges above.

Table 3-28: Uncertainties and potential management approaches with regard to accounting systems.

Uncertainties	Management approaches
In-house systems may need upgrading to provide national data requirements	Allocate more resources or national delivery of system
Need for consistency with other regional councils	Having a degree of national standardisation of the form of accounts. Current regional council initiatives for National Environmental Monitoring Standards (NEMS) and the NEMAR initiative may help
Updating data sets (continuity of data)	Transition from one method to another – maintain both Transparency over methods used to account
How do you implement	The use of shorter term consent durations and common catchment expiry dates provides some helpful tools for this
Government changing policy or approach for water accounting	Make policy for how takes are assessed clear in regional plan Allow flexibility for pragmatic assessments (in IRIS or GIS accounting tools)
Financial and resourcing	Need to predict the future demands in advance and allocate resources within council Explore cost-sharing and joint initiatives between councils and Government
Access to information/privacy issues	Essential to have good relationships with industry groups May need high level intervention / new powers
Estimates of stock water use in permitted activities	Undertake project work to estimate this and/or share outcomes between councils
Estimates of multiple other uses of irrigation water (e.g. also used for dairy shed wash down and stock drinking water)	Undertake project work to estimate this and/or share outcomes between councils
Robustness of the data and models to estimate/derive contaminant loads to aid accounting for non-point source inputs	Use best practice, share between councils Central/national standards (i.e. numeric objectives or suggested methods) could save a lot of time and resourcing. Improved accuracy of nationally held databases
Access to data for modelling e.g. data on land use and stock numbers by catchment	Improved access to nationally held data
Monitoring needs and relationship to national networks	Need to consider how to tie in changes in networks. e.g. down-sizing of NIWA network - how will that gap be compensated for in councils network?

In general, councils were confident or very confident in the systems that they use for accounting for all takes and 2 out of 5 councils said it was too early to be confident in their contaminant accounting.

There were mixed opinions as to whether further powers might be needed to collect accounting information. Some councils suggested that existing powers were sufficient although both plans and consents might need to be reviewed to impose the conditions for this, which would come with associated cost and time delays. The use of existing relationships with stakeholder groups and consent holders to ensure compliance was raised. Other suggestions included:

- Improvement of RMA powers to allow non-compliance with information provision conditions to be an infringement offence
- National regulations to provide support for regional plan and consent information requirements
- National direction to address privacy/data ownership debate to prevent this being re-litigated in each region
- National standard for environmental reporting
- Powers to enable cost recovery relating to data collect and QA, and
- Powers to enable collection of data regarding landuse.

In terms of science needs for accounting, the needs for water quantity centred on more information about water use efficiency, evaporation, and information, models and guidance on groundwater connected surface water systems. For water quality, the key science need is in understanding of both lags and attenuation with regard to nutrient accounting. Other needs for water quality included:

- Developing attenuation coefficients (or making use of CLUES and other river models)
- Understanding/benchmarking losses associated with different landuse types
- How to identify reference/baseline conditions
- Developing macroinvertebrate metric for non-wadeable streams
- Understanding cumulative effects of multiple stressors
- More monitoring data at good spatial and temporal resolution, in general.
- Reference was also made to the science priorities for the SWIM group.

Every council identified capacity issues in implementing accounting systems. These include the sheer amount of data to be entered, QA processes and system security, issues with cost-recovery for staff working in consents/compliance areas. For some councils with limited rates income, this work may come at the expense of other things. It was noted that Government policy (caps on rates, streamlining consent timetable) makes it difficult for councils to expand resourcing, whereas the Reforms 2013 agenda (e.g. accounting) will increase the need for resourcing.

We note that this study was completed before any clear signals from Government regarding the proposed National Objectives Framework (see Reforms 2013).

3.7.2 Information requirements

In terms of information requirements for accounting purposes, it was hard to discern a clear message regarding the critical or core information needs. Some thought what they were collecting now in existing databases was the core required, and referred to the relevant question recording that information. A key message was that requirements would vary from catchment to catchment depending on issues, the scale (i.e. catchment or farm) at which the resource had been allocated, and any national guidance on monitoring (i.e. NEMS, NEMAR). Horizons detailed requirements from their POP, which include:

- Water use and discharge volume from in-to-river point sources (quantity and quality)
- Nutrient budget information from farms – spatial extent, nutrient loss numbers, farm maps.

When asked, what extra (beyond core) information could be collected to improve your management of water quantity or water quality, the responses included:

- Better agri-database information (several councils)
- Targeted investigations if hotspots are identified
- Seasonal variations in allocation/use to help storage investigations
- Groundwater-surface water interactions (several councils)
- Groundwater recharge estimates
- Groundwater travel times (several councils)
- Use type
- Saline intrusion in groundwaters (1 council)
- Better geographic spread (but has to be balanced against need for monthly data which is better for trend detection)
- Farm scale contaminant data.

We note that this project was completed before any clear signals from Government regarding the proposed National Objectives Framework (see Reforms 2013).

3.8 Summary of accounting systems

Overall, our evaluations have shown that water quantity accounting systems are in place, although each system has strengths and weaknesses and often non-consented takes are still not being fully accounted for.

Water quality accounting systems are less well developed, and while some councils have produced accounts these are still more likely to be 'one-off' source analyses, with little or no regular accounting. Systems for accounting for nutrients are generally better developed than for other contaminants. All councils have some components of systems in place, as the building blocks for full systems to be developed.

Most systems, both quantity and quality, have been developed with regional needs in mind and are fit-for-purpose within region. Some systems have components that may be able to be transferred between regions, and the development of the IRIS information system (shared between 6 councils) may offer lessons for inter-region system requirements.

Costs for information systems that play a key role in accounting have been provided, and are widely variable due to their different natures. Such information systems are used for much more than accounting in most councils.

Councils have indicated that there are a variety of potential challenges with implementing accounting systems, such as establishing/upgrading, maintaining and quality assuring these systems. Issues with data ownership (privacy issues) and cost attribution (who benefits and therefore who should pay?) require resolution. Uncertainties exists across process, logistics and technical issues, but councils have offered potential management approaches to address these. Information requirements will vary from catchment to catchment depending on issues, the scale (i.e. catchment or farm) at which the resource had been allocated, and any national guidance on monitoring that is promulgated.

4 Limit setting

This project (for Task 7) focusses not just on setting freshwater objectives and limits but in particular the processes that councils use to derive limits from freshwater objectives.

In 2010, Norton et al. reported on *Technical and scientific considerations when setting measurable objectives and limits for water management*. This report provided an overview framework for setting objectives and limits for managing water quantity and quality. Norton et al. (2010) outlined a number of issues, including:

- the importance of terminology due to multi-disciplinary requirements of limit setting;
- the need for value judgements to be made in order to set objectives for environmental outcomes; and
- the need for the objectives to be measurable in order for science to be able to demonstrate relationships between desired environmental state and the amount of resource use possible in order to meet that environmental state.

Norton et al. (2010) suggested definitions of key terms such as narrative and numeric objectives, and limits, and discussed how these were related. Similar terminology is used in the NPSFM, which defines in particular freshwater objectives and limits to resource use.

Further to that, LAWF in their 2012a report outline the concept of an objectives-limits cascade. LAWF define this cascade as a series of increasingly precise objective statements that culminate in numeric objectives, and from which limits can be set. This concept was explored by Environment Canterbury when exploring limit setting in the Hurunui-Waiau catchment (see section 4.3.2 below) as shown in Figure 4-1. The framework diagram (also used in the NPSFM Implementation Guide, MfE 2011) illustrates the link between objectives, limits and methods and provides examples of each. The boxes to the left hand side show stages for setting limits, and those on the right illustrate how to operate within a limit. This cascade is a useful theoretical illustration of how this derivation could work.

The practicalities of this process are a little more uncertain, as in New Zealand, few councils have progressed very far with the NPSFM freshwater objective and limit-setting process. Hence, New Zealand case studies will offer useful insights as to how this can happen in practice. We can also learn lessons from other jurisdictions that have employed similar 'environmental outcome' and 'limit to resource use' approaches in freshwater management.

4.1 Methodology

With this background in mind, to address Task 7 of the project (as outlined in section 1.1) we first carried out a brief literature review of international approaches with particular reference to those that have a similar framework as required under the NPSFM (i.e., cascade from objective setting to limit setting). We have drawn from a (now annual) review of all regional plans carried out by MfE, along with other recent reviews and some unpublished NIWA research, to make some broad statements about the current status of limit setting in all regional plans. We then looked in depth at three regional case studies where good practice has been employed. Finally, we evaluated the methods and processes used in limit setting by the five councils visited in this study, commenting on the costs of their limit-setting processes, and offering comments on challenges and information requirements to enable limit setting.

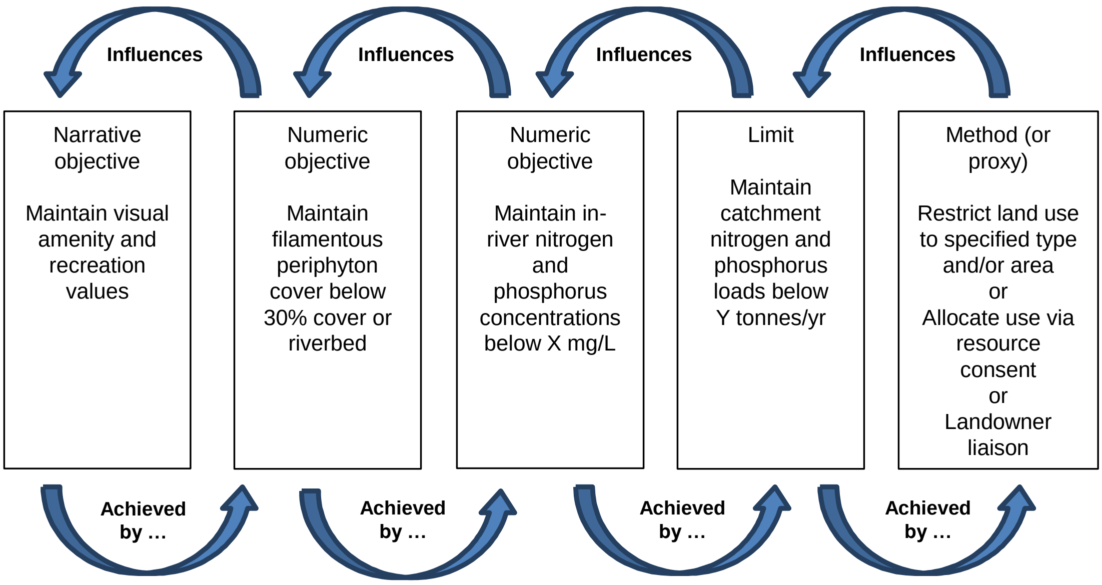


Figure 4-1: Objective-limits cascade example (From MfE 2011, and Environment Canterbury 2012). In the text below, the boxes are referred to by number from left to right.

4.2 International literature

In section 2 of this report we outlined how four different jurisdictions (states or countries) manage freshwater (England, Ireland, California and Victoria), and we identified those where similar approaches to our New Zealand 'limit setting' approach have been employed and might offer lessons for New Zealand. Another jurisdiction identified by the Water Directorate as worthy of attention with regard to limit setting was Queensland in Australia, which was also outline in section 2.7.

4.2.1 Summary of reviewed approaches

As highlighted in section 2, other jurisdictions may offer lessons to New Zealand in terms of the processes and methodologies for deriving limits from freshwater objectives (see Table 4-1 for equivalent terminologies).

In Europe, the Water Framework Directive (WFD) has made value judgements regarding the desired environmental outcomes (what we would call a freshwater objective) for European water bodies i.e. good status by 2015 (see section 2.2). The WFD then requires that Member States (such as England and Ireland) set limits (Environmental Quality Standards or EQS) that will enable this environmental outcome to be achieved. River Basin Management Plans (RBMPs) identify current ecological status, set objectives and design a programme of measures to maintain or achieve this. In England, Catchment Abstraction Management Strategies (CAMS) decide on minimum flows and how much water is available to be allocated, and outline how the Environment Agency intends to manage abstraction licensing within each catchment.

Table 4-1: Definitions of freshwater objectives and limits in New Zealand and equivalent terminologies in other jurisdictions.

New Zealand	England	Queensland	US
Freshwater objective: required environmental outcome. Set at regional level	Required environmental outcome of 'good status' set by the Water Framework Directive at EU level	Required environmental outcome set at state level e.g. under Environmental Protection Policy for Water for environmental values to be enhanced or protected or through water resource planning	Required environmental outcome for quality to not further degrade 'impaired waters' set at federal level; quantity objectives vary state to state
Receiving water quality standard (e.g. concentration-based, appearing in Third Schedule RMA or in a regional plan). [116]	Environmental Quality Standards (EQS) for "Priority Substances" set by the EU to meet good chemical status. For other contaminants EQS set by Member States	Water Quality Objectives based on Queensland Water Quality and/or Australian Water Quality (ANZECC) guidelines	Water Quality Standards set by the state. If these are not being achieved states must develop Total Maximum Daily Loads (TMDs) for "impaired" catchments (see below)
Limit (quality): – limit to resource use. Can be a catchment load limit, set by regional authorities in regional plans[117]	Load limits set in some specific cases only	Load limits set in some specific cases only	TMDLs set by state EPA and related allocations to point sources (waster load allocation) and diffuse sources (load allocation)
Minimum flow	Environmental Flow Indicators (EFIs) – consider not just minimum but range of flows	Environmental Flow Objectives (EFOs) – include more than a minimum flow	Minimum flows
Allocation limit (flow)	Resource availability (related to EFIs)	Resource availability (related to EFOs)	Available allocation /appropriation (allocated by water rights) (In California, called maximum cumulative diversion)

In the United States, for water quality the federal Environmental Protection Agency (USEPA) under the (federal) Clean Water Act (CWA) requires states to develop lists of impaired waters (which are too polluted or otherwise degraded to meet an environmental outcome or objective which is defined by water quality standards set by the state). Once a water body is agreed to exceed those standards, the CWA requires states to establish priority rankings for waters on the lists and develop Total Maximum Daily Load, or TMDL, for these waters for point and non-point source discharges. Water quantity management is not as clear and

[116] Note that New Zealand is in the process of turning some of these into numeric "freshwater objectives".
[117] Note that the definition of limit is not tightly prescribed in the NPSFM and it is possible that concentration-based receiving water quality standards are viewed as limits by some regional councils in some situations. The latter arguably *imply* the amount of resource use that is possible but do not explicitly quantify it in resource use terms. This comment applies also to receiving water concentration-based criteria in other jurisdictions (e.g. EQS (England), QWQ (Queensland) and WQS (US)) – whether or not they constitute a "limit" (in NPSFM terms) is unclear. Load-based criteria (e.g. load limits (NZ) and TMDLs (US)) certainly satisfy the NPSFM definition of limit.

varies more widely between states. For California, it includes policy to set minimum flows based on ecological instream values (salmonids).

In Australia, the management of water quantity and quality varies per state. In Queensland, the state level Environmental Protection Act and related Environmental Protection Policy for Water (EPP Water) sets desired environmental outcomes for water bodies depending on their agreed environmental values (EVs). Water quality objectives (WQOs) are then set per catchment or based on defaults, to enhance or maintain the EVs of that water body. Environmental flow setting is done through water resource planning and the setting of Environmental Flow Objectives (EFOs). Again the responsibility for these things lies with different agencies.

However, from the primary sources reviewed in section 2 it is not always easy to understand what processes and methodologies were used to derive limits from the freshwater objective. This information may be held in closed technical documents not available from primary websites. Within the timeframes of this project, it was decided to probe into this level of information by attempting to contact people within organisations with some role in 'limit setting' and ask them some direct questions related to their approaches.

In particular we wanted to explore how limits are justified in other jurisdictions and what "flow" of logic is used to arrive at limits, with reference to a freshwater objective (or equivalent). We provided an overview of the New Zealand framework with a copy of the objective-limits cascade framework (i.e. Figure 4-1) and some definitions of terms. We asked three specific questions:

1. In your country/jurisdiction, how/by whom is an intended environmental outcome set?
2. Is our conceptualisation of working from objectives to limits consistent with how this is approached in your country/jurisdiction? How does the relevant organisation set limits on water quantity (abstractions) and water quality (discharges)? In other words, do limits link to objectives and how well justified are any limits and methods in terms of environmental objectives?
3. Is there anything else you can tell us (or provide to us) that shows the mechanisms/methods/tools that are used to justify limits and/or to link objectives to limits?

Responses were received from Stuart Kirk (Defra and the Environment Agency (EA)) with regard to England; Sean Blacklocke (Environmental Consultant, Ireland) and Tim Cox (consultant, New Zealand) with regard to the US; and Barry Hart (Emeritus Professor Monash University and Director, Water Science Pty Ltd) with regard to Australia. It must be noted that the responses provided are personal opinions from these people, not necessarily representative of any organisation's official view. The responses were variable in length and the understanding of the terms used may have prevented a fuller response. The responses are summarised here.

England

1. Environmental outcomes are set by EU Directives, such as WFD good status. The Competent authority in each Member State is responsible for setting

numeric objectives and designing environmental limits to achieve them. This is carried out by technical groups such as the UK Technical Advisory Groups, who design both the monitoring regimes and setting limits or systems to set limits, which are then tested across EU Member States to ensure they offer parity of assessment.

2. In England, abstractions are controlled by the EA to protect flows. Where over-abstraction is indicated (by the RAM Framework) then studies are undertaken to ascertain the potential benefits of restoring flows. Where over-abstraction is not occurring new abstraction licences are set with conditions to help preserve the river's environmental flow. These flow limits (EFIs) are thought to protect the WFD status objectives. Similarly water quality standards/limits are also set to protect WFD status objectives. However WFD water quality status is measured by a mix of water quality and chemical criteria, and ecological criteria. The relationship between the ecological condition and water quality/chemical content is imperfect and lots of compounding factors are recognised. For example, the ecology of a river reach may be determined by a complex mixture of factors including habitat condition, water quality/chemistry and flows (low and high), impact of non-native species etc. The response of aquatic ecology to multi-pressures is a key area of research in the EU.

3. Three further points were made:

- Some argue that so far, England and Wales have taken a very techno-centric approach to implementing the WFD, regarding it as a compliance challenge, and now need to pay more attention to translating WFD objectives into more meaningful ones and enlisting communities in helping to realise them. Hence the recent rise of the UK Government backed 'Catchment Based Approach' to better encourage catchment level engagement of communities and NGOs to help improve their aquatic environment.

- One aspect of the WFD often misinterpreted is the requirement for Member States to achieve Good Status in all of its water bodies. In fact this is an 'aim to achieve objective' that is tempered by considerations of feasibility and economic assessments that consider disproportionate cost and affordability. These assessments are made by the competent authority which is the EA in England, and help to decide the management measures that will be pursued. Hence these tests are hugely important to the measures adopted under the WFD.

- There are significant science challenges for the future. For example, there is a need to research and develop more sophisticated means of assessing and monitoring the state of aquatic ecology that are fully cognisant of the impacts of multiple factors (multi-stressors) and the uncertainty in the relationship between stressors and ecology. Further, a better link between the state of aquatic ecology with ecosystem services e.g. amenity and recreation is needed. It may also be pertinent to carry out a critical review with respect to reductions in nutrient leaching/runoff that can be achieved by various mitigation measures.

United States

1. Water quantity allocations are managed at a state level and vary from state to state. In the eastern half of the U.S., where historically water has not been considered scarce, 'riparian use rights' legal doctrine is the basis for water quantity allocations. Generally speaking, landowners, municipal government or private communities can apply for a permit, and as long as the withdrawal request is consistent with the intended use and the relevant stream is not already 'water quality limited' for some pollutant under low-flow conditions, the application is usually granted. Thus, the management of water abstractions to date has not been driven by environmental outcomes (with the exception of water quality limited streams mentioned above). However some environmental standards are now being pursued by some eastern state governments.

   The western states are governed primarily by 'a priori use rights' legal doctrine. A common law system of water use rights evolved simultaneously with the development of the western U.S. states such that entities which first made use of water quantities effectively assumed ownership of those quantities. 'Environmental water accounting' is done by western state authorities pursuant to both state and federal regulations to identify the minimum in-stream water quantities needed to protect/restore aquatic natural resources and a plan of water purchases and/or legal acquisitions is executed by the state to meet these environmental objectives. Hence in the west, environmental outcomes in terms of instream values are more of a driver for allocating water.

   For surface water quality, water bodies are classified for uses and each class has a corresponding set of numeric pollutant standards below which ambient water quality is not supposed to fall. Water quality standards are set by the Federal EPA, under the Clean Water Act. Water body classes are generally assigned by states based on historic uses rather than contemporary assessments a water body's potential. Thus, river segments in which industry discharges are and have historically been prevalent are classed such that corresponding allowable pollutant levels are only regulated to protect secondary uses such as boating and fishing (i.e., swimming, drinking and aquatic life uses are not near-term objectives). The 'use attainability analysis' is the mechanism by which a reclassification can be pursued to either lower ambient pollutant standards or raise them based on a more comprehensive and objective analysis of a water body's potential uses. Streams classified for secondary uses are often the most sought-after streams for primary contact uses due to their proximity to highly populated areas. However, the process of reclassification typically meets with significant opposition and unwillingness to change. Conversely, streams in areas of sparse human populations, often difficult to access, tend to be those classified for primary contact and protection of aquatic resources such as salmonids. Thus, surface water quality objectives for U.S. water bodies can be said to be largely set based on historic uses rather than a contemporary and objective process of comprehensive assessments of each individual water body's current or future potential highest valued uses.

2. The approach is generally consistent. Using an example of water quality, as above every freshwater body in the US is assigned “designated uses”. This is done by Federal EPA, with support of State EPA. These designated uses reflect the values associated with the water body – why it is valued, how it is used. Example designated uses would include cold or warm water aquatic life (e.g. fish, ecology), water supply, recreation, etc. Based on these designated uses, specific standards are applied (e.g. DO must be at least 5 mg/L for cold water aquatic life). Based on these use-specific standards, and measured data from any point in the past (could even be a single data point from 10 years ago!), water bodies can be deemed “impaired”. Impaired water bodies are listed on the Federal “303d list”, which is a reference to the specific section of the Clean Water Act that describes this process. All water bodies on the 303d list then must be subject to a Total Maximum Daily Load (TMDL) analysis, which is the responsibility of the State. These analyses often include monitoring and modelling and set the total pollutant load allowable to achieve prescribed standards (they define the assimilative capacity of the water body). Once a TMDL is performed to the satisfaction of the Federal and State EPAs, a TMDL “implementation plan” is required to reduce actual loads down to the TMDL. These can consist of a variety of best management practices.

3. It is noted that the ‘rational and comprehensive strategy’ such as the one proposed (i.e. Figure 4-1) is useful as a guiding principle which authorities might frequently reference. But the cascade is theoretical and does not acknowledge two fundamental practical obstacles to limit setting, which are:

- acknowledgment of the political inertia in making policy changes, where these changes affect the balance between competing water uses (i.e. effectively redistribute the ‘wealth’ especially in cases of over-allocation); and
- the need for water policy to minimise the extent to which private property rights yield way to centralized administrative government decisions about the nature and distribution of these water use rights.

Australia

1. The legislation regarding management of freshwaters is quite different in each of the Australian states, and in almost all cases separates quantity (environmental flows or eFlows) and quality. For example in Victoria, the Department of Environment and Primary Industry (DEPI) controls eFlows and the State EPA controls water quality. There is some coordination, but not as much as might be useful.

2. The 'objectives limit' example (i.e. Figure 4-1) is very sensible and broadly represents how most of the jurisdictions in Australia work.

3. Two further comments:

- The Murray-Darling Basin Plan[118] was enacted in November last year, and may provide lessons as it is an example of where both flows and quality have been brought together.
- The Australian and New Zealand (ANZECC) Water Quality Guidelines are a key tool in Australia. The last version was prepared in 2000, and progress on the update is slow, but may provide more useful guidance - although the eFlows side of things will (assumed) be neglected.

While these responses (requested at very short notice) did not necessarily fill in the blanks for us in terms of exact process to derive limits from objectives, they did confirm aspects of our desktop review and offer international perspectives on these issues.

4.2.2 Key messages for application in New Zealand

In summary, based on the international desk-top review and supplementary comments from some overseas experts, there are a few key messages for application in New Zealand:

1. The objectives – limits cascade (Figure 4-1) exists more or less in these other countries at least down the cascade as far as setting concentration-based receiving water standards (for quality) and setting minimum flows and allocation limits (for quantity).
2. All countries have the same struggle with the linkages between objectives and water quality criteria (e.g. multi-stressor complications) and needing to accommodate practicalities of existing uses and socio-economic effects when setting limits.
3. A key challenge is in defining the limits to resource use to achieve the receiving water standards (i.e. the 3rd row in Table 4-1). The US have pursued this with TMDLs which are triggered once over-allocation occurs. This challenge is made more complicated in some jurisdictions where the responsibility for policy and river basin planning is often separated from the responsibility for administering abstraction and discharge licensing.

4.3 National stocktake

4.3.1 National reviews

The role of regional plans in managing New Zealand's freshwater resources has been reviewed by several organisations over the last decade or so. These reviews have all looked in varying degrees into the setting of freshwater objectives and limits, even before the terms were formally defined in the NPSFM in 2011, and are summarised here.

In 2005, the Office of the Controller and Auditor General (OCAG 2005) looked at two regional councils, Horizons (Manawatu-Wanganui) and Otago, to see how the RMA framework has been implemented by those councils for the management of the quality and quantity of freshwater in their regions. The two councils were assessed against audit criteria based on best practice guidance, looking at four aspects of regional council activities in relation to freshwater management – planning, implementation, monitoring, and acting on information.

[118] www.mdba.gov.au

In terms of planning, the OCAG looked at the councils' Regional Policy Statements and regional plans, and drew a number of conclusions. Of relevance here, the OCAG found the councils did not have measurable or specific objectives set, and concluded that "Planning documents can be significantly improved by the inclusion of simply worded, measurable objectives that clearly set out what the plan intends to achieve, and specifically outline the environmental state sought." (OCAG 2005, p13).

The Ministry for the Environment (MfE) commissioned a review of regional council practice for setting and meeting RMA-based limits for freshwater flows and quality (SKM 2012) as part of policy development for the New Start for Fresh Water programme (from which the NPSFM was promulgated). The review aimed to "identify the methodologies by which the councils develop water quantity and water quality limits and the methods by which these limits are given effect to in Regional Plans or other statutory documents." (SKM 2012, p2). This was done by a) a review of regional council planning and regulatory documents, building on earlier reviews of Hill Young Cooper (2008) and Auckland Council, and b) through discussion with the regional councils, asking a series of question relating to limit setting. In a national summary for water quality planning provisions, SKM found that:

- All (17) councils set objectives for water quality;
- 13 councils set region wide limits in their plans for surface water and 5 for groundwater;
- Councils found the identification of values and objectives more straightforward but then found it more difficult to develop appropriate limits for those values once in place; and
- Guidelines around the setting of numeric limits were one of the most frequently requested (12 of 17 councils) areas for central government assistance, especially on applying existing ecological guidelines with respect to setting limits for ecological values and how to develop limits for the more intangible values such as cultural, recreational and aesthetic.

The Land and Water Forum (LAWF) in its first report (LAWF 2010) quoted from the SKM work when it stated that amongst the problems with New Zealand's water management was our failure to set limits, and LAWF quoted (p12) that only 4 councils have a complete set of water quality and water quantity limits set for their whole region. LAWF completed further work on limit setting in preparation of their second and third reports, and found on the basis of the SKM review results that only 4% of 'large and significant' catchments were covered by quality limits (A. Smail, LAWF secretariat, pers. com.).

In 2011, the OCAG conducted another review of 4 councils, specifically looking at "how effectively regional councils are managing land use for the purpose of maintaining and enhancing freshwater quality in their regions." (OCAG 2011, p4). The OCAG made a number of recommendations to all regional councils and unitary authorities as a result of their audit, and with regard to regional planning the OCAG recommended that all such councils "include specific, measurable, achievable, relevant and time-bound objectives in their regional plans and in their long-term plans under the Local Government Act 2002." The OCAG also recommended that MfE consider providing guidance about monitoring the effectiveness and efficiency of plans.

At around the same time, Snelder et al. (2013) explored the relationships between science and water resource use limit setting. They explored how environmental flow-setting methods, hydrological analyses for setting allocation limits, and spatial characterisation tools, were used to set limits in New Zealand regional plans. They carried out a review of regional plans looking at four aspects:

- Do regional plans set minimum flow and total allocations for all rivers in the region?
- Are minimum flows and total allocations transparently linked to clear objectives (i.e. unambiguous and measurable) for both environmental values and reliability of supply?
- Are the limits justifiable? (i.e. derived using scientific assessments that are scaled appropriately to the level of environmental risk and in a replicable manner).
- Do the objectives and limits vary spatially?

Their findings are briefly summarised in Table 4-2.

Table 4-2: Summary of findings from Snelder et al.'s 2013 review of regional plans with regard to environmental flow limit setting.

Criteria	Finding
Are both minimum flow and total allocations set?	9 of 16 plans defined minimum flows and 7 plans defined total allocations. Only for 6 of 16 plans reviewed set both.
Are minimum flows and total allocations transparently linked to clear objectives for both environmental values and reliability of supply?	In general the links between plan objectives and limits are not transparent in the regional plan, and objectives tend to be narrative, especially for early (first generation) plans. Newer (second generation) plans tend to have more measurable objectives. One example is cited (Environment Southland)
Are the limits scientifically justifiable?	The review found regional plans to be using appropriate methods selected on a risk basis, e.g. rule of thumb methods for low risk situations and physical habitat modelling for higher risk (increasing demand for water, or higher instream values) situations
Do the objectives and limits vary spatially?	The review found early plans made very limited use of spatial frameworks, but noted more current plans use spatial frameworks. For example, 4 use the River Environment Classification system (REC).

Most of these studies were carried out before or very shortly after the NPSFM was gazetted. In terms of exploring progress with implementing the NPSFM, NIWA has been conducting research looking at freshwater objective and limit setting in regional plans (Rouse and Norton, unpublished) under the 'RMA matters' work-stream of the NIWA-led *Management of the cumulative effects of stressors on aquatic environments* research project, which is funded by the Ministry for Business, Innovation and Employment (MBIE). This research included (in 2012) a review of regional plans in respect to water quality management, and a survey of regional planners responsible for implementing the NPSFM, in the six months immediately following the gazetting of the NPSFM. Some of these results were summarised by Rouse and Norton (2012) but the full results are as yet unpublished and are quoted as such in what follows.

In the first part of this research, Rouse and Norton (unpublished) explored regional plans to see whether, at the time of review, the plan contained enough ‘numeric direction’ for scientists and technical advisors to be able to set water quality limits. In other words, whether from the plan it was possible to infer an ‘intended environmental outcome’ for water quality for the region’s water bodies, to sufficient level of detail that would enable a scientist to provide total load limits (or allocation) for the catchment so that the council could then be able to allocate proportions of that total to individual users (i.e. set limits to resource use). The review looked for the numeric direction at all levels in the plan hierarchy (i.e. objectives, policies and methods).

This plan review found that at the time of review, of 16 plans reviewed:

- 2 plans had sufficient numeric direction at objective level for the whole region
- 3 plans had sufficient direction at objective level for some specific catchments
- 7 plans had sufficient direction at policy level for the whole region
- 1 plan had sufficient direction at policy level for some catchments
- 5 plans had sufficient direction only at method or rule level for the whole region, and
- Only 1 plan did not provide sufficient direction for the whole region at any level.

Rouse and Norton (unpublished) also conducted a survey of regional planners, and asked a series of questions about their regional plans and progress and challenges with implementing the NPSFM, with regard to water quality. In this survey, the terms ‘freshwater objective’ and ‘limit’ were defined as in the NPSFM. 14 responses were received from individual planners and it is noted that their responses may not reflect their council’s official position.

Rouse and Norton asked councils first of all about objectives and policies at a Regional Policy Statement (RPS) level. With regards to whether their RPS has an objective regarding freshwater quality, 13 of 14 said yes their RPS does have an objective regarding freshwater quality, while only 1 said their RPS doesn’t. Of the 13 who said yes, 10 said that the relevant objective is narrative (such as ‘protecting life supporting capacity’) while only 2 said it is more directive (numerically) than that.

Overall, only 3 of 14 said their regional plan (as it is formulated now) is effective in managing water quality for their region at the moment, and 4 of 14 said their plan isn’t effective. The other 7 are more cautious or equivocal in their judgement. For example:

“[The plan provides a] good starting point but some way to go before we will be effectively managing water quality in the region”.

With regard to setting freshwater objectives:

- When asked, does your regional plan meet NPSFM requirements for freshwater objective setting? 6 of 14 said their plan does meet requirements, 7 of 14 said to some extent, and 1 of 14 said their plan does not meet requirements.
- There was an acknowledgement that the 'environmental outcome' required by the NPSFM definition of a freshwater objective may currently appear in different locations within the hierarchy of a plan. When asked about this, 9 of 14 said their freshwater objectives appear in the objectives of their plan; 9 of 14 said they appear in their policies, and 5 of 14 said that freshwater objectives appeared in the methods of their plan, most typically as rules.
- 9 of 14 said their freshwater objectives are measurable, at least in part, and 5 of 14 said they are not measurable.

With regard to setting limits:

- When asked, does your regional plan meet the NPSFM requirements for limit setting, 1 of 14 said their plan does meet requirements, 8 of 14 said to some extent, and 5 of 14 said their plan did not meet the NPSFM requirements.
- Within a plan hierarchy/structure, 2 of 14 said their limits appear in plan objectives, 7 of 14 in the policies, and 8 of 14 said their limits appear with the methods of their plan, most typically as rules.

MfE is in its third year of conducting a review of all regional plans and water conservation orders (WCOs) to assess progress with the implementation of the NPSFM. The review assesses planning documents to see whether limits have been set. For water quantity, a limit is defined as including a minimum flow and an allocation limit (as per the NPSFM). For water quality, a limit is a catchment load limit. The results from this analysis are shown in Table 4-3.

Table 4-3: Results from MfE review of regional plans and WCOs (Source: MfE unpublished data).

Year	% catchments with water quantity limits in place	% catchments with water quality limits in place
2010/2011	52	4
2011/2012	55	7
2012/2013	58	7

The NPSFM (Policy E) required councils to implement the requirements of the NPSFM by December 2014, or otherwise develop and publically notify a Progressive Implementation Plan (PIP) stating when this will be implemented with a final deadline of 2030. MfE has analysed the PIPs, and categorised them into four categories, as shown in Table 4-4.

4.3.2 Regional case studies

The following section attempts to trace development of objectives and the derivation of limits in three existing (operational) regional plans, and compare these with the objectives-limits cascade shown in Figure 4-1. The three case-studies here have been previously identified as examples of good practice in Norton et al. (2010): Waikato Regional Council (Lake Taupo), Bay of Plenty Regional Council (Lake Rotorua), and Environment Canterbury (Natural Resources Regional Plan in that instance, but the Hurunui-Waiau River Regional Plan here). We note that as with the overseas reviews, it is not always possible from the primary source (i.e. a regional plan) to understand exactly how this was done, and the relevant technical reports describing this are not always readily available. However, we do not think this will significantly alter our summaries. In the following, extracts from the regional plans discussed are denoted in *italic text*.

Table 4-4: Regional councils' progressive implementation of the NPSFM.

Category	Council
NPSFM will be fully implemented by 31 December 2014	Otago, Horizons, Taranaki
NPSFM to be implemented in one go (dates between 2013 and 2030)	West Coast, Nelson, Marlborough
Region-wide defaults followed by progressive plan changes for catchments/water management units before 2030	Southland, Canterbury, Wellington, Bay of Plenty. Auckland
Progressive plan changes for catchments/water management units, then final plan change to capture the rest of the region	Tasman, Hawkes Bay, Gisborne, Waikato, Northland

Waikato Regional Council – Lake Taupo

Lake Taupo-nui-a-tia is New Zealand's largest lake, and is 40 km long and is 30 km wide at its widest point[119]. The lake and its tributary rivers and streams support an internationally recognised trout fishery, and the lake provides valuable habitat for indigenous fish and invertebrates, and other aquatic and biotic life. However, past and present landuse practices in the catchment have led to problems with Lake Taupo's water quality due to excess loss of nutrients from land, particularly nitrogen.

A partnership approach between Waikato Regional Council (WRC), Taupo District Council, central government (MfE) and local iwi Tuwharetoa has been followed, developing a strategy called Protecting Lake Taupo[120], setting up the Lake Taupo Protection Trust[121], and following these steps with statutory backing by developing WRC's "Variation No. 5 - Lake Taupo Catchment" to the Waikato Regional Plan (WRP) which was proposed in 2005, and became operative on 7 July 2011. Variation 5 (V5) is now incorporated into chapter 3.10 of the WRP[122]. The following summary is based on a more thorough description provided by WRC in section 3.10 of the WRP.

Developing objectives

Scientific evidence indicated that water quality in the lake was showing early signs of declining, and levels of chlorophyll *a* (a measure of increasing algal biomass) were increasing, with associated increased frequency of nuisance levels of algae or blooms of toxic algae, and reduced water clarity. Following a review of this evidence, WRC developed

[119] http://www.waikatoregion.govt.nz/Council/Policy-and-plans/Regional-Policy-Statement
[120] http://www.waikatoregion.govt.nz/Council/Policy-and-plans/Rules-and-regulation/Protecting-Lake-Taupo
[121] http://www.laketaupoprotectiontrust.org.nz/page/lake_5.php
[122] http://www.waikatoregion.govt.nz/Council/Policy-and-plans/Rules-and-regulation/Regional-Plan/Waikato-Regional-Plan/3-Water-Module/310--Lake-Taupo-Catchment/

an *Issues and Options* report which identified four potential options for management of the lake. These included:

1. Better water quality than now, with much less intensive land use in the catchment.
2. Maintain current water quality by reducing nitrogen output from existing land uses and preventing further land use intensification.
3. Slightly lower water quality than now, with existing land use remaining the same but no further intensification.
4. Lower water quality. Do nothing to change land use in the catchment.

Following community consultation, WRC did not further consider options 1 or 4, and in 2001 chose option 2, on the basis that this option was consistent with both community expectations of a clean lake, and an RMA mandate to sustainably manage land in order to protect water quality, further reinforced by objectives and policies in the Waikato Regional Policy Statement. As a result, four objectives were set for the lake in the WRP:

Objective 1: Maintenance of the current water quality of Lake Taupo

> *The effects of nutrient discharges in the catchment are mitigated such that by 2080 the water quality of Lake Taupo is restored to its 2001 levels as indicated by:*

Water Quality Characteristic	Mean	Standard Deviation
Total Nitrogen (mg/m^3)	70.3	19.1
Total Phosphorus (mg/m^3)	5.57	1.4
Chlorophyll *a* (mg/m^3)	1.18	0.6
Secchi depth (m)	14.6	2.7

Objective 2: Effect on Lake Taupo water quality from land use activities

> *Land use activities which result in nitrogen leaching, particularly farming, are managed to facilitate the restoration of the water quality characteristics of Lake Taupo to their 2001 levels.*

Objective 3: Avoidance of near-shore effects from wastewater

> *No greater concentrations of domestic wastewater nitrogen or pathogens in shallow near-shore waters of Lake Taupo in the vicinity of wastewater treatment and disposal systems.*

Objective 4: Economic costs minimised and social and cultural effects mitigated

> *Economic costs of managing land use activities to achieve Objective 1 are minimised, and spread across local, regional and national communities. Social and cultural effects of managing land use activities to achieve Objective 1 are mitigated.*

Objective 1 is numeric, and clearly states the intended environmental outcome for the lake. In terms of the cascade framework in Figure 4-1, this objective fits into the second or third box from the left.

Deriving and setting limits

In order to meet these objectives, particularly 1 and 2, WRC undertook further work to investigate the relationships between local landuse activities and the nitrogen levels in the lake. Scientific studies looked at:

- Current and historic landuse in the Lake Taupo catchment
- Modelling of a nutrient budget for the lake
- Monitoring of water quality indicators in streams and rivers in the Taupo catchment
- Modelling of nutrient loads entering Lake Taupo under various future land use scenarios.

WRC's nutrient budget estimates that nitrogen loads entering the lake (from natural and human-generated sources) are about 1360 tonnes per year. A pre-development or natural nitrogen load entering the lake is calculated to be about 650 tonnes per year, and thus about 710 tonnes per year of nitrogen can be attributed to human-generated sources. This is the 'manageable load'.

The studies confirmed that there is a time lag between the land and the lake, which means that current nitrogen leaching on the land and nitrogen loads entering the lake are not in equilibrium. As a result, it is necessary to do more than hold nitrogen discharges on the land at current levels in order to maintain current water quality. The amount of nitrogen 'still to come' before equilibrium is reached with current land use has been estimated at between 30% and 41% of the annual manageable load attributed to human-generation.

Studies concluded that there would need to be at least a 20 percent reduction in nitrogen to ensure lake water quality would eventually stabilise at 2001 levels. Therefore, a nitrogen reduction of 20% of the manageable load was considered a scientifically defensible target to maintain the current water quality of the lake. A higher target was not chosen because of the estimated cost/benefits of doing so, as assessed in the V5 RMA section 32 report.

The policy developed in order to achieve the freshwater objective (environmental outcome) for the lake is contained in the V5 chapter of the WRP. This includes 14 policies to help achieve the four stated objectives, including:

- *Policy 3: Cap nitrogen outputs from land in the catchment,*
- *Policy 4: Reduce nitrogen outputs from land use activities and wastewater, and*
- *Policy 5: Review of Nitrogen Reduction Target and its method of achievement.*

According to the explanation and principle reasons for adopting these policies provided in the WRP, policy 3 caps current nitrogen outputs from the land, and ensures nitrogen is capped on individual properties by setting an initial allowance or 'allocation' of nitrogen, based on recent historical (2001-2005) nitrogen leaching output.

Policy 4 requires a permanent 20% reduction of total annual manageable load of nitrogen leached from land use activities and wastewater by 2020. Policy 5 allows for this target to be reviewed in 2018 to see whether it is still considered appropriate.

Methods to achieve the objectives and policies include:

- Non-regulatory methods – such as monitoring of Lake Taupo water quality, and
- Regulatory – such as rules to manage existing and new nitrogen leaching activities either as permitted activities with standards, or as controlled activities that determine landowner nitrogen discharge allowances.

In terms of the cascade framework in Figure 4-1, the policies and rules contained in the WRP Taupo chapter are equivalent to the fourth and fifth boxes from the left. We note WRC has also used robust limit-setting processes for water quantity in developing their water allocation Variation 6 of the WRP.

Bay of Plenty Regional Council – Rotorua Te Arawa lakes

Lake Rotorua is another nationally valued lake, which welcomes over half a million international visitors each year. Excessive nutrient inputs from septic tanks, livestock and other farming practices have led to declining water quality in Lake Rotorua, Rotoiti and others. This degradation in water quality may affect the lake's use for tourism, and in addition the excess nutrients can lead to algal blooms that are a potential public health concern.

Bay of Plenty Regional Council (BoPRC) have worked with Rotorua District Council, the Crown and local iwi (establishing the Te Arawa Lakes Trust) to develop an approach to managing the lakes. This Rotorua Te Arawa Lakes Programme[123] has a goal to achieve water quality targets set with the community for each of the 12 lakes. These water quality targets have been included in regional plan tools, as highlighted below.

Developing objectives

BoPRC's Regional Water and Land Plan[124] (RWLP, operative since 2008) includes an objective for the management of the lakes, which uses Trophic Level Index (TLI) to set the intended environmental outcome numerically. Objective 11 reads:

Objective 11 The water quality in the Rotorua lakes is maintained or improved to meet the following Trophic Level Indices:

(a) Lake Okareka – 3.0

(b) Lake Okaro – 5.0

(c) Lake Okataina – 2.6

(d) Lake Rerewhakaaitu – 3.6

[123] http://www.rotorualakes.co.nz/
[124] http://www.boprc.govt.nz/knowledge-centre/plans/regional-water-and-land-plan/

(e) Lake Rotoehu – 3.9

(f) Lake Rotoiti – 3.5

(g) Rotokakahi – 3.1

(h) Lake Rotoma – 2.3

(i) Lake Rotomahana – 3.9

(j) Lake Rotorua – 4.2

(k) Lake Tarawera – 2.6

(l) Tikitapu – 2.7

Table 6 of the RWLP explains how these were decided, many being based on measured 1994 TLI levels. Objective 11 is numeric, and clearly states the intended environmental outcome for the lakes. In terms of the cascade framework in Figure 4-1, this objective fits into the second or third box from the left.

Deriving and setting limits

In order to achieve this, the RWLP includes policies to integrate the management of water and land, such as:

Policy 21 To manage land and water resources in the Bay of Plenty within an integrated catchment management framework to:

(a) Maintain or enhance water quality in individual lakes to meet their Trophic Level Index ('TLI') and Water Quality Classification.

(b) Require the management of nitrogen or phosphorus in individual Rotorua lake catchments.

(c) Reduce cyanobacterial algal blooms on the Rotorua Lakes by managing nutrient inputs in the lake catchment. …

And to manage discharges according to receiving environment, such as:

Policy 38 Discharges of contaminants to water are to comply with the following requirements – Table 10 Contaminant Discharge Requirements.

Table 10 includes comments for receiving environments, such as for lakes:

(i) Direct discharges of contaminants to lakes are discouraged, while allowing for minor discharges that are unlikely to have adverse effects on water quality.

(ii) There shall be no net increase of nitrogen or phosphorus in lake catchments. This does not preclude the use of nutrient trading within the same lake catchment to achieve this policy.

(iii) Where discharges are made directly to lakes, the discharge is to:

Meet the water quality classification of the lake after reasonable mixing.

Avoid, remedy or mitigate adverse effects on heritage values and existing users of the lake. This will include implementing appropriate treatment and mixing methods for the discharge.

Various methods are invoked to achieve the objective and are summarised in RWLP Table 7 (p54). This includes *Method 41 Develop and implement Action Plans to maintain or improve lake water quality to meet the TLI set in Objective 11*, with a four stage process for achieving this is detailed. Other non-regulatory methods such as education, riparian planting, and upgrading of sewage and reticulation systems are also supported. Part 9.4 of the RWLP includes rules that limit N and P discharges, for example Rule 11 and 11A-E which are specific to certain Lake catchments. In general the rules allow:

- Permitted - small scale, low nutrient activities; certain land-uses; where run-off is reticulated;
- Controlled – land use activities where N and P increases are offset within catchment; and
- Restricted discretionary – other activities not captured by the above.

Properties less than 0.4 hectares where the nitrogen export is greater than 10 kilograms per hectare per year are subject to Rules 11B, 11C, 11D and 11E. This applies to existing land use activities, and modification to existing land use activities that increase the nitrogen export level to greater than 10 kilograms per hectare per year. The rules require landowners to benchmark nutrient levels and not to alter these within +/- 10%, or provide acceptable mitigation to ensure this is the case[125]. Thus this rule does not improve water quality, but it ensures that no more nutrients can enter lake that may result in further degradation.

We understand BoPRC is developing a lake nutrient budget to provide a clear link from the stated TLI objective and the policies and methods described, even though this is not explicit in the currently operative version of the RWLP. In terms of the cascade framework in Figure 4-1, the policies and rules highlighted above are equivalent to the fourth and fifth boxes from the left. BoPRC are using both limits on nutrient exports per property and other management tools to achieve the stated TLI outcomes.

Environment Canterbury – Hurunui and Waiau catchments

The following summary is based on a more thorough description provided by Environment Canterbury (Environment Canterbury) on their website[126].

Under the Canterbury Water Management Strategy, ten water management zones have been created one of which is the Hurunui-Waiau Zone Committee. In July 2011, the Hurunui-Waiau Zone Committee released its Zone Implementation Programme (ZIP), which contained recommendations as to how water management issues in the Hurunui-Waiau Zone should be addressed. Some of these ZIP recommendations will be implemented by non-regulatory actions, but some require statutory (RMA) backing and so an RMA regional plan has been developed.

[125] http://www.rotorualakes.co.nz/vdb/document/136
[126] http://ecan.govt.nz/our-responsibilities/regional-plans/regional-plans-under-development/waiau/Pages/Default.aspx

The Hurunui and Waiau River Regional Plan (the H-W Plan) is a sub-regional plan, the purpose of which is to promote the sustainable management of rivers, streams and groundwater in the Hurunui, Waiau and Jed River Catchments. The Waiau catchment extends from the Main Divide in the vicinity of the Lewis Pass to the Pacific Ocean. The Hurunui Catchment is directly south of the Waiau Catchment and also extends from the alpine hinterland to the sea. The Plan outlines what is sought to be achieved (the objectives), and then states how the objectives will be achieved through policies and rules. The Plan works in combination with the operative Natural Resources Regional Plan (NRRP), but will instead fit under the umbrella of the Proposed Land and Water Regional Plan (LWRP) when that becomes operative. This Plan is the first of other RMA regional plans that will be developed to implement intended management actions of the other Canterbury Zone Committees.

Developing objectives

The H-W Plan includes objectives for both water quantity (including environmental flows and water allocation) and quality (the cumulative effects of land use on water quality).

Objective 2: Management of water levels and flows in the Hurunui, Waiau or Jed rivers and their tributaries does not result in adverse impacts on:

> *(a) the mauri of the waterbodies;*
>
> *(b) instream aquatic life;*
>
> *(c) upstream and downstream passage of native fish, salmon and trout;*
>
> *(d) the existing landscape and amenity values present;*
>
> *(e) breeding and feeding of riverbed nesting birds;*
>
> *(f) river mouth opening of the Hurunui River, and maintaining an open river mouth in the Waiau River, to provide for the migration of native fish and salmonid species and the collection of mahinga kai by tangata whenua;*
>
> *(g) the extent of periphyton and cyanobacterial growth and the impact on recreational activities; and,*
>
> *(h) recreationally important flows in the mainstem of the Hurunui and Waiau rivers for kayaking, jetboating, swimming and salmon and trout fishing.*

Objective 3 Water is allocated so as to enable further economic development, while:

> *(a) protecting the mauri of the waterbodies;*
>
> *(b) ensuring that water quality is not decreased;*
>
> *(c) ensuring flow variability is maintained and that flows of between 1.5 and 3 times the median flow required to flush periphyton and mobilise gravel and reset the bed of the mainstem of the Hurunui and Waiau rivers are not adversely effected;*
>
> *(d) ensuring that the water temperature is not unnaturally increased to levels which affect salmonid species;*

(e) protecting the ability of native fish, salmon and trout to traverse the river from the marine environment to upstream habitats;

(f) protecting the reliability of supply for existing abstractors; and,

(g) maintaining the ability to navigate the river by Jet Boat.

Objectives 2 and 3 can be said to be narrative, and give broad environmental outcomes for the rivers as a result of setting environmental flows and allocation limits. In terms of the cascade framework in Figure 4-1, these objectives fit into the first box from the left.

The H-W Plan includes 2 objectives relating to cumulative effects of landuse on water quality.

Objective 5.1 Concentrations of nutrients entering the mainstems of the Hurunui, Waiau and Jed rivers are managed to:

(a) maintain and enhance the mauri of the waterbodies;

(b) protect naturally occurring biota including riverbed nesting birds, native fish, trout, and their associated feed supplies and habitat;

(c) control periphyton growth that would adversely affect recreational, cultural and amenity values;

(d) ensure aquatic species are protected from chronic nitrate toxicity effects; and,

(e) ensure concentrations of nitrogen do not result in water being unsuitable for human consumption.

Objective 5.2 Concentrations of nutrient entering tributaries to the Hurunui, Waiau and Jed rivers are managed to meet agreed community outcomes while ensuring they do not give rise to:

(a) chronic nitrate toxicity effects on aquatic species; and,

(b) water being unsuitable for human consumption.

Objectives 5.1 and 5.2 can be said to be narrative, and give broad environmental outcomes for the rivers as a result of managing nutrients. In terms of the cascade framework in Figure 4-1, this objective fits into the first box from the left.

Deriving and setting limits

Objective 2 for environmental flows is immediately linked to eleven policies, the first two of which set minimum flows by reference to Table 1 (see H-W Plan, accessed from the link in footnote 126) which specifies monthly minimum flows for a number of tributaries along the rivers:

> *Policy 2.1 No resource consent to take, dam or use water should be granted if the proposed activity will cause the minimum flows specified in the Environmental Flow and Allocation Regime in Table 1 to be breached; unless the take is for a community or stock drinking water supply and there is a Water Supply Asset Management Strategy in place.*

The policies also set defaults for the catchments where specific minimum flows haven't been set by H-W Plan Table 1:

> *Policy 2.2 Where a minimum flow has not been set for a tributary in the Environmental Flow and Allocation Regime in Table 1, then either:*
>
> *(a) a residual flow shall be set for that tributary at 90% of 7dMALF if there is not a robust relationship between the flow record in the mainstem of the Hurunui or Waiau rivers; or;*
>
> *(b) if there is a robust relationship between the tributary and a minimum flow site listed in Table 1 then the take will be required to comply with the Environmental Flow and Allocation Regime minimum flow in Table 1.*

Objective 3 for allocation of water is linked to six policies which address issues of over-allocation and setting 'blocks' (A, B, C) of water of varying reliability. For example:

Policy 3.1 To reduce the size of the catchment wide A Allocation Block in the Waiau River Catchment to 18 cumecs; and to reduce the size of the catchment wide A Allocation Block in the Hurunui River Catchment at 11 cumecs.

Rules relating to water quantity include a mixture of permitted, restricted discretionary, discretionary, non-complying and prohibited activities for both surface water and groundwater. These include for example:

Rule 2.3 The taking, diverting, discharge and use of surface water in accordance with the Environmental Flow and Allocation Regime in Table 1, with the exception of the use of the C Allocation Block for the Waiau and Hurunui Rivers, is a restricted discretionary activity, …

The H-W Plan does not contain 'other' methods for implementing the objectives and policies, which are instead included in the Hurunui-Waiau ZIP.

In terms of the cascade framework in Figure 4-1, the water quantity policies and rules contained in the H-W Plan, including the reference to H-W Plan Table 1 Environmental Flow and Allocation Regime, are equivalent to the fourth and fifth boxes from the left.

There are four policies related to the nutrient management objectives:

Policy 5.1 To take a tributary and community based approach to managing water quality and improving nutrient management practices.

Policy 5.2 To ensure all existing and new land use activities in the Nutrient Management Area shown on Map 4, have best nutrient management practices in place by 2017.

Policy 5.3 To protect existing values, uses and the mauri of the Hurunui River and its tributaries while also providing for future development in the catchment by ensuring the annual nutrient loads (as set out in Schedule 1) at the:

> *(a) Mandamus flow recorder, for both Dissolved Inorganic Nitrogen and Dissolved Reactive Phosphorous, are maintained at 2005 – 2010 levels.*
>
> *(b) State Highway 1 flow recorder:*

(i) dissolved Reactive Phosphorous, is maintained at 2005 – 2010 levels;

(ii) dissolved Inorganic Nitrogen prior to 2017, does not increase more than 20% above 2005 – 2010 levels; and

(iii) dissolved Inorganic Nitrogen post 2017, is improved to 2005 – 2010 levels or better.

Policy 5.4 To progressively set nutrient limits in tributaries of the Hurunui River, at the river mouth and in the Waiau River Catchment to ensure that Objective 5.1 and 5.2 are met.

Rules for nutrient management are included in the H-W Plan but with a proviso that the four rules 10.1, 10.2, 11.1 and 11.2 do not come into effect until 1 January 2017. The H-W Plan includes the rules in order to provide a transitional lead in period, so that land managers in the area can modify their farming practices outside of a regulatory framework. The rules act by identifying Nutrient Management Areas which are mapped, and permitted and discretionary rules are given with certain conditions to be met. For example:

Rule 10.2 After 2017, any change in land use, resulting in an increase to a discharge of nitrogen or phosphorous which may enter water, in the Nutrient Management Area shown on Map 4, is a permitted activity, provided the following conditions are complied with:

(a) the annual nitrogen and phosphate load at the downstream water quality monitoring site is less than the limit specified for that site in Schedule 1; and,

(b) on or before 1 January 2017, one of the following is being implemented by the landowner or occupier:

(i) an Industry Certification System; or

(ii) a Catchment Agreement; or

(iii) an Irrigation Scheme Management Plan; or

(iv) a Lifestyle Block Management Plan.

In terms of the cascade framework in Figure 4-1, the water quality policies and rules contained in the H-W Plan, including the reference to the Schedule 1, are equivalent to the fourth and fifth boxes from the left.

Environment Canterbury's *Preferred Approach*

It is noted that the approach used by Environment Canterbury for nutrient management was developed using a case study of the Hurunui catchment as part of the Land Use and Water Quality project[127]. The relevant technical reports provide a thorough background to the development of this nutrient management approach, and the cascade diagram used here (Figure 4-1) was developed by Environment Canterbury and is used by them in their 2012 report called *The preferred approach for managing the cumulative effects of land use on water quality in the Canterbury region: A working paper*. This report describes how Environment Canterbury intend to set limits to manage nutrients (N and P) and identifies 7 steps in the limit-setting process:

[127] http://ecan.govt.nz/get-involved/water-projects/land-use-and-water-quality/Pages/Default.aspx

1. Confirming priority outcomes
2. Establishing 'nodes' where limits are set
3. Developing scenarios
4. Undertaking environmental, social, economic, and cultural analysis
5. Conducting on farm analysis
6. Discussion and decision making, and
7. Translating freshwater objectives into load limits.

The report explicitly states an intention to set integrated water quality and quantity limits. The report also includes discussion on how to manage within limits, once these are set (Figure 4-2).

Environment Canterbury's *Preferred Approach* includes the use of Nutrient Discharge Allowances or NDAs (in kg/ha/yr). NDAs are one way of allocating the total catchment load and making it clear what each individual landowner's responsibility is (i.e. NDAs define the amount of resource use that is possible at the farm scale). They do this in the same way that TMDLs are used in the USA.

Other councils

Similar measurable/numeric objective or limit-setting approaches have been taken by Horizons Regional Council for all catchments in the POP[128] and technical reports outlining the derivation of nutrient limits (e.g. Roygard and McArthur 2008) are available on the Horizons website[129]. Horizons were one of the councils visited in this study, and their POP approach is evaluated below. The West Coast Regional Council also set limits in their Regional Land and Water Plan with regards to Lake Brunner[130].

4.4 Evaluation of limit-setting processes

As described in Section 3.1, visits to five councils were undertaken by the project team, and questions asked (Appendix B) which included the topics of accounting systems and limit setting. Based on the questions asked regarding limit setting for both water quantity and water quality, an evaluation of these councils' limit-setting processes has been conducted. As described in section 3.1, some criteria for this evaluation were developed by the project team and the Water Directorate, and tested during the pilot visit to Waikato. The final criteria used here are shown in Table 4-5.

The evaluation of the limit-setting processes for the five councils visited follows.

[128] http://www.horizons.govt.nz/about-us/one-plan
[129] http://www.horizons.govt.nz/about-us/publications/about-us-publications/one-plan-publications-and-reports/technical-reports/
[130] http://www.wcrc.govt.nz/plans/rma_plans/land_water.htm

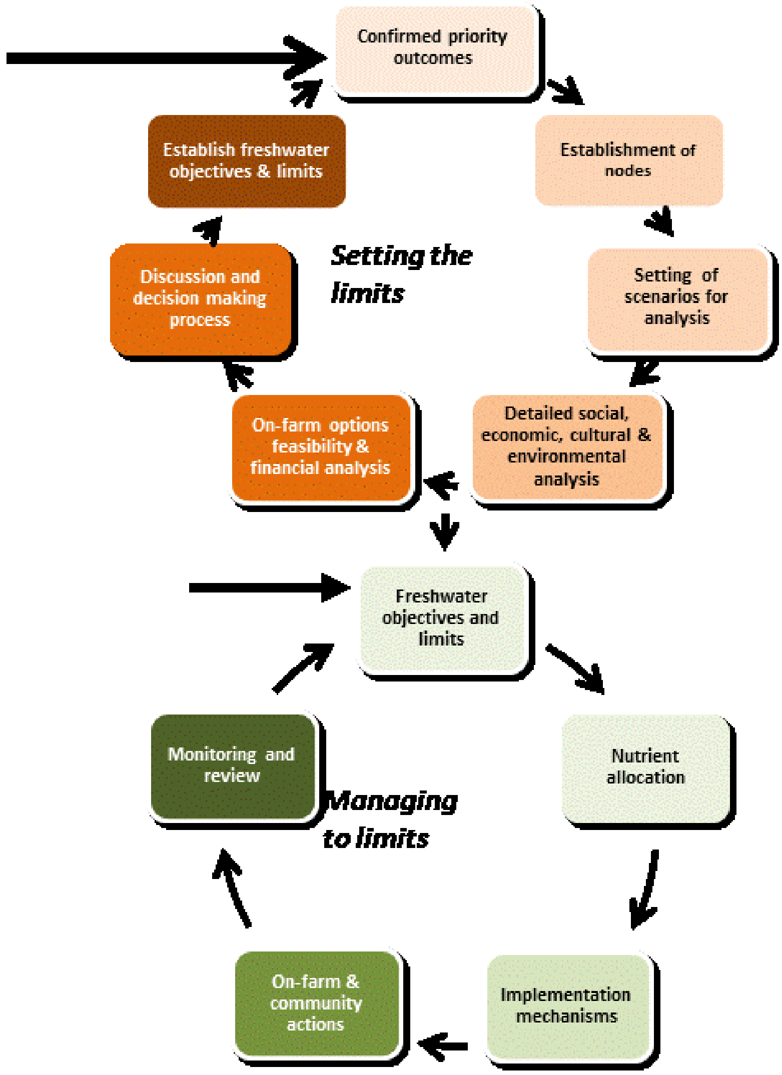


Figure 4-2: Environment Canterbury's *Preferred Approach* to setting and managing within limits.

Table 4-5: Criteria for evaluating limit-setting processes.

Criteria	includes
Technically robust	Is it measurable? (could you tell if it was breached/ can it be managed) Is the science behind it defensible? (Can you see the cascade from objective to a manageable limit? Does it include different parameters/attributes i.e. for the example of managing periphyton does it include limits for quantity and nutrients)
Practical	Is it feasible for the council to implement it – costs and resources required, info availability, and so on?
Transparent	Can users and council staff follow the logic of how limits were derived?
Adaptable	Is the process transferable between catchments and/or could other regions use it?

4.4.1 Waikato Regional Council

Water quantity

Description of water quantity limit-setting systems and processes

The WRC water quantity limit-setting systems and processes include:

1. When WRC assessed the quantity of their surface water resources, long term flow monitoring recorder sites and specific flow measurements at non-recorder sites were used.

   WRC have an understanding of the size of their groundwater resource. Assessing the state of the groundwater resource will continue more thoroughly with investigations and modelling when any aquifer's allocation management level is approached.

2. A simplified summary of objectives from the Waikato Regional Plan (WRP) for managing water bodies are:

   - that people are able to take and use water for their social, economic and cultural wellbeing,
   - the avoidance of significant adverse effects on aquatic ecosystems,
   - the range of uses of water reliant on the characteristics of flow regimes are maintained or enhanced,
   - the range of reasonably foreseeable uses of groundwater and surface water are protected

3. Surface water management units employed by WRC range from major rivers down to the individual tributaries. All the key groundwater aquifers have allocations set in the plan.

4. Minimum flows on surface water streams are set to a flow statistic ranging between 70% and 100% of the 1 in 5 year 7 day low flow (Q5); the exact value is determined based on the sensitivity of the catchment as assessed with local investigations. This minimum flow is common for both the primary allocation (A Block) and secondary allocation (B Block).

5. The allocation limit is a flow statistic and is no greater than 30% of the Q5, of which for example, the A Block may be 20 % and B Block 10% of Q5. These may vary depending upon the current allocation and catchment sensitivity. The amount for the A block is determined as the difference between minimum flow percentage and 100% of Q5, e.g. minimum flow is 80% of Q5 therefore A block allocation is 20% of Q5.

6. High flow harvesting is allowed.

7. Rainfall recharge estimates are used to determine allocable limits for aquifers. In high use aquifers groundwater levels are monitored to assess the impact of abstraction. As the individual aquifer allocation limits are approached a thorough resource assessment will be made and regulatory minimum levels and total allocation volumes set to manage the groundwater resources.

Evaluation of water quantity limit-setting systems and processes

It is considered that because the total allocation is so small e.g., 30 % of the 1 in 5 year 7 day low flow, that all the management objectives for surface water quantity related to environmental impacts are likely to be achieved.

There are only minor reductions to flows which are unlikely to affect the flow regime and hence achieves the first two bullet points under point 2 above.

The high reliability of supply over the whole region no matter where the abstraction is located make abstraction fair and equitable to all water users in the region, achieving objectives described in the third and fourth bullet points above. However, in the future, water requirements may increase and the small allocation may be contested by water users – some new users may be happy with a lower supply reliability.

Table 4-6: Evaluation of WRC water quantity limit-setting processes.

Criterion	Evaluation	Comments
Technically robust	Yes	Strengths Surface water management units are catchments. WRC has investigated on what aspects of regional specific issues are important in setting limits. Instream Flow Incremental Methodology (IFIM) studies on fish habitats were carried out and the results were assessed with flow statistics and water quality data. In addition other relevant aspects such as recreational water demand and cultural values also considered. With these findings, WRC has identified that water allocation limits for surface water are primarily driven by water quality. It was found that ranging minimum flows between 70% and 100% of the 1 in 5 year 7 day low flow (Q_5) provide sustainable limits to adequately meet all the values of the water body. The exact % of Q_5 to be used is determined based on the sensitivity of the catchment as assessed with local investigations. The allocation limit = 100% of Q_5 – minimum flow; thus use of up to 100% of Q_5 as the maximum allocation is a robust method to protect instream values, however, this approach may be conservative. Permitted activity water uses (Includes s14 3b water) have been calculated/estimated using a calibrated model. The model was calibrated using AgriBase data for stock numbers, community water supply data, population data and scheme water meters. By 2015 all dairy shed takes will be consented (but not stockwater takes). The flow data used in setting limits are the measured stream flows naturalised using water meter data and water use estimates from the permitted activity (water use) model. Therefore, the flow statistics used are very accurate. WRP (V6) allows high flow harvesting that is clearly defined. As the system uses a relatively simple flow statistics (Q_5) for limits, it is easily measureable with appropriate recorders and identify where it is breached. Groundwater consent applicants must complete a pump test and demonstrate that interference of the proposed activity on neighbouring groundwater takes is minor. This protects the existing water users. WRC is in the process of developing groundwater models for high use catchments; that would enable refining current limits. Potential weaknesses Although some science investigations were carried out to determine the allocation limits, which are primarily driven by water quality issues, limits are mostly set using the default/rule of thumb statistic Q_5 (i.e. 70% and 100% of Q_5,

Criterion	Evaluation	Comments
		based on the sensitivity of the catchment). Using hydrological statistics (defaults or rules of thumb) to set limits has advantages and disadvantages. On one hand they are relatively cheap and easy to set and monitor, but they do not account for spatial variability (which is an issue if they are used for a whole region) and so could result in varying outcomes for the environment and for resource availability. The minimum flow set for a catchment is common for both the primary allocation (A Block) and secondary allocation (B Block). This is difficult to manage and can result in misunderstandings/confusions and reduction in supply reliability for A Block water users. WRC do not use the current groundwater limits for regulatory purposes. The limits are set for management purposes only.
Practical	Yes	<u>Strengths</u> The current limits on both surface water and groundwater use are very simple and easy to follow. Therefore, they are easy to implement and use by stakeholders and WRC consent officers. Determining limits using flow statistics is highly cost effective. High flow harvesting rules are clear and allow very practical solution to store water during high flows for use during low flows. <u>Potential weaknesses</u> The sustainability of groundwater is managed using water level monitoring. However, aquifer systems are currently not well understood. Therefore, current monitoring may be inadequate to sufficiently determine the status of the resource. In addition groundwater level variation, not like surface water, can happen over a reasonable period due to hydraulic connection between aquifers and other water bodies. Therefore, insufficient understanding can lead to over-allocation. As current surface water limits are set based on % of Q_5 and most of the resources in some catchments are at or near full allocation, some water users may legally challenge the validity of the limits or adequateness of science used to define the limits. Such challenges can be expensive for both the council and water users.
Transparent	Yes	<u>Strengths</u> The methods used, and how and what limits have been set are very transparent. All the procedures and results are available through council reports and website. The water users and consent staff can easily identify resource availability.
Adaptable	Yes	<u>Strengths</u> Both current surface water and groundwater limits have been set using simple methods that can be transferrable to other catchments or regions with relative ease. <u>Potential weaknesses</u> Default methods have advantages and disadvantages, and for instance this approach may not be suitable for highly valued catchments or those where a high degree of hydrological alteration is proposed, unless this is supported with other scientific studies.

Water quality

Description of water quality limit-setting systems and processes

WRC's approach to limit setting for Lake Taupo has already been discussed as a case-study in section 4.3.2. We have evaluated Variation 5 (V5) here, and we note that V5 was promulgated prior to the introduction of the NPSFM and the Reforms 2013, but the process WRC went through was largely compatible with these policy documents.

The WRC limit-setting systems and processes include:

1. Assessing current state of the lake using field investigations, trend analysis, and modelling
2. Set objective and timeframe for achieving
3. Work out what overall catchment loads should be
4. Model contributions from different land uses, make policies in terms of permitted activities.
5. Set N caps on controlled activities, consenting and N trading mechanisms instituted.

Evaluation of water quality limit-setting systems and processes

Table 4-7: Evaluation of WRC water quality limit-setting processes.

Criteria	Evaluation	Comments
Technically robust	Yes	Strengths The same steps were taken for Taupo as would be used under NPSFM (i.e. objective – maintain lake in 2000 condition, numeric objective – reduce present N loads 20% to take into account lag effects, in-water concentration limits set for lake in terms of TN, TP, Chlorophyll *a*, secchi depth). Catchment load limit set from combined monitoring /modelling and targets, restrictions to individual resource use set in terms of N caps (planning) + trading. Because of the national interest in this issue, robust science was sought and thorough peer reviews undertaken. Potential weaknesses The limits set have been based on best scientific information and analysis but there are still uncertainties principally based around the issues of attenuation and lags of nutrients through the groundwater systems. As a result the reductions in nutrients that have been used (20%) may not be sufficient in the long-term (however there is the ability to review this). The versions of models and the values that they predict may be an issue. This leads to the 'locking-in' of consented N allowances to those predicted using OVERSEER 5.4.3. The newest version of OVERSEER (6.0) predicts much greater leaching losses for some intensive landuses. Whilst the 'actual' amount of N leached doesn't change, the new model version represents a better understanding of the scientific processes involved. Whilst it is possible to redo the nutrient budgets done previously in OVERSEER versions 5.4.3 to 6.0 there may be legal difficulties in doing so, and difficulties in acceptance. Under the nutrient trading scheme, it appears that the worst leachers could gain competitive advantage by changing to new version.

Criteria	Evaluation	Comments
Practical	Yes	Strengths Setting objectives and linking them to resource use limits will enable them to achieve the environmental outcomes for Taupo that are expected by the community. The 20% reduction target was the practical (best cost-benefit) option. The process was appropriate for Taupo given its national status. Potential weaknesses This process was very long, involved, and expensive. Central Government has partnered with WRC to help achieve restoration goals for the lake. This type of process could not be rolled out for each catchment. WRC doubt that the same process would be attempted again, due to economic and political changes.
Transparent	Yes	Strengths All the data, calculations, predictions, that went into V5 were subject to intense peer review. All resulting rules in WRP V5 are very clearly stated. All the technical documents were available via the WRC site and so the process itself was transparent. Issues and options were explored with stakeholders before policy options were developed. Potential weaknesses Users may need to dig into technical reports if they want to understand the links between objectives and load limits, which may prevent some non-technical people for completely understanding the desired approach.
Adaptable	Yes	Strengths V5 allows for review to amend the limits (target N reduction). However it is not clear whether this requires a formal process to do so (e.g. plan change). It was noted that that monitoring indicates that the current load reduction target (20%) may have been conservative and that limits my need to be revised, but the process for doing so was not discussed. Potential weaknesses The issue of which version of OVERSEER to use in any revision also indicates the lack of adaptability to new scientific advances in reassessing the limits. This makes the agility of the planning process in order to adapt even more important.

4.4.2 Horizons Regional Council

Water quantity

Description of water quantity limit-setting systems and processes

The Horizons limit-setting system and processes include:

- The limits have been determined under the water management framework that is underpinned by the use of Water Management Zones (WMZ) and sub-zones (WMSZ) for surface water, and corresponding but larger Groundwater Management Zones (GWMZ).
- Individual limits are set for each WMSZ and WMZ, and cumulative core allocation limits are set for surface water catchments.

- The POP specifies core allocation limits for rivers/streams and GWMZ, and minimum flows for rivers/streams.
- Permitted activity water uses have been estimated within a set of specific conditions (includes s14 3b water) for both surface and groundwater takes.

Surface water

- The surface water in the region is managed with 45 WMZs and 145 WMSZs.
- The hydrological characteristic variation between WMZ is high. Therefore, different studies have been conducted to determine limits.
- Internal and external experts in diverse disciplines have contributed to these studies.
- Instream Flow Incremental Methodology (IFIM) studies on fish habitats showed that there are similar characteristics for a number of streams and allowed derivation of a model that illustrated a link between physical habitat and hydrological statistics, which could then be used in other catchments.
- Based on similarities and variations, the limits have been set using a decision tree (i.e. flow chart).
- Minimum flows for streams were set based on IFIM results and 1-day mean annual low flows (MALF).
- MALF has been calculated by creating naturalised flows with recorded flows corrected using water use data for consented takes and surveys for permitted activity use. However, in some cases logical assumptions have been made to estimate the water use, where use data is unavailable.
- The minimum flows have been set based on the following three categories:
  - Minimum flow = 0.95 x MALF, where MALF $< 0.46\ m^3/s$
  - Minimum flow = 0.85 x MALF, where $0.46 \leq$ MALF $\leq 3.7\ m^3/s$
  - Minimum flow = 0.80 x MALF, where MALF $> 3.7\ m^3/s$
- Where studies have not been completed, a default minimum flow limit of MALF is used with an allocation limit of 10% MALF.
- B permit minimum flows are set at the median flow.
- The limit setting has also taken other matters into considerations such as water quality issues (e.g. using periphyton monitoring), values for other water uses (e.g. recreational), cultural values (e.g. Māori) and landscape.
- The volumes that can be allocated above the minimum flows are determined based on flow statistics (with 1-day MALF), water supply reliability and flat lining the river (i.e. state of the flow after the take).

- Consents are usually structured to contain a maximum instantaneous rate (m^3/s) and maximum daily volume (m^3/d).

Groundwater

- GWMZ generally comprise of many WMZ.
- GWMZ boundaries may not align with aquifer boundaries.
- Groundwater limits are not well understood compared to surface water.
- Sustainable yield of an aquifer is estimated as a % of average annual rainfall following protocols developed by Pattle Delamore Partners (PDP).
- Water level monitoring is used to assess the sustainability of current level of allocation.
- Groundwater-surface water interaction is managed using riparian buffer bands from the surface water bodies. The stream depletion effects are progressively reduced with the distance away from the stream.
- Horizons are in the process of developing a detailed 10 year groundwater study program to enhance the understanding of the resource. This includes sponsoring a Ph.D. with Massey University. It is likely that groundwater models will be developed for many aquifer systems to assess current limits.
- Groundwater limits are primarily based on daily (m^3/d) and annual limits (m^3/yr).

Evaluation of water quantity limit-setting systems and processes

Table 4-8: Evaluation of Horizons' water quantity limit-setting processes.

Criterion	Evaluation	Comments
Technically robust	Yes	<u>Strengths</u> The surface water limits have been set based on robust methods (e.g. IFIM) and using industry experts. As characteristics of streams and level of information available vary between WMZ, detailed separate studies have been conducted. Thus, they are scientifically defensible. The limits have set using in-stream habitat studies along with hydrological statistics (1-day MALF) and other relevant factors such as water quality issues (e.g. using periphyton monitoring), values for other water uses (e.g. recreational), cultural values (e.g. Māori) and landscape. Minimum flows are determined using a range of methods depending on the level of information available. Measured stream flows have been naturalised using water meter data, stock water use calculated by taking stock number estimates and estimates for other permitted activity water uses. A very detailed decision support flow diagram is used to determine the limits based stream flow characteristics. <u>Potential weaknesses</u> Horizons use a default minimum flow limit of MALF and allocation limit of 10% MALF for the streams where detailed studies have not been completed. Using hydrological statistics to set limits has advantages and disadvantages. On one

Criterion	Evaluation	Comments
		hand they are relatively cheap and easy to set and monitor, but they do not account for spatial variability and so could result in varying outcomes for the environment and for resource availability. However Horizons only use defaults in 31 of 124 WSMZs. Groundwater allocation limits are currently set based on a % of rainfall recharge. Although protocols are used, such simple statistical limits could adversely affect the sustainability of those confined aquifers that are primarily recharged through other sources than direct rainfall. As aquifer boundaries and their individual resource availability are not well-defined, that could lead to spatially variable effects on groundwater resource availability and sustainability.
Practical	Yes	Strengths Although the surface water limits are set using detailed studies, they have been grouped into three classes based on flows. Therefore, it is a practical and simple method that can be easily used by end users such as consent officers. Determining limits using three classes is cost effective. Current groundwater limits also follow an easy to use protocols, thus they are practical. When limits are improved and reset at a later date, having a common catchment expiry date will assist with their adoption and achievement of water management objectives. Potential weaknesses The sustainability of groundwater is managed using water level monitoring (138 manual and 19 automated sites). There is potential that lags in groundwater response may mean that the resource is adversely affected before indicators show signs or resource pressure. However Horizons' 2013 SoE report suggests that the resource is being managed sustainably.
Transparent	Yes	Strengths The methods used, and how and what limits have been set are very transparent. All the procedures and results are available through council reports and the Horizons' website. The water users and consent staff can easily identify resource availability. Potential weaknesses Some technical details used in setting limits may be difficult to understand for some non-technical people.
Adaptable	Yes	Strengths The surface water limits have been set using scientific regionally specific studies. Current groundwater limits (% rainfall recharge) could be applied anywhere nationally, but such defaults may not account for spatial variability (which is an issue if they are used for a whole region) and so could result in varying outcomes for the environment and for resource availability. Potential weaknesses The specific methods developed in setting surface water limits (i.e. relationships between MALF and IFIM studies) may not be transferable to other regions due to different characteristics of the system such as type of recharge area (head waters), flow patterns, geology and climate.

Water quality

Description of water quality limit-setting systems and processes

Horizons' limit-setting systems and processes are centred around the POP, which predates the NPSFM. The POP (and associated systems) contains narrative objectives, numeric objectives both in terms in biotic metrics such as periphyton cover and MCI, and in-river concentrations (comprehensive, not just nitrogen and phosphorus) specified in terms of a comprehensive classification system (water management zones and subzones). In-river numeric objectives are well-supported scientifically through a regional periphyton model, and comprehensive SoE monitoring.

The POP is not explicit about the link between water quality standards and the setting of limits at a catchment level. The rule in the POP controlling non-point source nutrient loads is centred around farms as the most effective way to reduce the overall catchment N load. All the information, models, and systems are in place that enable Horizons to set catchment nutrient load limits.

The Horizons water quality limit-setting processes include:

1. Classifying streams, rivers and lakes according to their dominant characteristic (Water Management Zone) and identifying priority catchments.
2. Assessing the current state of the environment within each water management zone (WMZ) from water quality and biological response metrics (periphyton cover, chlorophyll *a*, MCI), point source information and intensity of land use.
3. From the above setting numeric objectives within each WMZ for chemical and biotic metrics
4. Rules in POP determine those farms that are controlled activities and those that are restricted discretionary based on whether N leaching meets on-farm allocations or not. Both types of consent require nutrient budgets
5. Comprehensive SoE monitoring allows flow binning, and calculation of catchment loads at any 10%-ile increments. Top 20% of flows omitted because of less relevance to biotic response.
6. Estimate maximum annual load of contaminants from a catchment (or subcatchment) by using flow x concentration target. Point sources are included by subtracting from calculated totals to yield the non-point component. This is checked by dividing maximum load by attenuation factor (standard of 0.5 used) to estimate loss from land.
7. Regional periphyton model and other models used to support numeric objective decisions and scenario testing.
8. Non-regulatory methods used for non-point source control for contaminants other than nutrients (e.g. sediment, *E.coli*).

Evaluation of water quality limit-setting systems and processes

Table 4-9: Evaluation of Horizons' water quality limit-setting processes.

Criterion	Evaluation	Comments
Technically robust	Yes	<u>Strengths</u> The POP follows the 'cascade' diagram given in Figure 4-1. A comprehensive WMZ classification is in place and numeric objectives are assigned for biotic and chemical metrics. This is supported by SoE monitoring, suitable modelling tools, and calculators. <u>Potential weaknesses</u> The lack of knowledge on groundwater pathways and lag times is a potential weakness. This weakness is being addressed in part through water aging during drought conditions. The scientific uncertainty behind determination of actual and potential stream concentrations can be managed by assuming that present nutrient loads leaving the root zone, will eventually be reflected in in-stream concentrations (potentially using an attenuation factor). Whilst the timing (lag-time) is uncertain it can be modelled within known extremes and a sensitivity analysis performed (to aid decision making). There is some difficulty and uncertainty associated with which version of OVERSEER was used to calculate farm losses (the actual losses haven't changed but estimates have, which affect the subsequent calculations and perceptions).
Practical	Yes	<u>Strengths</u> The scientific methods and systems used in the POP have been extensively tested through the Environment Court. The systems required for limit setting under the NPSFM are largely in place and have been tested. <u>Potential weaknesses</u> A review of the POP against NPSFM requirements identified some issues to be addressed. The council may have resourcing issues to deal with a full implementation of catchment load limits, allocation of load, and compliance issues.
Transparent	Yes	<u>Strengths</u> All technical reports supporting the POP are available on Horizons' website. The transparency of decisions made has been tested through the Environment Court process.
Adaptable	Yes	<u>Strengths</u> The approach is adaptable to different catchments/subcatchments. While the issues may vary between catchments, the processes set up, modelling approaches and data requirements are all similar. The processes and systems supporting the POP have the potential to be transferred to other regions (outside of Horizons), where farming (diffuse sources) and nutrient loads in particular are the dominant contaminants affecting water quality and meeting freshwater objectives.

4.4.3 Tasman District Council

Water quantity

Description of water quantity limit-setting systems and processes

The Tasman Regional Policy Statement (TRPS) has a number of high level water quality objectives:

- General Objective 1 - maintenance and enhancement of the quality of the Tasman District environment
- General Objective 2 – maintenance of the biological diversity and healthy functioning of land, freshwater, coastal and marine ecosystems
- General Objective 3 – avoidance, remedying or mitigation of the adverse effects on the environment and the community from the use, development or protection of resources
- General Objective 4- efficient use and development of resources.

TDC's plan for freshwater management is the Tasman Resource Management Plan (TRMP). The water quantity management framework is primarily developed based around separate water management zones (WMZ) that represent catchments. As variations in water resources from east to west in the district is large (for example differing rainfall and geology), allocation is driven by catchment hydrology. Most of the WMZ are managed as surface water-groundwater integrated systems as the hydraulic connections between them are high.

The TDC limit-setting system and processes include:

- TDC manage its water resources by dividing the district into Water Management Zones (WMZ).
- Surface water and groundwater in WMZ (primarily that are with high water demand) are considered as hydraulically connected.
- The instantaneous rate (l/s) limits are defined for each WMZ.
- The limits are managed with a combination of surface flow records and groundwater level monitoring.
- Permitted activity water uses have been estimated within a set of specific conditions (includes s14 3b water) for each WMZ.
- The hydrological characteristic variation between WMZ is high. Therefore, different studies have been conducted to determine limits.
- The limits for both surface water and groundwater in high use WMZ are determined using a combination of methods, that can include:
  - Integrated surface water-groundwater modelling
  - Habitat models (there are six models for different WMZ)
  - Flow statistics

- Expert judgements
- Stakeholder input.

- In unstressed catchments default allocations are based on 1:5 year low flow (i.e., 7-day MALF) flow, and value either 10% or 33% of MALF depending on significance of specified uses and values (Schedule 30A of TRMP).
- Surface water measured records (i.e. long term flow data and field monitoring, concurrent gaugings) are naturalised using:
  - Actual water usage records (70% takes are metered)
  - Permitted activity water use using surveys or estimates
  - Groundwater level surveys for the catchments where surface water and groundwater interaction is significant.
- The above methods are used to define minimum flow level for surface water and sustainable yield for aquifers. However, in many WMZ these are considered as a single resource as they are hydraulically connected.
- Once minimum flows are determined for each surface water body, the maximum allocable rate, often a total integrated (surface and groundwater) volume limit in high use areas, is set.
- There are also provisions to address localised transfers.
- The total allocation level is set so that all the water users would have average annual supply reliability of approximately 90%.
- Allocation limits also take into account that the TRMP aims for no more than a 35% reduction in allocated water during a ten year drought. The limit varies depending on knowledge of the water resource, community aspirations, and level of demand.
- Where Water Conservation Orders are in place narrative objectives are used
- Where detailed modelling work has not been completed, rainfall recharge estimates are used to define aquifer recharge (generally 20% of average annual rainfall).
- There is no B-allocation block allocation, primarily due to lack of demand as the reliability of supply will be low.

Evaluation of water quantity limit-setting systems and processes

Table 4-10: Evaluation of TDC's water quantity limit-setting processes.

Criterion	Evaluation	Comments
Technically robust	Yes	Strengths The water quantity allocation framework is driven by catchment hydrology. Variations in hydrology, geology, climate and land use are high within the district

Criterion	Evaluation	Comments
		(e.g. differing rainfall from east to west). Therefore, TDC has identified that one method of limit setting would not suit for all catchments, and WMZ specific studies have been carried out. TDC has commissioned experts to assist them with WMZ studies. Thus, outcomes of these studies are scientifically defensible. The limits have been set using in-stream habitat studies, integrated groundwater modelling along with hydrological statistics (1-day MALF) and other relevant factors such as water quality issues, cultural values (e.g. Māori), values for other water uses (e.g. recreational) and landscape. Measured stream flows have been naturalised using water meter data, stock water use by taking stock number estimates and estimates for other permitted activity water uses. The above parameters help TDC to determine the minimum flows and aquifer sustainable yields. The limits for high water demand WMZs generally represent the total limit for both surface water and groundwater as they are hydraulically connected. The TRMP outlines all limits. Potential weaknesses TDC's use of large WMZ may hinder the limits of individual aquifers. Although cumulative limits for the WMZ are accurate/reasonable, allocations from some aquifers can be high, if the aquifer boundaries are not well defined and individual limits are set. However TDC has sound hydrogeolgical reasons for WMZs, which account for sub-zone variances at the aquifer level. For example for the Buller, the size reflects the links to the river and the fact that a significant proportion is within conservation estate. Default allocation limits of 10% or 30% of MALF have been set for the streams where detailed studies have not been completed. Using hydrological statistics (defaults or rules of thumb) to set limits has advantages and disadvantages. On one hand they are relatively cheap and easy to set and monitor, but they do not account for spatial variability (which is an issue if they are used for a whole region) and so could result in varying outcomes for the environment and for resource availability. However, the TRMP states that these will be replaced with site specific studies and limits if water demand warrants this.
Practical	Yes	Strengths TDC has used "horses-for-courses" approach in setting limits based on individual hydrological, geological, climate and other values of the catchment. The limits have been clearly stated and can be easily used by end users such as consent officers. WMZ's have common expiry dates, therefore any future plan limit revision, can be applied as a blanket change when consents expire The reliability of supply values of average annual supply reliability of approximately 90% and no more than 35% reduction during a 10 year drought, provides water users a known reliability of supply to develop their business. Potential weaknesses Use of large scale WMZ can potentially be impractical for sustainable groundwater use. Although groundwater levels are monitored, WMZ wide allocation can cause over allocation for some aquifers, if these individual aquifers are not well defined and understood.
Transparent	Yes	Strengths TDC has been very transparent on all the aspect of managing water allocation framework. The methods used, and how and what limits have been set are clearly published through council reports and website.

Criterion	Evaluation	Comments
		The water users and consent staff can easily identify resource availability. Potential weaknesses As TDC primarily use a combination of surface water and groundwater integrated methods, some technical details used in setting limits may be difficult to understand for some non-technical people.
Adaptable	Yes	Strengths While the findings of the WMZ specific studies cannot be directly used in other WMZs regions, lessons can be learned from these systematic studies and they would help in other similar studies. The nested approach of defaults for limits in low demand areas and site specific studies in high demand areas allows adaptation with the region. Potential weaknesses As TDC has conducted WMZ specific studies, the findings in total cannot be easily adapted elsewhere.

Water quality

Description of water quality limit-setting systems and processes

Chapter 33 (Discharges to Land and Water) of the TRMP contains the general, district-wide Objective 33.1.2:

> *The discharge of contaminants in such a way that avoids, remedies or mitigates adverse effects while:*
>
> *(a) maintaining existing water quality; and*
>
> *(b) enhancing water quality where existing quality is degraded for natural and human uses or values.*

The Buller and Motueka River are under Water Conservation Orders (WCOs) and have separate water quality standards (e.g. TSS/turbidity/clarity, temperature, pH, and DO).

To date, management of contaminants in the TDC region has been within this policy framework that seeks the “maintenance and enhancement of water quality” in this narrative way, but this is currently under review. Newly proposed (2013) policy is being developed to address the issue of surface and ground water degradation from non-point sources associated with intensive land use activities, and include ‘good practice’ approaches with industry and more numerically in terms of nutrient losses in the Waimea Plains, as follows:

> *33.1.3.7a – To reduce the risk of land use intensification in the Waimea Plains for water quality, especially nitrate leaching to groundwater and ecology of Neiman, Pearl and Borck Creeks. This will involve both the development of concentration-based limits and nutrient loss limits from farms. Water body concentration limits (Figure 33.1A) for NO3-N, DRP, E.coli and periphyton will be developed for Waimea aquifers, Waimea River, Lee River, Roding River, Wairoa River, Neiman, Pearl and Borck Creeks.* [Author emphasis added].

Figure 33.1A in the TRMP is currently blank and will be populated prior to 2020.

In this sense, TDC could be said to not yet have a process for setting water quality limits, as they are just embarking on this process, but TDC does have a sound foundation and building blocks to help it to do so. TDC's thinking with regards to limits includes:

1. Provisions for a recharge protection area and point discharge-related limits – water classes and standards as under 3rd Schedule RMA;
2. Two water conservation orders (Buller and Motueka) include preservation objectives for water quality and point source discharge quality limits;
3. No numeric objectives as yet – work is underway to set them. TDC have set some high level narrative objectives under the TRMP. Translating numeric objectives into limits represent a major challenge;
4. TDC suggests that a potential weakness of the NPSFM is that it does not include a relative risk assessment upfront - i.e. to determine when different workflows for objective/limit setting are/are not required. Their view is that limit setting, in the NPSFM sense, is not required for most of the Tasman District because of the lack of issues/pressures;
5. TDC are considering limits as they develop work programmes to meet objectives of the NPSFM and any guidance documents. They are asking questions about what needs to be done at national /regional level for least effort and cost. They consider themselves 'fast followers' and are looking for relevant guidance;
6. TDC consider that any limits set would be catchment or aquifer specific and related to a particular issue. For example land use intensification of the Waimea Plains as a result of the proposed dam in the catchment. This will involve both the development of concentration-based limits and nutrient loss limits from farms.

Evaluation of water quality limit-setting systems and processes

Because TDC is only just starting the process of setting objectives and limits we could not fully evaluate their 'system'. The table below offers comments on the building blocks that TDC have in place.

Table 4-11: Evaluation of TDC's water quality limit-setting processes.

Criterion	Evaluation	Comments
Technically robust	NA	TDC are only just beginning to formulate numeric objectives and limits, and then only for specific catchments such as the Waimea discussed above. Current approaches are based on pre-NPSFM requirements, which TDC consider have served them well. The types of work carried out by TDC to date suggest that whatever scientific research they use to underpin limit setting will likely be technically robust.
Practical	NA	TDC's current methods of seeking the maintenance and enhancement of water quality appears to be serving them well. With an emphasis on non-regulatory approaches and good communication with stakeholders the current method appears largely successful as evidenced by their SoE reporting. However there

		is no current system for setting numeric objectives or limits. TDC would be likely to use a risk-based approach to limit-setting for priority catchments, so the process they use is likely to be practical for them.
Transparent	NA	The current work undertaken by TDC is transparent, with technical reports concerning specific issues available on the TDC website. However there is no system for setting numeric objectives and limits as yet.
Adaptable	NA	TDC stress that they are ‘fast followers’ and would certainly be candidates for guidance on a workable cost-effective system for setting objectives and limits (where necessary) that could be adapted from other regions.

TDC also offered many useful thoughts on the challenges faced, which are included in section 4.6 below.

4.4.4 Auckland Council

Water quantity

Description of water quantity limit-setting systems and processes

Auckland Council (AC) is a unitary authority, made up from the previous Auckland regional council plus the seven territorial authorities that governed in the Auckland region prior to re-organisation in 2009. The Auckland Regional Council had developed a plan to manage water resources, which is now the Auckland Council Regional Plan: Air, Land and Water Plan (ALWP; 2012). Most of the ALWP is operative but some parts (including some that cover the management of discharges) are not yet operative. The NPSFM transitional provisions (policies A4 and B7) have been inserted into the ALWP. The Auckland Council has also prepared a Proposed Unitary Plan, which will implement the NPSFM.

AC’s water quantity limit-setting system and processes (used in the AWLP) include:

- AC manage its water resources by dividing into specific aquifers and catchments.
- Surface water and groundwater in high water demand areas are considered as hydraulically connected.
- There are instantaneous rate (m^3/s) limits for surface water and annual maximum volume for groundwater (m^3).
- The limits are managed with a combination of surface flow records and groundwater level monitoring, however there are only few high allocation aquifers.
- Permitted activity water uses have been accounted for in some groundwater allocation limits.
- The limits for both surface water and groundwater are determined using a combination of methods, that can include:
  - Integrated surface water-groundwater modelling
  - Habitat models, WAIORA and RHYHABSIM

- Flow statistics
- Expert judgements
- Stakeholder input
- Flow reliability
- Saline intrusion avoidance
- % of rainfall recharge
- Recharge to aquifers with lower piezometric head.

- In unstressed catchments, default allocations are based on a % of 7-day MALF for minimum flow and % of 7-day MALF for allocation limits. For some higher allocated catchments the allocation varies with the time of year e.g. higher allocation in some streams from May to January which includes the first half of the irrigation season (i.e. November and December) with a lower allocation from February to April.

- Surface water measured records (i.e. long term flow data and field monitoring, concurrent gaugings) are naturalised using:
  - Actual water usage records (100% takes are metered)
  - Permitted activity water use using surveys or estimates
  - Groundwater level surveys for the catchments where surface water and groundwater interaction is significant
  - Analysis of hydrograph recessions for the month with the lowest flows of each year.

- The above methods are used to define minimum flows for surface water and sustainable yield for aquifers. AC consider their groundwater resources are not highly allocated.

- One South Auckland stream has the allocation limit set to provide a reliability of no restrictions one year in two.

- Large surface water and groundwater, applicants such as Watercare services and the District Councils have used physical habitat models like RHYHABSIM in municipal supply applications.

Evaluation of water quantity limit-setting systems and processes

Table 4-12: Evaluation of AC's water quantity limit-setting.

Criterion	Evaluation	Comments
Technically robust	Yes	<u>Strengths</u> The limits have been set using: integrated surface water-groundwater modelling; habitat models, WAIORA and RHYHABSIM; flow statistics; expert judgements; stakeholder input; flow reliability; saline intrusion avoidance; % of rainfall

Criterion	Evaluation	Comments
		recharge; recharge to aquifers with lower piezometric head. Measured stream flows have been naturalised using water meter data, stock water use by taking stock number estimates and estimates for other permitted activity water uses and studying annual recession of the lowest month. The above parameters help AC to determine the minimum flows and aquifer sustainable yields. The set limits for high water demand catchments generally represent the total limit for both surface water and groundwater as they are hydraulically connected. The Air, Land and Water Plan outlines the limits. Generally groundwater resources are well managed and not highly allocated. <u>Potential weaknesses</u> AC use a default allocation limit of a % of 7-day MALF for the streams where detailed studies have not been completed. Using hydrological statistics to set limits has advantages and disadvantages. On one hand they are relatively cheap and easy to set and monitor, but they do not account for spatial variability (which is an issue if they are used for a whole region) and so could result in varying outcomes for the environment and for resource availability. There is a need to understand the impacts of urbanisation upon rainfall recharge into the various groundwater aquifers.
Practical	Yes	<u>Strengths</u> The limits have been clearly stated and can be easily used by end users such as consent officers. AC catchments and aquifers have common consent expiry dates, therefore any future plan limit revision, can be applied as a blanket change when consents expire, therefore providing a higher probability of achieving future plan objectives. <u>Potential weaknesses</u> With the AC priority to expand the growth of Auckland, urbanisation may alter the natural water resources and reduce stream base flows and rainfall recharge into the aquifers.
Transparent	Yes	<u>Strengths</u> AC has been very transparent in all aspects of managing water allocation framework. The methods used, and how and what limits have been set are clearly published through council reports and the website. The water users and consent staff can easily identify resource availability. <u>Potential weaknesses</u> As AC primarily use a combination of surface water and groundwater integrated methods, some technical details used in setting limits may be difficult to understand for some non-technical people.
Adaptable	Yes	<u>Strengths</u> While the findings of the AC specific studies cannot be directly used in other urban regions, lessons can be learned from these systematic studies and they would help in other similar studies. <u>Potential weaknesses</u> AC, with a large number of urban catchments, have had to deal with different issues such as stormwater conveyance and heavy metals in water, these may not be transferable to other regions with predominately rural catchments to manage.

Water quality

Description of water quality limit-setting systems and processes

As above, AC's ALWP is not yet fully operative in terms of the management of discharges. Here we discuss the proposed Unitary Plan, which includes Auckland's RPS and Regional Plans.

AC has made limited progress in relation to implementing an NPSFM framework for the management of freshwater in the region. The proposed Unitary Plan includes (Section 2.6.3 freshwater) five objectives, including of relevance to water quality:

- 2. The quality of freshwater is maintained and where appropriate restored and enhanced, and
- 5. Stormwater quantity is reduced and stormwater quality is improved in both urban and rural areas by the use of appropriate techniques.

The proposed Unitary Plan also includes a further 3 Auckland wide objectives and 9 policies with regard to water quality (section 3.1.3.16.1). This section states that the approach to implementing the NPSFM being taken in the proposed Unitary Plan is an interim water quality management strategy based on the macroinvertebrate index (MCI), with the rationale being that if macroinvertebrate health is maintained, other water body values are also maintained. This interim guideline will eventually be replaced by a more comprehensive set of water quality standards that reflect the additional variables identified in the NPSFM. Limit-setting, in the context of the NPSFM has only recently been initiated, because all resources have been concentrated towards the recently proposed Unitary Plan. However an NPSFM implementation team has been set up (see further discussion in section 4.5.4), and some preliminary measures have been taken, such as commissioning work to advise whether AC needs to classify waters into types (similar to WMZ in Canterbury and Horizons terms) – which is a useful starting point.

There is, therefore, no full 'limit-setting system' at present for us to evaluate. However, components of Auckland's current systems that may have some utility in implementing NPSFM limit setting include:

- A strategic approach to managing water quality in the (non-RMA) Auckland Plan; which includes 'targets' (not in the NPSFM sense) to:
  - reduce the overall yield of suspended sediment to priority marine receiving environments from 2012 levels by 15% by 2040,
  - reduce the vulnerability of identified ecosystems by ensuring a 95% probability of each ecosystem type being in a viable state by 2040, and
  - reduce wet weather overflows to an average of no more than two events per discharge location per annum, where the stormwater and wastewater systems are separated, by 2040 (with priority given to bathing beaches and other sensitive receiving environments by 2030);
- The current objectives and policies in the proposed Unitary Plan using an interim MCI approach;

- A comprehensive SoE monitoring system (including lakes and groundwater) that will provide the backstop for setting of numeric objectives;
- Experience and good understanding of biotic responses to contaminants that will also be useful in setting numeric objectives
- Access to all the databases needed to provide data input for modelling rural non-point source nutrient loads; and
- 'Guideline' MCI values for all streams/rivers in the Region (within Unitary Plan) that could serve as a numeric objective.

Evaluation of water quality limit-setting systems and processes

Because AC is only just starting the process of setting objectives and limits we could not fully evaluate their 'system'. The table below offers comments on the building blocks that AC have in place.

Table 4-13: Evaluation of AC's water quality limit-setting.

Criterion	Evaluation	Comments
Technically robust	NA	Current systems are interim guidelines within the proposed Unitary Plan based on pre-NPSFM requirements. The MCI approach in the proposed Unitary Plan splits the region into four broad categories of Native forest, Exotic forest, Rural Areas and Urban areas, and assigns a numeric MCI value to each. This does provide some guidance as to the environmental outcome sought, which as it stands can be measured and it is obvious if this outcome is not being achieved. The region-wide water quality section of the proposed Unitary Plan includes policy 5: *Develop catchment specific water quality limits identified by community consultation and scientific research, to replace the MCI guideline values, if this is necessary to maintain catchment specific freshwater values.* The types of work carried out by AC to date (including sediment control and stormwater contaminant loads work done using the CLM model) suggest that whatever scientific research AC use to underpin this limit setting will likely be technically robust.
Practical	NA	The current stated approach is to develop objectives and limits as required by the NPSFM, including scientific research and community consultation. The AC has a full team responsible for implementation for the NPSFM. As they will be developing an approach from the ground, it is likely that they will develop an approach that is cost-effective and based on relevant information
Transparent	NA	Current practice at AC is transparent, for example with technical reports supporting the proposed Unitary Plan available on the AC website. SoE data is available to interested parties for the cost of retrieval.
Adaptable	NA	AC will likely have to consider contaminants specific to the urban catchments that they manage. They may need to develop slightly different approaches to set limits for their relatively few rural catchments. As such, some of the work they carry out will be potentially be transferable to other regions

AC also offered many useful thoughts on the challenges faced, which are included in section 4.6 below.

4.4.5 Environment Canterbury

Water quantity

Description of water quantity limit-setting systems and processes

The Canterbury Region has high demand for water use. Two examples of their high allocation are the consumptive stockwater takes in the 1870's and 1880's which equate to 50% of the 7-day MALF from foothill streams, and secondly the first large irrigation take from the Rangitata River for the Rangitata Diversion Race was allocated 80% of the 7-day MALF in the 1940's. These consents have been renewed periodically since then, but with little change in the allocation. Many more surface water irrigation schemes and a multitude of groundwater takes has led to the high allocation overall in Canterbury.

Canterbury has developed the (non-statutory) Canterbury Water Management Strategy (CWMS) which splits the region into 10 Water Management Zones (WMZ), and the visions and principles of which were enshrined into the Environment Canterbury Act. The CWMS sets up (collaborative) Zone Committees to help make decisions regarding water resources in the zone.

Environment Canterbury's regional planning environment includes:

- The Natural Resources Regional Plan (NRRP) is operative and sets freshwater objectives and limits for many specific catchments, and groundwater zones. With landuse change limits for the entire region.
- The proposed Land and Water Regional Plan (pLWRP) sets defaults limits for the whole region which can be modified by Sub-Regional Plans (SRP), creating a two-tier structure to this planning approach. An SRP may cover part of a WMZ.
- SRPs have a 10 year life - currently 7-8 SRPs in development where individual limits are set.
- In general, Environment Canterbury have tended to use intensive knowledge of the natural water resource and the application of specific science with less reliance on standardised approaches when setting limits.

Surface water

- All three types of plans (NRRP, pLWRP, and SRP) use minimum flows and an allocation cap in l/s.
- Considerable effort is applied to develop naturalised flow records.
- s14 takes are not accounted for in the naturalising and nor are they part of the allocation.
- Various methods are applied so that informed decisions can be taken in setting limits. The methods used include:
  - Physical habitat models for significant rivers.
  - Some use of flow statistics as a default.

- Cultural Opportunity Mapping And Response (COMAR).
- Water user reliability of supply.
- Hapua river mouth flow requirements.
- Degree of 'flat lining' of river flows based upon ecological expert opinion.

- B Block minimum flows are set from flushing flows, the hydrological index FRE3 and periphyton models.

Groundwater

- Allocation limits are set to maximum rates (l/s) and annual volumes (m^3), based upon 50% of the rainfall recharge (i.e. not total recharge), with consideration for impacts upon spring-fed streams.
- Many groundwater zone allocations were set in the NRRP.
- The 10 WMZ may not necessarily be aligned with aquifer boundaries.
- Allocation limit setting will become more specific in the SRP process.
- s14 takes are not accounted for as part of the allocation.
- Individual aquifer and stream knowledge of interactions is required in the SRPs.

Evaluation of water quantity limit-setting systems and processes

Table 4-14: Evaluation of Environment Canterbury's water quantity limit-setting processes.

Criterion	Evaluation	Comments
Technically robust	Yes	<u>Strengths</u> The surface water limits have been set using various scientific methods, coupled with expert knowledge on risk and other factors using a collaborative approach. As characteristics of streams and the level of current allocation vary between catchments and aquifers, specific studies have been conducted in detail. Thus, they are scientifically defensible. The limits have been set using in-stream habitat studies along with hydrological statistics (7-day MALF) and other relevant factors such as expert opinion, water quality issues (e.g. using periphyton monitoring), ecosystem health and biodiversity, values for other water uses (e.g. Recreational, drinking water and amenity opportunities), cultural values (e.g. Māori kaitiakitanga), drinking water, landscape and Hapua river mouth flow requirements. Measured stream flows have been naturalised. Environment Canterbury has undertaken very detailed decision support modelling. <u>Potential weaknesses</u> Such detailed water resource investigations and modelling for limit setting can be time consuming, costly and still contain uncertainty. Use of default minimum flow of 7-day MALF for the streams where detailed studies have not been completed can have advantages and disadvantages. Groundwater limits are currently set based on a 50% of rainfall recharge with consideration for impacts upon spring fed streams. For confined aquifers that are

Criterion	Evaluation	Comments
		primarily recharged through other sources than direct rainfall this default may not be appropriate. Limit setting of an aquifer within an SRP is complicated when the aquifer lies under two WMZs.
Practical	Yes	Strengths Although the surface/ground water analysis assists quantity/quality limit setting using detailed studies for SRPs, an example being the Te Waihora catchment, using surface water/ groundwater models, along with surface water and groundwater quality models on the plains and upper catchment feeding into lake water balance water quantity and quality modelling. This complicated limit setting occurs using the best available science to inform and provide confidence to decision makers. Current groundwater limits are set using rule of thumb methods, thus they are easy to implement. Potential weaknesses However, the effects of using this a simple methodology to set limits on the sustainability of the aquifer systems are currently not well understood. Due to hydraulic connection between aquifers and other water this lack of understanding may lead to over-allocation.
Transparent	Yes	Strengths The methods used, and how and what limits have been set are very transparent. All the procedures and results are available through council reports and the Environment Canterbury website. The water users and consent staff can easily identify whether a resource is available or not. Potential weaknesses Some technical details used in setting limits may be difficult to understand for some non-technical people.
Adaptable	Yes	Strengths Current groundwater limits are adaptable at anywhere nationally, but the % recharge value (of rainfall) used may require to adjust to reflect geology, land slopes and vegetation. The landuse change limit-setting methodology for sensitive catchments from pasture to forestry has defaults that are used region wide. Potential weaknesses Surface water limits have been set using location specific studies. These are not readily adaptable to other streams.

Water quality

Description of water quality limit-setting systems and processes

The Environment Canterbury water quality limit-setting processes include, in approximate order of progression:

- Classifying streams, rivers and lakes according to their dominant characteristic (Natural state; alpine upland; alpine lower; hill-fed – upland; Hill-fed lower; lake fed; banks peninsula; spring fed upland; spring fed lower basins; spring fed plains etc.). This was done as part of development of the NRRP, using the REC, and is now in the pLWRP.

- Setting fresh water objectives appropriate to each classification (reflected in Tables WQL5 and 6 of NRRP, and transferred to Tables 1a and b of pLWRP).
- Setting Water Management Zones appropriate to communities of interest, under to CWMS. These zones are the basis of the Zone Implementation Programme (ZIPs).
- Assessing the current state of the environment within each zone from water quality and biological response metrics (periphyton cover, chlorophyll *a*, MCI), groundwater chemistry, point source information and intensity of land use.
- From the above, classifying water management zones as red (objectives - not met, orange, objectives at risk, and green – objectives met).
- Formulating default nutrient limits reflecting good management practice for different enterprise, climate soil combinations by June 2015.
- Interim controlled activities (existing farming) up to 2017 require landowners to supply OVERSEER runs to Environment Canterbury. Only 10% increases in N load from enterprise relative to 2011 state allowed before triggering need for resource consent.
- Zone committees identify values in their zones important to their communities. Environment Canterbury advises which contaminants affect values.
- Environment Canterbury decides on sub-regional plan divisions based on catchments.
- Zone committees decide on objectives and limits within their catchment(s) with extensive technical support including scenario modelling provided by Environment Canterbury. Decisions must at least meet default limits in pLWRP. Limits are expressed as a whole of catchment load (tonnes/y). Draft SRPs are also taken to the wider community, with Zone Committee members playing a role in presenting the approach.
- SRP notified and goes through normal (for Environment Canterbury) submission, and hearing processes.
- SRP checked for consistency with pLWRP before becoming operative.

Environment Canterbury's Hurunui-Waiau SRP was discussed as a case-study in section 4.3.2 above. Some parts of this are referred to in the evaluation below.

Evaluation of water quality limit-setting systems and processes

Table 4-15: Evaluation of Environment Canterbury's water quality limit-setting processes.

Criterion	Evaluation	Comments
Technically robust	Yes	Strengths: The 2-level plan (pLWRP and SRPs) follows the 'cascade' diagram given in Figure 4-1, which is not surprising given that the diagram was adapted from the Technical Report on the Hurunui Catchment. In the Hurunui-Waiau example there is a clear path for establishing whether the limit (contained in Schedule 1) has been breached. This can be done by: (i) continuous flow monitoring, sampling of nitrogen and phosphorus at the sites designated in Schedule 1 at intervals sufficient to calculate an annual load with a prescribed level of confidence (ii) using a periphyton sampling programme within the specified reaches and determining whether the numeric objectives (expressed as policies) have been breached (iii) sampling DRP and nitrate-nitrogen at the sites specified with sufficient frequency to determine whether the annual median and 95%ile concentrations breach the policies concerning DRP concentrations (as the single nutrient limiting periphyton growth) and nitrate toxicity, respectively. The science behind the Hurunui-Waiau SRP appears technically robust (with the possible exception of reliance on Redfield ratios, discussed below). The science and decisions based on the science is transparent with technical reports supporting the plan placed on the Environment Canterbury website, and discussed in the Plan decision. This has included considering both water quantity and quality issues in the determination of nutrient limits (Schedule 1). Potential weaknesses The question as to whether the plan will be effective in managing to limits (particularly periphyton in the example of Hurunui-Waiau) is dependent on the veracity of the science behind the decision. In this case the commissioners accepted the view of the majority of experts that periphyton was limited by phosphorus in the lower reaches. This was based on Redfield ratios (i.e. N:P ratios). If, as some experts believe, nitrogen may be co-limiting and/or the limiting nutrient may switch depending on other influences, then in the event of periphyton exceeding policy targets, and with the decision made to increase nitrogen loading by allowing dairy intensification and irrigation, then the breaches in periphyton targets would be very hard to reverse. There is no mechanism within the current Hurunui-Waiau plan to allocate NDAs amongst individual landowners. However this will be remedied once the pLWRP becomes operative. Whilst not impacting on the Hurunui-Waiau Plan, the absence of default limits in the pLWRP (until June 2015) is a weakness, at least in terms of perception. Without these default limits the only barriers to decline in water quality in catchments currently 'not meeting' freshwater objectives or 'at risk' of not meeting them, is the requirement to get a resource consent if leaching > 10% more than was the case in 2011. This is dependent upon surveillance of farm enterprises and knowing that such changes have taken place. The lack of knowledge on groundwater pathways and lag times is a potential weakness. The scientific uncertainty behind determination of actual and potential stream concentrations can be managed by assuming that present nutrient loads leaving the root zone, will eventually be reflected in in-stream concentrations. Whilst the timing (lag-time) is uncertain it can be modelled within known extremes and a sensitivity analysis performed (to aid decision

		making).
Practical	Yes	<u>Strengths</u> One of the strengths of the 2-tier plan is that Environment Canterbury staff, Zone committees and submitters will learn by experience as they develop subsequent SRPs[. To that extent the limit-setting process is practical, as succeeding plans will benefit from the lessons learned from its predecessors. Some efficiency should also become apparent with time, as databases and models improve, and uncertainties (such as lag times) become smaller. The systems are largely are in place for Environment Canterbury to implement the limit-setting process. The overarching LWRP is nearly complete and a 'pilot' - (Hurunui-Waiau SRP) is all but operative. Thus the template to complete the process is there. <u>Potential weaknesses</u> One of the rationales behind the pLWRP is that it should be a collaborative process. Whilst collaborative processes require much more effort 'up front' in theory there should be much less litigation once the operative plan has 'bedded in'. Whether or not this is the case has still to be determined. There are 3 appeals to the High Court on the Hurunui-Waiau Plan and likely to be more on the pLWRP. Once the pLWRP becomes operative and the remainder of the SRPs is complete (including appeals) the framework for managing water quality to limits should be in place and in theory there should be fewer consent hearings and appeals to the Environment Court. However whether the process is an improvement over previous process (and is therefore practical) will be judged in part on whether there is a significant decrease in litigation. The limit-setting process in Canterbury is placing large pressures on key staff members, who have the knowledge, skills, and experience to make the whole thing work. There is a risk that such staff will leave the organisation for a less stressful environment and this has the potential to derail the process.
Transparent	Yes	<u>Strengths</u> This is key to the success of the process and it is our view that Environment Canterbury have largely succeeded. All technical reports supporting the objectives and limits are available on the Environment Canterbury website. There is always room for improvement in this regard and one suggestion we make is that a summary document be produced with each SRP that summarises the logic behind the limit-setting process, the consultations that have taken place, and the technical reports produced that support the limit setting together with their location. We acknowledge this might be an information need peculiar to researchers and other councils learning from the process. <u>Potential weaknesses</u> The absence of default limits in the pLWRP and communication of the reasons for their absence is a significant weakness and may be responsible for at least some of the submissions on the pLWRP. The manner in which current farming enterprises are 'held' to their 2011 leaching losses is also not well explained and lacks transparency.
Adaptable	Yes	<u>Strengths</u> As discussed under practicality - the approach is adaptable to different SRPs (catchments). While the issues may vary between plans, the processes set up, modelling approaches and data requirements are all similar. The process has the potential to be transferred to other Regions (outside of Canterbury), where farming (diffuse sources) and nutrient loads in particular are the dominant contaminants affecting water quality and meeting freshwater objectives. Testing of the collaborative process in Canterbury will also provide transferrable lessons for other councils.

4.5 Costs of limit setting

As described in section 3.1, the five councils were asked questions related to the costs of going through a limit-setting process. While we have dubbed these costs as related to 'limit setting', what councils have provided is variable and often broader in scope than the setting of limits. Information provided by the five councils is summarised here.

4.5.1 Waikato Regional Council

Table 4-16: Summary of WRC's limit-setting cost information.

Water quality limit-setting policies	
Variation 5 Lake Taupo Catchment	$9M policy development costs $2,429,526 science/policy implementation costs $11,429,526 total costs (2000-12) No additional costs since the NPSFM Costs savings of $0-200,000 over two years and $100,000 annually over the policy development phase (2000-2011) if there had been a national limit-setting scheme in place
Healthy Rivers Plan Change	$7,752,319 total costs No additional costs since the NPSFM as this project started after 2011
Water quantity limit-setting policies	
Water Allocation Variation 6	$4.5M policy development costs (2002-12) $3,908,000 implementation costs (2009-13) $13,825,000 expected implementation costs over next 5-20 years V6 is NPSFM 'compliant' so therefore these costs are the costs for WRC from the advent of NPSFM water quantity. Estimated NPSFM consent processing labour component of $100,000 since 2011 (likely to tail off after 5 years)

Waikato Regional Plan Variation 5 – Lake Taupo Catchment

Background

Regional Plan Variation 5 – Lake Taupo Catchment (V5) has been developed to cap the amount of nitrogen entering Lake Taupo from urban and rural activities. The variation covers policies that reduce and require the formation of the Lake Taupo Protection Trust to assist in achieving the 20 per cent reduction in the amount of nitrogen entering Lake Taupo. V5 took almost six years of discussion and consultation with the project partners (Taupo District Council, Ngati Tuwharetoa, Ministry for the Environment) and stakeholders from the Taupo Catchment.

Indicative costs of Variation 5

V5 consisted of policy development and implementation costs, which have been summarised below.

Table 4-17: Summary of Variation 5 policy costs over the period 2000-12.

Type of costs	Period	Amount
Policy Development costs	2000-2011	$750,000 annually $9M total costs
Policy Implementation costs	2009-2012	$1,829,526
Science Implementation costs	2009-2012	$200,000 annually $600,000 total costs
Total costs	**2000-2012**	**$11,429,526**

Policy development costs

Research and policy development costs of V5 started back in 2000 and ended by 2011. WRC has not kept records of historic costs that far back, therefore indicative costs were given[131]. The annual budget has been estimated at $750,000 since 2000. Costs were broken down as follows.

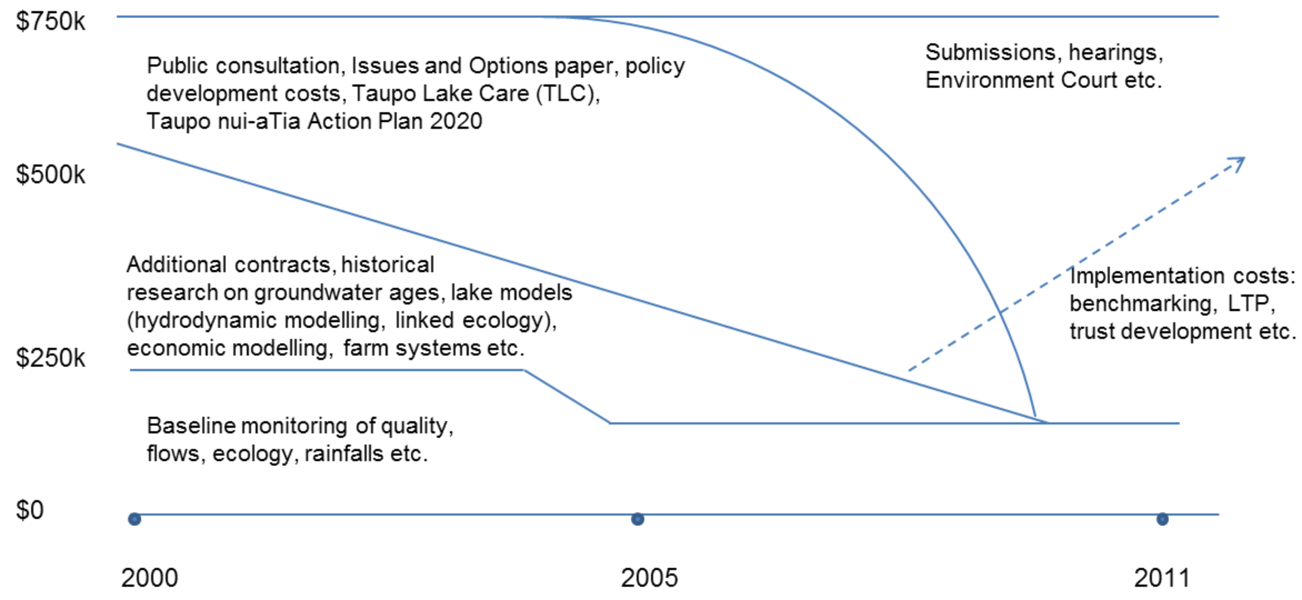


Figure 4-3: Overview of indicative WRC V5 policy development costs.

Implementation costs

WRC provided detailed implementation costs of V5 as these were more recent[132]. Table 4-18 outlines the summary of Taupo / Variation 5 (nitrogen cap and trade scheme to protect lake Taupo) Implementation costs for the last 3 years. Total costs over the period 2009-12 amounted to $1,829,526.

[131] Discussions with Tony Petch, WRC, 23rd May 2013.
[132] Discussion with Natasha Hayward, WRC, 23rd May 2013.

Table 4-18: Summary of V5 Implementation costs for 2009-2012.

	09/10	10/11	11/12
Direct Costs	159,081	152,390	113,685
Labour	515,251	458,157	402,716
Rate Collection Costs	13,597	6,773	7,876
Total Expenditure	687,929	617,320	524,277
Funded by LT Protection Trust	341,251	350,723	183,139
Funded by targeted rate	346,678	266,597	341,138
Total Expenditure	687,929	617,320	524,277

These costs have been broken into the following categories.

Table 4-19: Detailed cost break-down of V5 implementation phase 2009-2012.

	09/10	10/11	11/12
Materials	0	0	12
Contracted Services	127,655	128,146	67,061
Legal Fees		8,137	8,416
Vehicle Running	25,289	6,825	4,752
Plant Running/Hire			356
Accommodation and Meals	1,193	452	238
Advertising and Promotion			801
Training, Courses, Conference	1,000	244	573
Entertainment		27	
Meeting Expenses	146	1,039	358
Other Expenses	11		25,093
Publicity and Information	1,377		0
Printing and Stationery	20	97	2,122
Postage and Courier		2,395	375
Telecommunications	2,391	4,737	3,175
Travel		290	353
Total Direct Costs	159,081	152,390	113,685
Labour	515,251	458,157	402,716
Rate Collection Costs	13,597	6,773	7,876
Total Expenditure	**687,930**	**617,321**	**524,277**
Onbilled to Trust	341,251	350,723	183,139
Net cost funded by targeted rate	346,679	266,598	341,138
Management Costs Variance A	27,270	42,205	32,951
Management Costs	233,790	208,322	178,318
Total Labour (Raw)	254,191	207,630	191,447
	515,251	458,157	402,716

In addition to the implementation costs provided above, there were also science implementation costs for Taupo in project D1604 of $200,000 per annum over the same period[133].

Cost advantages of a national limit-setting system in place

In discussions with WRC, the following cost advantages, if there had been a national water quality limit in place prior to V5, were outlined:

- WRC feels that there would have been reduced consultation costs about problem definition, and setting targets and limits on water quality. It is likely though that a similar debate with stakeholder would have taken place about where the limits are placed, i.e. protect, restore, or 'to what level'. Estimated savings are set at between $0-200,000 for around 2 years. There would still have been debates about whether to have consents or not, and about the initial allocation of scarce resources, i.e. grandparenting rights.
- In retrospect there would have been savings from the industries being prepared for change and that they would already be having industry discussions about what they can do to offset environmental discharges. Research today is more focused on resource use efficiency and to reduce footprint per product sold, therefore policy development would have been easier. The rural community would have been better prepared and supplied for change. Estimated savings of $100,000 per year throughout the policy development phase.

Healthy Rivers

Background

Healthy Rivers: Plan for Change/Wai Ora: He Rautaki Whakapaipai works with stakeholders to develop changes to the regional plan to help restore and protect the health of the Waikato and Waipa rivers, which are key to a vibrant regional economy. The Waikato and Waipa catchments are the focus of this plan change. The plan change aims to help achieve reduction, over time, of sediment, bacteria and nutrients (nitrogen and phosphorus) entering water bodies (including groundwater) in the Waikato and Waipa catchments.[134]

Indicative costs

Summary of the indicative costs for the Healthy Rivers project are as follows.

Table 4-20: Summary of indicative costs of Healthy Rivers plan change.

2012/13	2013/14	2014/15	2015/16	Total costs 2012-2016
$1,871,221	$1,970,855	$1,980,577	$1,929,666	**$7,752,319**

Costs includes management overheads, labour, direct costs, accommodation (WRC buildings component etc.), cost of rate collection. A further breakdown can be seen in Table 4-21 below.

[133] Discussions with Ed Brown, WRC, 27th May 2013.
[134] http://www.waikatoregion.govt.nz/healthyrivers, downloaded 27th May 2013.

Table 4-21: Detailed breakdown of WRC costs for the Healthy Rivers project.

LTP 2012-2022	12/13	13/14			14/15			15/16
Proposed Annual Plan			13/14			14/15		
Approved Annual Plan				13/14			14/15	
Contracted Services	296,000	300,704						
Consultancy Fees	212,500	158,720			162,529			166,755
Legal Fees	30,000	30,720			303,092			270,036
Communications	50,000	50,000			50,000			50,000
Accommodation and Meals	2,000	2,064			2,130			2,202
Advertising and Promotion	13,000	6,708			6,923			7,158
Meeting Expenses	110,600	98,143			101,284			65,083
Printing and Stationery	20,000	20,640			21,300			22,035
Travel	2,000	2,064			2,130			2,202
Vehicle Expenses	7,500	2,500			2,500			2,500
General Rates (total costs)	**1,871,221**	**1,970,855**			**1,980,577**			**1,929,666**
Management Costs	480,467							
Corporate Labour Burden Costs	19,520							
Rate Collection Costs	43,612							
Labour	584,022	661,941			659,384			663,979

Water Allocation Variation 6

Background

WRC prepared and notified a variation to the Waikato Regional Plan to manage the allocation and use of freshwater overall of the Waikato region. The method by which surface and groundwater was allocated in the region had come under increasing scrutiny and sometimes criticism from both political and technical perspectives[135]. Council's decisions were appealed to the Environment Court by a large number of parties. On 29 March 2012, Council resolved to make the Variation operative. Variation 6 (V6) became operative on 10 April 2012.

Indicative costs of Water Allocation Variation 6 - Policy development costs

[135] http://www.waikatoregion.govt.nz/Council/Policy-and-plans/Rules-and-regulation/Water-allocation-variation/, downloaded 28th May 2013.

WRC provided the policy development costs for V6[136]. The V6 Plan policy development started in 2003 and finished in 2012. Budgets were spent prior to the notification on investigations and staff time in preparation of the proposed policy. This excluded the V6 hearing process costs from the notification to the final decision, including lawyers, staff and contractors. V6 is NPSFM ‘compliant’ (i.e. it aims to set objectives and limits to water quantity use) so therefore the costs given can be considered to represent the costs for WRC from the implementation of the NPSFM for water quantity.

Table 4-22: Break-down of Variation 6 policy development costs over the period 2002-12.

Project name	Period	Dollars	Cost category
D1002	**2011/12**	$664,512	Making Variation an operative part of the WRP, minor legal matters that did not affect the outcome of the Environment Court case.
D1002	**2010/11**	$1,223,821	Final evidence preparation, Court directed mediation, Environment Court hearings.
D1002	**2009/10**	$495,759	Meetings with appellants, preparation of evidence.
D1002	**2008/09**	$370,752	Council deliberations on submissions, release of Council decision and receipt of Environment Court appeals.
D1002	**2007/08**	$675,864	Preparation of staff report on submissions, Council Hearings (21 days) and deliberations.
D1002	**2006/07**	$382,427	Public notification of Variation 6, processing submissions and preparation of staff report.
PL300 10.4	**2005/06**	$192,903	Allocated costs not included (allocated costs defined as the costs of running a business, e.g. electricity, computers. The costs in this part of the table represent labour only.)
PL300 10.4	**2004/05**	$82,385	allocated costs not included
PL300 10.4	**2003/04**	$45,638	allocated costs not included
PL300 10.4	**2002/03**	$16,448	allocated costs not included
	2002-12	**$4,150,509**	**Total costs**

There have been only very minor development costs in 2012/13. The current development budget of about $30,000 for the year 2013/14 is well under spent, as all the focus is on implementation.

WRC think that some of the costs are a bit light, especially at the start of the project where much was spent undertaking investigations, some internal reviews and public consultation, therefore the $4,150,509 is likely to be an underestimate. WRC estimates that the actual costs overall should be closer to $4.5M. It is very difficult to break down the costs further without WRC spending a lot of time tracking back through the budgets.

V6 Implementation costs

[136] Discussions with Bruce McAuliffe, WRC, 27th May 2013.

WRC provided indicative costs for the main implementation costs incurred by WRC's Resource Information Group (RIG)[137].

The V6 operational (implementation costs) started in 2009. V6 implementation costs (D1003) amounted to $596,000 per annum for investigations of new limits and developing tools to implement the plan – e.g. water accounting GIS system. $188,000 of this is in contract services and the remainder in labour and overheads. This started in 2009 and is in the Long Term Plan for the next three years at least, but is likely to be required for the next 15-20 years.

Table 4-23: Summary of policy implementation costs for Variation 6.

Implementation Costs		
New limits investigation and tool development for implementing plan	$596,000 per annum $2,384,000 historic costs $11,920,000 total costs over next 20 years	2009-2013 (likely to be on-going for the next 15-20 years)
Farm water implementation costs	$381,00 per annum $1,524,000 historic costs $1,905,000 total costs over next 5 years	2009-2013 (on-going until 2015 years, afterwards budgets may be used for monitoring)
Additional consent processing staff costs due to NPSFM *(as more detailed needs to be provided)*	*$100,000 per annum (part of the $381,000)*	*Since 2011 expected to tail off in five years*
Total Costs	$3,908,000 historic costs	2009-2013
	$13,825,000 expected costs	Over the next 5-20 years

WRC provided indicative costs for the implementation costs for farm water implementation incurred by WRC's Resource User Group (RUG)[138].

WRC indicated that this is a rough estimate with the following assumptions:

- Farm water allocation team salaries (incl. ACC, training) – $381,000 annual costs for the period 2009-2013. These costs will extend to 2015, when the budgets are likely to be used for on-going monitoring for as long as WRC requires it. Budgets may fall after 2015 depending on the level of monitoring required, but this has not been decided yet by WRC.
- Currently WRC are recovering 80% of all consenting division costs, leaving around 20% funded by rates – $76,000. This cost comprises issuing consents and then monitoring them going forward.
- Costs are constant whether for current consenting activities or future monitoring.

[137] Discussions with Ed Brown, WRC, 24th May 2013.
[138] Discussions with Alan Taylor, WRC, 23rd May 2013.

These costs resulted from the consenting team having had to employ new staff to process consents and monitoring compliance which is in addition to the implementation project (D1003). WRC estimate that the increase due to the NPSFM compared to old allocation rules is staff labour equivalent to $100,000 per annum (this is expected to tail off after 5 years) of the $381,000 allocated. Much of this is recouped from fees an applicant pays to get their water permit processed (user pays). It has been difficult to isolate what is the cost solely due to the NPSFM compared to WRC requirements which may not be driven by the NPSFM.

4.5.2 Horizons Regional Council

Table 4-24: Summary of Horizons' limit-setting cost information.

Water quantity and **quality limit-setting policies**	
Proposed One Plan (POP)	$9.45M total policy development costs *$4.57M water quality and quantity proportion* *$3.44M 'objective/limit setting' proportion* No additional costs since the NPSFM Maybe some Environment Court costs savings if there had been a national limit-setting scheme in place

Proposed One Plan (POP)

Background

Horizons has been developing a new regional policy statement and regional plan to guide the management of natural resources in their Region. It is called the One Plan because it weaves together the six separate plans and Regional Policy Statement Horizons currently has into one easy-to-use document. When the final POP is adopted it will provide Horizons with an environmental roadmap, directing how the council will manage the Region's resources for the next 10 years and beyond.

One of the main issues remaining to be resolved by the Court are nutrient management rules. Consultation was undertaken across the whole spectrum of the plan and in 2007 the plan was notified. After the Horizons hearing decisions were released in August 2010, appeals were made to the Environment Court on that decision. Mediation on appeals occurred during 2011 and Court hearings were held during 2012 on the matters remaining in contention after mediation, e.g., indigenous biological diversity, land, landscapes and nutrient management topics.

It was not an easy task for Horizons to identify costs of the POP, because when the Council started the Plan review they did not predict the level of interest and the amount of work that would be required to get the plan through the formal process. Nor, of course, did they anticipate the contents of the NPSFM when they began the POP process back in 2006. This means that Horizons monitored overall costs, but did not separate them out according to Plan topics. Horizons did provide a breakdown of costs, but warned that it should be considered a guesstimate of the resourcing required to set water quality and quantity limits.

In practice the boundary between policy and science business as usual and the beginning of a Plan Review process is very fuzzy. Horizons used the publically reported POP costs from the Horizons' Annual Reports from 2006-07 to 2011-12. Prior to 2006-07 Horizons were essentially in a transitional period and the costs of getting the review underway were not separated out.

Indicative costs of POP

Horizons' best estimate of the breakdown of costs for the POP is represented in the table below. Total costs amount to $9.45M for the period 2006-2013. Implementation costs are not included as Horizons are currently working on that programme with Council.

Table 4-25: Estimated POP costs. Note the cost proportions are estimates. The accuracy diminishes toward the right of the table.

Date	RMA Process Stage	Costs	Proportion attributed to Water Quality and Quantity Management	Proportion attributed to "objective/limit setting"[4]
2006 to 2007	Pre-Notification	$960,000[1]	$432,000 (45%)	$302,000 (70%)
2007 to (Sep) 2010	Notification, submissions, Council hearing	$6,540,000[1]	$2,943,000 (45%)	$2,060,000 (70%)
(Sep) 2010 to (May) 2013	Environment Court Appeals	$1,852,000[2]	$1,111,000 (60%)	$1,000,000 (90%)
(Oct) 2012 to (Aug) 2013[3]	High Court Appeals	$100,000[3]	$80,000 (80%)	$80,000 (100%)
	TOTAL	**$9,450,00**	**$4,566,000**	**$3,442,000**

[1] Reported Costs in Horizons Annual Reports
[2] Provisional at 30 Jun 2013
[3] Predicted 2013-14
[4] Objective and limit setting for water quality and water quantity in the POP are inseparable as they were developed as an integrated package.

Cost advantages of a national limit-setting system in place

In discussions with Horizons, they could not see any particular cost advantage if national limits had been in place when they developed the POP. There was much confusion during the Court hearings about what limits mean. Horizons understands that limits under the NPSFM are the amount of resource available for use, e.g., tonnes per year, kg per day, volume of water available for takes not the concentration of contaminant in the water or the minimum flow (which Horizons believes is a numerical objective). If there was no requirement to go through an Environment Court process then that may have saved costs. Horizons noted that national limits could be a two-edged sword because if actual monitoring demonstrated more stringent limits were necessary to achieve water quality or quantity objectives, there is likely to be significant opposition from resource users to accepting anything but the default national limits.

Additional costs since the NPSFM

Since the NPSFM came into force the only slight change to the consenting process has been a small change in reporting, so no additional costs have been incurred due to the NPSFM in that area of activity.

Annual Plan activity 'Improve Knowledge and Understanding of the Region's Water Resource'

Like the POP, the systems set up to collect, manage, and report data and information about water quality and quantity in the Horizons region is an integrated multipurpose package in which the operating costs are difficult to split out from the whole. Horizons have approached this by providing estimates of the 'WaterMatters' and 'WaterQualityMatters' display software development costs (as discussed in section 3.3.3), and these are a very small proportion of the annual water quality and quantity programme costs.

Taken from Horizon's Annual Plans, the operating costs of the activity 'Improve Knowledge and Understanding of the Region's Water Resource' for the last three years are represented below.

Table 4-26: Operational costs of Horizons' water (Water quality, groundwater and surface water quantity) activity.

Financial Year	OPEX
2010-11	$3,035,000
2011-12	$3,274,000
2012-13	$3,282,000
Total costs	**$9,591,000**

The purpose of the 'Improve Knowledge and Understanding of the Region's Water Resource' programme is to undertake research and monitoring to:

- Track changes in the health of the Region's water resource;
- Inform policy and non-regulatory programme development; and
- Assess policy and implementation effectiveness.

The costs do not just represent those related to limit setting, but cover the whole range of work to get reliable information from on-site data collection to the display of information on the website and everything that supports equipment operation, database management and quality control. It also includes the science and research staff costs that turn the data into information to manage the water resources. It includes an appropriate proportion of the telemetry operation and maintenance activity costs, which are split amongst several other outputs, including flood response and management.

Essentially this programme underpins freshwater management in the region, including whether limits are being met and whether they are appropriate to achieve the Water Management Values identified for Water Management Sub-zones in the region. In other words whether freshwater water quality and quantity management in the region is making progress toward achieving POP objectives. It is Horizons' 'formula' for determining whether the numerical water quality objectives, water quality limits, minimum flows and cumulative core allocations for water takes are effective.

The additional costs of setting up the 'WaterMatters' and 'WaterQualityMatters' display software is of the order of $20,000 to $30,000 since 2005, which are minimal when compared to the on-going operating costs of research and monitoring. Annual upgrade/maintenance costs amount to $4,000.

4.5.3 Tasman District Council

Other TDC costs are given in section 3.4.3, where it is noted that TDC had difficulties with separating out limit setting related costs, but here we provide TDC policy related costs.

Table 4-27: Summary of policy costs received from TDC.[139]

Water quantity and quality limit-setting policies	
Water Policy	$245,851 policy development costs (2010-12). Annual costs fairly constant since 1992 allowing for inflation and one FTE increase in team membership No additional costs since the NPSFM No costs savings envisaged if national limit-setting scheme in place, unless governments sets rules which cannot be appealed. Problem is local catchment circumstances will often necessitate some local variability

Water policy

TDC has been working on water quantity and quality management since 1992 when it became a unitary authority. Policy development costs involve creating planning platforms for both quantity and quality frameworks, e.g. water allocation; minimum flows; and objectives, policies and rules relating to this. Costs relate to setting new policies and rules to achieve sound water resource management, including going through statutory process (consultation and hearings etc.). Costs have been compiled for the last two financial years to give an indication of their magnitude (Table 4-28). They have remained relatively constant over the past few years.

Costs relate to a number of Council activities. For example, the first two cost items (water wages and Motueka wages) are related to TDC's Tasman Resource Management Plan (TRMP) proposed changes to replace the interim water management provisions currently in the TRMP for the Waimea Water Management Zones and allocation limits in the Motueka Groundwater Management zone. The Waimea plan provisions include provisions for the land use activities associated with a proposed dam and new river flow and water allocation regimes[140]. Costs for 2011/12 amount to $68,448.

[139] Discussions with Dennis Bush-King, Tasman District Council, 13th June 2013.
[140] http://www.tasman.govt.nz/policy/plans/tasman-resource-management-plan/planning-proposals-and-summaries/proposed-changes-and-variations/proposed-plan-changes-45-to-48-waimea-water-management-and-augmentation-lee-dam/ downloaded 13th June 2013.

Table 4-28: TDC indicative costs for developing water policy for water quantity and quality management.

Cost type	YTD Actual 2010/11	YTD Actual 2011/12
Water policy (water quantity and quality)		
TRMP-WATER WAGES	$ 32,646	$ 66,634
TRMP-WATER MOTUEKA WAGES	$ 8,260	$ 1,814
TRMP - WATER MOUTERE WAGES	$ 32	$ 981
SALARIES/WAGES ENGINEERING	$ -	$ -
TRMP-WATER WAIMEA WAGES	$ 415	$ 606
R/P Trmp Water Legal Fees	$ 50,622	$ 34,975
R/P Trmp Water Consultancy	$ 6,994	$ 17,368
R/P Trmp Water Travel	$ 1,566	$ 1,498
R/P Trmp Water Information	$ -	$ -
R/P Trmp Water Materials	$ 183	$ 1,612
R/P Trmp Water Accommodation	$ 568	$ 1,758
R/P Trmp Water Training Fees	$ -	$ -
OVERHEAD ALLOCATION-FCSC	$ 10,892	$ 11,782
Service Centre Oncharge-RESOUR	$ 1,519	$ 1,659
STAT COMPLIANCE ONCHARGE-RESOU	$ 352	$ 115
Total Operating Costs	**$ 114,049**	**$ 140,802**

4.5.4 Auckland Council

Other AC costs are given in section 3.5.3, but here we provide limit setting related costs.

Table 4-29: Summary of AC limit setting costs.

Water quantity and **quality limit-setting policies**	
NPSFM Programme	$1.6M total operational costs No additional costs since the NPSFM Maybe some Environment Court costs savings if there had been a national limit-setting scheme in place

NPSFM programme

Background

AC's current work is planning for the implementation phase of the NPSFM. AC have currently have 5 workstreams: Engagement, Objectives and Values, Limits, Information and Integrated Management.

The work undertaken so far includes:

- Gaining a greater understanding of the collaborative process as this is a step (at least) beyond the consultative practices of the past.
- Seeking to establish a mechanism for the involvement of Mana Whenua in the management of water.
- Understanding and tailoring the CLUES models for the Auckland rural environment.

- Improving AC's mapping of water bodies in the region.
- Determining some generic values and objectives that may assist local collaborative groups articulate values and narrative objectives for their water bodies.
- Understanding values of ecosystem services for future discussions with local collaborative groups.
- Understanding criteria for significant water bodies and the significant values of wetlands.

Future work will likely involve continuing some of the themes above, modelling for urban contaminants and providing support for local collaborative engagement.

Indicative costs

For the financial year 2012/13 the salary for the team engaged in this work (and trying to split it from other activities) is approximately $430,000 with the next financial year being of the same order[141]. Costs have been provided from 2012 until 2019.

The operational expenditure budget for this programme is in the AC Long Term Plan and consists of:

Table 4-30: Operational cost of AC's NPSFM programme.

Financial year	Operational costs
2012/13	$404,000
2013/14	$342,000
2014/15	$332,000
2015/16	$208,000
2016/17	$157,000
2017/18	$105,000
2018/19	$53,000
Total costs	**$1,601,000**

It is intended that the salaries budget will reduce from the current level as the programme is rolled out and the planning is complete, but it was too difficult for AC to put any actual values on this at this stage.

[141] Discussions with Roger Bannister, Auckland City, 18th June 2013.

4.5.5 Environment Canterbury

Other Environment Canterbury costs were discussed in section 3.6.3, but here indicative costs of Environment Canterbury's limit-setting policies are discussed.

Indicative costs

Table 4-31 outlines the planning costs associated to Environment Canterbury's water quality limit-setting planning exercises over the past three years (2010-13) and covers a number of catchments[142]. Of note, at the Hurunui-Waiau hearing cross examination was encouraged by the Hearing Commissioners. That necessitated Environment Canterbury to have legal counsel attendance for the entire hearing increasing the costs from a budgeted $70,000 to $254,000. In hindsight Environment Canterbury may have been able to manage that situation better, but the costs would still have far exceeded the legal costs of any other process. Total costs amount to $8,286,152 for the period 2010-13.

Costs include internal labour costs and Goods and Services, but exclude internal science labour costs and Plant (Car usage). 2012/2013 figures are current and include commitments projected for this financial year. Projects are of varying sizes and complexity; there is no 'one size fits all'.

In addition to the costs identified in Table 4-30, it is estimated that since 2011 Environment Canterbury has provided another $1 million from scientific investigations for catchment modelling projects to support limit-setting processes, which is likely to be ongoing while they develop SRPs.

[142] Correspondence with Christina Robb, Environment Canterbury, 21st June 2013.

Table 4-31: Environment Canterbury's planning costs for RPS, Land and Water Regional Plan and several sub-regional plans.

		Research & Consultation	Drafting	Hearing	Hearing: Legal	Commissioners	Commissioner Costs	TOTAL
Regional Policy Statement								
2011/12	Regional Policy Statement	$ -	$ -	$ 617,054	$ -	$ -	$ -	
2011/12	Regional Policy Statement	$ -	$ -	$ -	$ -	$ 359,186	$ -	
2011/12	Regional Policy Statement	$ -	$ -	$ -	$ -	$ -	$ 48,477	
2012/13	Regional Policy Statement	$ -	$ -	$ 151,690	$ -	$ -	$ -	
2012/13	Regional Policy Statement	$ -	$ -	$ -	$ -	$ 79,292	$ -	
2012/13	Regional Policy Statement	$ -	$ -	$ -	$ 57,267	$ -	$ -	**$ 1,312,966**
Land & Water Regional Plan								
2011/12	Land & Water Regional Plan	$ 648,597	$ -	$ -	$ -	$ -	$ -	
2012/13	Land & Water Regional Plan	$ -	$ 187,601	$ -	$ -	$ -	$ -	
2012/13	Land & Water Regional Plan	$ -	$ -	$ 563,293	$ -	$ -	$ -	
2012/13	Land & Water Regional Plan	$ -	$ -	$ -	$ -	$ 509,999	$ -	
2012/13	Land & Water Regional Plan	$ -	$ -	$ -	$ -	$ -	$ 46,468	
2012/13	Land & Water Regional Plan	$ -	$ -	$ -	$ 69,000	$ -	$ -	**$ 2,024,958**
Ashburton Zone								
2012/13	Hinds	$ 331,922	$ -	$ -		$ -	$ -	**$ 331,922**
Hurunui Waiau Zone								
2010/11	Conway	$ 52,380	$ -	$ -	$ -	$ -	$ -	
2011/12	Conway	$ -	$ -	$ 54,294	$ -	$ -	$ -	
2011/12	Conway	$ -	$ -	$ -	$ -	$ 27,879	$ -	**$ 134,553**
2010/11	Hurunui Waiau	$ 193,651	$ -	$ -	$ -	$ -	$ -	
2011/12	Hurunui Waiau	$ -	$ 284,153	$ -	$ -	$ -	$ -	
2012/13	Hurunui Waiau	$ -	$ -	$ 359,761	$ -	$ -	$ -	
2012/13	Hurunui Waiau	$ -	$ -	$ -	$ -	$ 197,999	$ -	
2012/13	Hurunui Waiau	$ -	$ -	$ -	$ -	$ -	$ 34,705	
2012/13	Hurunui Waiau	$ -	$ -	$ -	$ 254,703	$ -	$ -	**$ 1,324,972**
2010/11	Waipara	$ -	$ -	$ 98,924	$ -	$ -	$ -	
2010/11	Waipara	$ -	$ -	$ -	$ -	$ 84,076	$ -	
2010/11	Waipara	$ -	$ -		$ 6,524	$ -	$ -	
2011/12	Waipara	$ -	$ -	$ 28,552	$ -	$ -	$ -	
2011/12	Waipara	$ -	$ -	$ -	$ -	$ 17,158	$ -	
2011/12	Waipara	$ -	$ -	$ -	$ 5,419	$ -	$ -	**$ 240,653**
Kaikoura Zone								
2010/11	Kaikoura	$ -	$ -	$ 10,633	$ -	$ -	$ -	
2010/11	Kaikoura	$ -	$ -	$ -	$ -	$ 32,103	$ -	**$ 42,736**
Orari Opihi Pareora Zone								
2010/11	Orari	$ 170,207	$ -	$ -	$ -	$ -	$ -	
2011/12	Orari	$ -	$ 159,080	$ -	$ -	$ -	$ -	
2012/13	Orari	$ -	$ 36,589	$ -	$ -	$ -	$ -	**$ 365,876**
2010/11	Pareora	$ 79,736	$ -	$ -	$ -	$ -	$ -	
2011/12	Pareora	$ -	$ -	$ 98,954	$ -	$ -	$ -	
2011/12	Pareora	$ -	$ -	$ -	$ -	$ 82,622	$ -	
2011/12	Pareora	$ -	$ -	$ -	$ 9,500	$ -	$ -	**$ 270,812**
Selwyn Waihora zone								
2010/11	Selwyn te Waihora	$ 144,392	$ -	$ -	$ -	$ -	$ -	
2011/12	Selwyn te Waihora	$ 497,466	$ -	$ -	$ -	$ -	$ -	
2012/13	Selwyn te Waihora	$ 938,823	$ -	$ -	$ -	$ -	$ -	**$ 1,580,681**
Lower Waitaki-south coastal Canterbury zone								
2010/11	Waihao Wainono	$ 8,011	$ -	$ -	$ -	$ -	$ -	
2010/11	Waihao Wainono	$ 27,610	$ -	$ -	$ -	$ -	$ -	
2011/12	Waihao Wainono	$ -	$ 69,167	$ -	$ -	$ -	$ -	
2012/13	South Canterbury Streams	$ 377,539	$ -	$ -	$ -	$ -	$ -	
2012/13	Waihao Wainono	$ -	$ 60,433	$ -	$ -	$ -	$ -	**$ 542,760**
Waimakariri zone								
2010/11	Waimakariri	$ -	$ -	$ -	$ -	$ 69,158	$ -	
2010/11	Waimakariri	$ -	$ -	$ 44,105	$ -	$ -	$ -	**$ 113,263**
		$ 3,470,334	**$ 797,023**	**$ 2,027,260**	**$ 402,413**	**$ 1,459,472**	**$ 129,650**	**$ 8,286,152**

4.6 Challenges and information requirements

4.6.1 Recent reviews of challenges to limit setting

The challenges of limit setting have been identified by a number of relatively recent reviews, summarised here.

Norton et al. (2010, p39-41) outlined 13 challenges with setting measurable objectives and limits. These included [with some editors notes]:

1. Significant integration and communication challenges including problems with inconsistent use of terminology across multidisciplinary project teams [although this has since improved as a result of the NPSFM and related guidelines, there is still inconsistency particularly in what constitutes a limit].

2. The need to integrate expertise from scientific, planning, [economics] and legal disciplines, which requires greater use of scientific knowledge by planners, thinking at more expansive scales by scientists and more creative use (i.e. fully exploring all the tools provided, beyond those that might be used more commonly) of the available legal tools in the RMA.

3. The difficulty in making value judgements, because it involves trade-offs and may foreclose resource use, can be politically unattractive.

4. The need for clarity with regard to the roles of science [and other technical input including economics] versus decision-making – where the role of science is to assist decision-makers faced with the challenge of making value judgements, by describing the effects of various management options, on environmental, social and economic values, so that informed choices between options can be made.

5. The reliance on science-defined relationships between measures of resource uses and environmental states, when various aspects of environmental state and relationships with resource use are not well described and further research to extend existing guidelines and develop new relationships is required. Thus there is a need to acknowledge the extent of knowledge and ignorance, and provide flexibility for incorporating new information as it becomes available in future.

6. It is necessary to simplify science [link science to the relevant policy question] and make informed assumptions for management applications, which requires best estimates and/or simplifications of science-defined relationships between measures of resource uses and environmental states.

7. The difficulty of defining numeric terms for some aspects of environmental state (e.g., those relating to cultural and spiritual values), which may always require narrative expression.

8. The need to manage scientific and other types of uncertainty (and associated risk). Science based arguments highlighting uncertainty are sometimes used as a basis to retreat from making a decision to adopt a numeric objective, and to

instead adopt a narrative objective that is less arguable but also less helpful for defining the capacity for use of a resource.

9. The need to manage spatial variability within a region. [That is, take into account differences in climate, soil types and land uses when managing water resources. This is a fine balance between having too many water management zones with complex administration and lots of different standards, or too few WMZs where global rules apply.]

10. The requirement to use science but to also work within, and make good use of, the planning framework defined in the RMA (e.g., existing RMA sections and existing instruments such as NPS, NES, RPS, RP's). This requires collaboration between many different technical people including scientists, planners and lawyers.

11. Difficulty with preparing legal arguments for some detailed planning aspects. For example a problematic requirement is s69 RMA "…a regional council shall not set standards in a plan which result, or may result, in a reduction of the quality of the water in any waters at the time of the public notification of the proposed plan unless it is consistent with the purpose of this Act to do so." In order for a regional council to form a value judgement that it is acceptable to allow some further resource use (e.g., point discharges or intensified land-use) in a particular catchment after the date of plan notification, and to set numeric objectives and water quality standards accordingly, it must transparently argue that reduction of water quality in the catchment is consistent with the purpose of the Act. This can be a politically awkward argument to make.

12. Spatial and temporal variability in monitoring information, which can make it difficult to justify using generic criteria from national guidelines for setting measurable objectives and limits, without being able to confirm their appropriateness with local data.

13. The requirement for regional plans that set measurable objectives and limits to undoubtedly be more complex documents [in the need to set specific numeric objectives and limits for potential many catchments] than plans that rely on broad narrative provisions [for the whole region].

SKM (2012, p24) talked to all councils about the main barriers to water quality limit setting, and found them to be:

- A lack of political will to set limits around non-point source pollution and land use that require the management of agriculture (Gisborne and Waikato).
- The level of stakeholder/community buy in to issues (again more related to non-point source pollution).(Auckland, Bay of Plenty, Canterbury, Horizons, Marlborough, Northland, Otago, Southland, Tasman, Waikato and Wellington).
- A lack of availability of guidelines/robust science to translate ecological values to limits (Bay of Plenty, Canterbury, Gisborne, Hawkes Bay, Horizons, Marlborough, Northland, Southland, Wellington and the West Coast). Waikato had a noticeably different opinion to this in that they considered that all the

science they needed existed but what they lacked was politically will to implement the science.

- A lack of availability of guidelines to translate intangible (cultural, amenity, recreation) values to limits (Hawkes Bay, Horizons and Marlborough).
- Understanding how to trade and balance social versus economic outcomes (Canterbury, Horizons and Wellington).
- Time and resources required to develop specific limits for catchments (Chatham Islands, Northland and Taranaki).
- The ability to pollute up to any limit that is set (Taranaki).

OCAG (2011) reiterated the barriers from the SKM (2012) report. They also mention that councils raised the issue that “the speed of getting policy through the RMA process is frustrating and cannot keep up with the speed of changes to the factors affecting water quality.” (p57). Such policy delays also introduce a potential for change in councillors, and thus political support for certain policy directions. The OCAG (2011) notes that the first LAWF report (2010) outlines potential ways for increasing plan agility, which might address this barrier.

All the above (SKM 2012, LAWF 2010, OCAG 2011) were conducted pre-NPSFM. Some of the barriers identified in those documents, e.g. political will, have (at least in part) been removed by the NPSFM requirement to set limits.

Post NPSFM implementation, Rouse and Norton (unpublished) in their survey of regional planners also asked questions regarding challenges with implementing the NPSFM. They asked planners to list their top 5 main obstacles to implementing the NPSFM, i.e., setting freshwater objectives and limits. The open statements were grouped into categories, and the most commonly occurring were:

1. Costs (time and staff resources, investigations)
2. Availability of (catchment specific) data
3. Understanding existing/baseline conditions
4. Balancing instream and out-of-stream values
5. Lack of support for plan process (political or council staff)
6. Lack of clear process for getting parties together/getting agreement
7. Lack of understanding of/difficulty communicating complex issues.

Rouse and Norton provided a list of 23 potential obstacles to setting freshwater objectives and limits, derived from literature sources and personal observations, and asked planners to score these obstacles according to their importance, from 1 (Small barrier) to 5 (Large barrier). The mean scores are summarised in Table 4-32:

Table 4-32: Mean scores of 23 identified barriers to limit setting, from Rouse and **Norton (unpublished).**Scores are listed from highest to lowest.

Barrier	Mean
Setting objectives and limits requires significant technical expertise (planners and scientists)	3.9
It takes significant time to set objectives and limits	3.8
Legal challenges during plan hearing processes are a significant impediment	3.7
Setting objectives and limits requires a significant amount of monitoring data that is not sufficiently available	3.7
Scientific predictions about economic and social effects of resource use are too uncertain	3.5
Balancing environmental and cultural objectives against economic outcomes (i.e. making value judgements) is difficult	3.5
There is too much uncertainty about cultural effects of resource use	3.3
Obtaining community input into understanding the relative importance of competing values is difficult	3.2
Activity or value-based classifications (e.g. RMA Schedule 3 classes) are not good enough for limit setting	3.2
Politics (local and regional) significantly hinders objective and limit setting	3.2
Scientific predictions on environmental effects of resource use are too uncertain	3.1
Physical classification systems (e.g. REC, FENZ etc) are not good enough for limit setting	2.9
Setting objectives and limits is complex and leads to unwieldy plans	2.9
Available classification system tools (see following 2 rows) don't adequately deal with environmental variability	2.8
There is not a nationally defined, consistent process to follow for setting freshwater objectives and limits	2.7
Methods for setting limits vary across the country and this creates confusion and inefficiency	2.6
There is inconsistent use of terminology around limit setting between planners, lawyers, scientists and others	2.6
Identifying values associated with water quality is difficult	2.6
Obtaining community input into the value-judgement making process is difficult	2.6
Regional variability in water bodies and their values makes it difficult to set objectives and limits across regions	2.6
Implementation and acceptance of limits, once set, is a significant obstacle	2.6
The different roles of planners, scientists, stakeholders, advocates and decision-makers is not always clear	2.5
The planning framework provided for in the RMA creates obstacles for limit setting	2.5

The largest barrier according to the mean scores in Table 4-31 is "Setting objectives and limits requires significant technical expertise (planners and scientists)" with a mean score of 3.9. The smallest barriers (both scoring a mean of 2.5) are "The different roles of planners, scientists, stakeholders, advocates and decision-makers is not always clear" and "The planning framework provided for in the RMA creates obstacles for limit setting".

However Rouse and Norton noted that many of these obstacle statements scored a minimum rank of 1 AND a maximum rank of 5, which demonstrates that planners from different regions can have very different views on what is a barrier for them.

Rouse and Norton also asked, "To what extent is the lack of science knowledge an obstacle to limit setting?". Two of 13 council planners said "Not at all – there is plenty of science", and 11 of 13 said "There is some science but it isn't addressing all the needs". No councils answered "Big obstacle – no science available to help".

The recent focus on setting catchment load limits (i.e. moving right down the objectives – limits cascade to the far right boxes of Figure 4-1) has highlighted a number of specific technical challenges in addition to those identified above. These include (but are not limited to) the difficulties in estimating existing and future loads of contaminants (loads being the key to water quality limits). These issues arise because:

1. It can be hard to estimate non-point "source load" by measurement, and often we need to use models (e.g. OVERSEER) that are inherently uncertain and subject to user decisions;
2. There are catchment scale processes that mean there is a difference between the source and "realised" loads (i.e. the loads that appear at the locations of interest in downstream of the sources. These processes can be categorised as 'attenuation' (natural processes by which many contaminants; N, P, sediment, bugs are lost from the system (do not arrive at the downstream point) or are transformed in a way that reduces their contamination potential) and 'lags' (the delay possibly of decades between the source and the appearance at the downstream location: for nitrogen only); and
3. There are limited experts and models that can be used to tackle these technical requirements. There is a need for greater investment in development of interoperable models for this purpose.

Attenuation and lags have big implications with respect to the utility of systems for accounting for contaminant loads, because simply adding up all the source loads in the catchment (challenging though that is) is not sufficient for limit setting – as we need to know losses and lags in order to complete a true contaminant account. However, until such time as technical expertise is able to produce better models that account for lags and attenuation accurately (if that ever is the case), councils will need to think carefully about how they address these challenges of contaminant accounting, and what assumptions they might need to make to produce workable limits to resource use which enable environmental outcomes to be achieved. Some councils are already tackling this issue.

4.6.2 Challenges and information requirements identified in this study

When the project team visited councils, we asked a number of questions relating to the challenges and information requirements of limit setting. Analysis of the answers has identified commonly occurring themes for water quantity and water quality topics, which are discussed briefly below.

Councils have either faced or anticipate facing a number of challenges in deriving limits from freshwater objectives. For example:

- Time and effort required for the collaborative process, including working better with iwi/hapu
- Helping communities to understand the information presented so that they can help the limit-setting process
- Supporting scientists in the new arena of presenting science to lay audiences
- Understanding land use change implications in urban settings (e.g. change from sheep to houses)
- Understanding groundwater legacy effects
- Illustrating costs and benefits of limit setting
- Presenting uncertain science (groundwater-surface water, nutrients in catchment) to community
- Overcoming resistance to change, especially where existing operations perceive threat to their activities
- Cost implications – planning, monitoring, compliance, resource care/educators (for voluntary Best Management Practice (BMP) approaches)
- Setting guidelines for BMP activities
- Difficulty setting load limits for sediment and *E.coli*
- Availability of (affordable) tools.

Councils identified a number of potential uncertainties that may arise in the limit-setting process, and in some cases were able to offer ways to manage these uncertainties. These are summarised in Table 4-33 below for water quantity and quality, and include process, logistics and technical issues. There is overlap between the uncertainties identified in this table and the list of challenges above.

Table 4-33: Uncertainties and management approaches with regard to limit setting.

Uncertainties	Management approaches
Management process during limit setting, i.e. being able to hold the line until investigations into appropriate limits completed	Adopting default regimes provides some protection.
Development of clear policies	Needs work and funding to understand long term goals and water allocation objectives to develop clear policies
Costs and benefits information	Needs work and funding for development of better economic and social indicators, data / information Use scenarios to explore and explain different options
How to incorporate things like climate change into 10 year limits	Include scenarios for changing water supply Signal potential for change in RPS/ regional plan issues and objectives

Uncertainties	Management approaches
Modelling costs and robustness – especially multi-scale resolution	Use models to provide indicative ranges, state assumptions and uncertainties
How to use catchment or water management unit load limit to assign an allocation to landusers	Learn from other councils, develop catchment budgets – guidance would be useful
Setting numeric 'hard' limits	Providing for a +/- factor – needs agile policy
The extent to which industry best management approaches (e.g. nutrient management) can deliver environmental outcomes	Monitoring of improvements in on-farm losses
Collaborative process	Require experts to sign up to Environment Court's code of conduct Have good facilitators to manage collaborative group discussions
Stakeholder and wider community understanding	Improve community awareness about issues, regular reporting to and involvement with stakeholders
Iwi - different understanding from 'western' science approaches, can also be different understanding between iwi/hapu	Start communicating as soon as possible, maintain communication, allow time for this Learn from others about co-governance
Science uncertainties: • in general	Precautionary limits until better/more long term data collected and ongoing investigation into health and trends of aquatic systems
• when communicating with the community	Scientist need good communication skills, especially to explore disjoints between prediction and current effects
Dealing with over-allocation sustainably prior to common expiry date for the water body	Working to get an agreement with water users, before the expiry date; consent variation on the consent renewal
Limits subject to legal challenges as limits approached - consent process may undermine policy intentions	Needs clear policy to aid decision makers
Uncertainty about timing and content of Government guidance about limit setting and development of National Objectives Framework (NOF)	Need to work with MfE/Water Directorate
Costs – e.g. scale and scope of monitoring required is unclear and also ability to pay at a regional/local level	Potential to budget via long-term planning (with-in reason) for cost of different 'work streams' related to giving effect to the NPSFM
Need for models which can integrate water quantity (surface and ground water) and quality issues to improve catchment based planning	Communicate needs and work with model developers Test existing models (e.g. MIKESHE)
Cumulative effects of groundwater abstractions on groundwater and surface water bodies	Undertake project work to estimate this and/or share outcomes between councils
Uncertainty about science of groundwater lags and attenuation	Undertake project work to estimate this and/or share outcomes between councils
Lack of understanding about multiple stressors	Undertake project work to estimate this and/or share outcomes between councils Improve communications between CRIs and councils to understand outcomes from MBIE funded research in this area (and more generally)

Every council identified capacity issues in setting limits. The time taken for limit-setting processes can be very long (cf. Taupo). Staff of all types (planning, monitoring, compliance, resource care/educators, science) will be required for this work. Some smaller councils will continue to rely on external expertise for science inputs (and value EnviroLink funding that covers the translation of science to management for that). Some councils are highly reliant on a very small number of key staff. Once limits are set, councils' efforts and resources will shift to the managing within the limits and subsequent review of limits. There is a recognition that some staff will thrive in the 'new' collaborative process, whereas some will find it challenging. Nationally, it is thought there are a limited number of people with sufficient science, planning and on-the-ground experience to fully engage in the limit-setting processes. More training or support may be required for new and existing staff taking on this role.

In terms of information requirements for limit setting, councils overall thought they have sufficient information to deal with water quantity. The main issue mentioned was groundwater information and modelling, and in particular integrated surface water-groundwater models. It was noted that councils need to pre-empt changes in demand for a catchment and start gathering information early before the intended limit-setting process starts.

Information requirements for water quality were generally greater than for quantity. Key needs for water quality included better information on groundwater-nutrient lags and attenuation, catchment models capable of integrating with water flows, improved periphyton-nutrient-flow models, relationships between water quality and aquatic ecosystem health, improved information on contaminant loss mitigation methods from different landuse types, and more information across a variety of flows (not just low flows). Good tool kits to help establish BMPS were also desired.

When asked, "What else do you want to tell us about limit-setting processes and methodologies?", the responses included:

- The importance of monitoring information such as water metering (i.e. accounting) to help develop and then manage within limits
- The need to improve understanding and modelling of the interconnection between surface water, groundwater and water quality science
- The challenge of communicating the science better to non-technical people as part of a collaborative process
- Helping communities understand the importance of water quality limits (where they are more comfortable with quantity limits) and how their activities may be impacting on water quality – especially challenging in the face of uncertain science and models (lags and attenuation etc.)
- The need for guidance to be developed that is 'fit for purpose' for the issues in a WMU/catchment/region – not one size fits all
- The importance of partnerships between community, industry, councils and government to develop tools and methodologies.

4.7 Summary of limit setting

Through this section we have tried to develop a picture of the extent to which jurisdictions, regions, and catchments have in place a framework covering the full length of the Figure 4-1 cascade. At the jurisdiction level all have at least the first box and some have the second and third (numeric objectives or receiving water standards). At regional level most have proceeded to the third box (concentration based receiving water criteria).

Progress to the fourth and fifth boxes varies and only occurs for catchment-scale examples, generally where obvious over-allocation has prompted the action (e.g. TMDLs in the USA for impaired water bodies, New Zealand lake examples such as Taupo, Rotorua Te Arawa lakes, Waihora/Ellesmere, Wainono lagoon, and for the Manawatu River). In New Zealand we are also trying to set resource limits pre-emptively before over-allocation occurs (e.g. Lake Benmore, Hurunui River). To do this, a clear picture of water abstractions and contaminant sources (i.e. accounting) is needed, in order to allocate load allowances across enterprises at the catchment scale.

Our evaluation of councils suggests that overall councils are making good progress with limit setting, particularly for water quantity and for water quality in high risk catchments and lakes.

Setting of minimum flows is common among all councils, and the setting of allocation limits is becoming more so. Some councils are also considering the role of ‘other’ flows (flushing flows, mid-range flows, flood flows) in maintaining healthy instream environments and meeting needs of recreational and other users. Methods used to do this are at least equivalent to international approaches.

Water quality/contaminant limit setting is in its infancy and there are more scientific uncertainties. Not all councils are setting limits for water quality yet. A TMDL style approach has been used by Horizons and Environment Canterbury (NDAs), and appears transferrable. Again such methods are equivalent to international approaches. However, from a water quality perspective progress is variable by contaminant, and for instance while nutrients are being tackled, councils are grappling with the different methods for setting limits in regard to other contaminants such as *E.coli* or sediments.

In general, councils’ approaches are technically robust, practical, transparent, and adaptable. The exception is possibly in the practicality of using intensive and time-consuming methods for limit setting (including collaborative processes) for all catchments in a region. In terms of adaptability of systems, adaptability between regions is variable because systems have been developed first and foremost to address regional needs.

Councils have noted that there are many challenges to limit setting, including time and staff resourcing to go through these processes (especially in a collaborative way). There are process and technical uncertainties, although some councils have identified management approaches that can be used to overcome these challenges.

Councils have also identified the significant costs required to go through such limit-setting processes. Policy development such as Horizons’ POP or WRC’s Taupo V5 cost in the vicinity of $20m, although these policies were broader in scope than NPSFM required limit setting.

Given the administrative burden of calculating contaminant load limits, some councils there may be room for some pragmatism in the approach taken. Some councils have suggested that there may be merit in developing some form of trigger or threshold, so that councils don't have to go to the trouble of setting load limits everywhere for every contaminant where the administrative burden is unjustified. The USA trigger of identified already 'impaired' water bodies may be considered too reactive, and a better one might be to develop a trigger based on "at risk" catchments first, where resource use pressure and sensitivity is predicted to be high. The current initiatives in the Reforms 2013 workstream, such as the proposed National Objectives Framework, should address this issue. For these catchments, load limits should be set (box 5 of the cascade) whereas elsewhere (in lower risk catchments) limits in the form of catchment concentrations (box 4) may be more appropriate.

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6 References

Acreman, M., Dunbar, M., Hannaford, J., Mountford, O., Wood, P., Holmes, N., Cowx, I., Noble, R., Extence, C., Aldrick, J., King, J., Black, A., Crookall, D. (2008) Developing environmental standards for abstractions from UK rivers to implement the EU Water Framework Directive. *Hydrological Sciences*, 53(6): 1105-1120. December 2008.

Environment Canterbury. (2012) The preferred approach for managing the cumulative effects of land use on water quality in the Canterbury region: A working paper. *Environment Canterbury report*, January 2012. 36 p.

Environment Agency. (2001) *Water Resources for the future: a strategy for England and Wales*. English Environment Agency, England, March 2001. 96 p.

Hill Young Cooper. (2008) Water Allocation Policy Stocktake. Prepared for Local Government New Zealand and the Resource Managers Group.

Howard-Williams, C., Snelder, T.H., Norton, N., Hickey, C., Cooper, B. (2010) *The European Water Framework Directive and the applicability of the underlying science for New Zealand.* Paper to the Land and Water Forum, February 2010.

Land and Water Forum. (2010) *Report of the Land & Water Forum: A fresh start for freshwater*. Wellington: Land & Water Forum, September 2010.

Land and Water Forum. (2012a) *Second Report of the Land & Water Forum: Setting limits for water quality and quantity & freshwater policy-and plan-making through collaboration Wellington*. Land & Water Forum, April 2012.

Land and Water Forum. (2012b) *Third Report of the Land and Water Forum: Managing Water Quality and Allocating Water. Wellington*. Land & Water Forum, October 2012.

Ministry for the Environment. (2011) *National Policy Statement for Freshwater Management 2011: Implementation Guide.* Wellington: Ministry for the Environment. ME 1077, November 2011.

Ministry for the Environment. (2013) *Freshwater Reform 2013 and beyond*. Wellington: Ministry for the Environment, ME1109, March 2013.

New Zealand Government. (2011) *National Policy Statement for Freshwater Management 2011*. New Zealand Government, Wellington, May 2011.

Norton, N., Snelder, T.H., Rouse, H.L. (2010) Technical and scientific considerations when setting measurable objectives and limits for water management. *NIWA Client Report* prepared for MfE.

OCAG. (2005) *Horizons and Otago Regional Councils: Management of freshwater resources.* Wellington: Office of the Auditor-General, May 2005.

OCAG. (2011) *Managing freshwater quality: challenges for regional councils. Performance audit report*. Wellington: Office of the Auditor-General, September 2011.

Redeker, M. (2009) 493million people and 1 Water Framework Directive for integrated and sustainable water resource management in Europe – a look beyond the rim of the teacup. *Opus report* for WaterNZ.

Rouse, H.L., Norton, N. (2012) *Setting water quality limits in regional plans: how are we doing?* New Zealand Hydrological Society Conference, 27-30 November 2012, Nelson.

Rouse, H.L., Norton, N. (Unpublished) *Obstacles to using limits to manage freshwater quality in New Zealand: Current trends and early suggestions for a way forward*. DRAFT report, prepared for MSI contract C01X1005. (Due for completion September 2013).

Roygard, J., McArthur, K. (2008) *A Framework for Managing Non-Point Source and Point Source Nutrient Contributions to Water Quality*. Technical Report to Support Policy Development. Horizons, October 2008, 202pp.

SKM. (2012) *Regional Council Practice for Setting and Meeting RMA-Based Limits for Freshwater Flows and Quality*. National summary report. Prepared for MfE. Snelder et al. 2013

Snelder, T.H., Norton, N., Howard-Williams, C. (2010) *Options for freshwater management in New Zealand using the principles of the European Union Water Framework Directive (WFD)*. Paper to the Land and Water Forum, March 2010.

Snelder, T.H., Rouse, H.L., Franklin, P.A., Booker, D.J., Norton, N., Diettrich, J. (2013) The role of science in setting water resource use limits: a case study from New Zealand. *Hydrological Sciences Journal, Special Issue – Environmental Flows*. DOI:10.1080/02626667.2013.793799.