TOWARDS THE NEXT GENERATION DRINKING-WATER STRATEGY

A discussion paper

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A discussion paper

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SUMMARY

The Ministry of Health's drinking-water strategy of the past 15–20 years has seen steady improvement in compliance with the drinking-water quality standards. As a result of this strategy, New Zealand's drinking-water quality management programme is now based on risk management principles. The question, in relation to the drinking-water quality management programme, now arises of "Where to next?"

This project aims to provide guidance on the development of the next drinking-water strategy. To do this the authors have reviewed information available from other jurisdictions with drinking-water quality management programmes considered to have reached a similar stage in drinking-water quality management as New Zealand, namely, Singapore, England and Wales, Australia, the USA and Canada. All of these countries are following a risk management-based approach to water supply management; none are working to a new paradigm. Having identified the challenges they expect drinking-water quality to face over the coming years, they have put in place research programmes to help meet these challenges.

We believe a similar approach should be used to develop New Zealand's drinking-water strategy. To provide a focus for the strategy, a goal for New Zealand's drinking-water quality needs to be stated. We suggest the following, or some variation:

All New Zealanders have access to a reliable supply of safe drinking-water

With the identification of a goal, the function of the strategy becomes one of ensuring that New Zealand's drinking-water quality management programme is robust enough to meet the expected challenges while reaching the stated goal.

The goal will be best achieved through co-ordinated governance of drinking-water quality management. This should involve organisations with environmental responsibilities or undertaking environmental research, as well as the Ministry of Health, because of the influence activities in the environment have on drinking-water quality.

We have suggested five steps, based on risk management principles, for developing the strategy, namely:

1. *Identify the challenges the drinking-water quality management programme faces*
2. *Determine the consequences of inadequately addressing a challenge*
3. *Assess what can be done to meet the challenges and implement these measures*
4. *Evaluate the success of these measures and continue to monitor the effectiveness of measures already in place*
5. *Identify what can be done to mitigate the effects of challenges being inadequately addressed and implement these measures.*

Development of the strategy is outside the project's scope, but the review of information available from overseas jurisdictions shows that the challenges to drinking-water quality in these countries are broadly similar to those in New Zealand. We have recorded the directions

of scientific research being taken in these countries in response to these challenges. Maintaining awareness of the outputs and outcomes of these foreign research programmes will be an important mechanism in the development of measures to meet the challenges to drinking-water quality in New Zealand. Establishment of a process to achieve this is a key component of the next-generation drinking-water strategy.

1. INTRODUCTION

1.1 The New Zealand context

The Ministry of Health has followed a strategy for the past 15–20 years that has steadily improved compliance with the *Drinking-Water Standards for New Zealand* (the *Standards*)[1]. The heart of the strategy promotes a paradigm shift in thinking and action from end product monitoring to whole-supply preventive risk management. The strategy has guided the improvement of drinking-water quality management to the stage of:

- having a clear definition of what is considered safe drinking-water
- having the national picture of compliance with the *Standards* and communicating this to New Zealanders
- encouraging water suppliers to take responsibility for providing safe drinking-water and demonstrating the drinking-water complies with the *Standards*
- raising the standard of knowledge and consistency of application of this knowledge for designated health officers
- introducing an effective statutory basis for the public health protection of drinking-water supplies.

New Zealand's drinking-water quality management programme is at a crossroads. The programme's future direction will be influenced by the goal New Zealand wants to set for water quality and supply, the extent to which this goal is currently met in New Zealand and external challenges to maintenance of acceptable water quality and its reliable supply.

1.2 Purpose of Report

This report presents an approach for developing the next drinking-water strategy, but does not propose the strategy. To help the discussion about 'where to next' for New Zealand's drinking-water, the report summarises the challenges to drinking-water supply seen by overseas jurisdictions, the research they are undertaking to meet these challenges and reach their drinking-water quality goals, and it discusses how the research from these countries could contribute to addressing the challenges New Zealand faces.

1.3 Report Structure

The report begins by summarising reviews of information from five overseas jurisdictions (Singapore, England and Wales, Australia, the USA and Canada), focusing on the situations they face and the ways they are addressing the challenges they face (Section 2). Section 3 examines the New Zealand situation – what constitutes our drinking-water quality management programme and what challenges drinking-water quality faces. It considers what the function of a drinking-water strategy might be, and how a strategy might be developed. The key challenges to drinking-water quality identified by the selected jurisdictions are then reviewed to explore how science could be used to help address the challenges New Zealand faces, and how overseas research may be harnessed for New Zealand's benefit. Appendix 1 details the information gathered from the five jurisdictions under the headings of: Country Drinking-Water Landscape; Responsibilities and Regulations; Processes and Tools; Reporting and Performance; Vision; Challenges; and Scientific Research Priorities.

[1] Ministry of Health. 2008. *Drinking-Water Standards for New Zealand 2005 (Revised 2008)*. Wellington: Ministry of Health. Available at http://www.moh.govt.nz/water/

2. INFORMATION FROM SELECTED COUNTRIES

2.1 Selection of Similar Overseas Jurisdictions

The report uses the following list of features as the basis for considering an overseas jurisdiction as having reached a similar stage in drinking-water quality management as New Zealand. Not every jurisdiction selected has every feature, but each has the majority of them.

- The country has adopted a whole supply, or source-to-tap, preventative risk management approach, known as public health risk management planning (PHRMP) in New Zealand, or Drinking-water Safety Planning (DWSP) elsewhere.
- The country has a clear definition of what is considered safe drinking-water, a drinking-water standard.
- The country reports nationally on compliance with drinking-water standards.
- The country's water suppliers have the responsibility for providing safe drinking-water and demonstrating the drinking-water complies with the standard.
- The country has drinking-water quality legislation.

On this basis, we have selected Singapore, England and Wales, Australia, the USA and Canada. Specific information including population is included in the appendix. The following overview focuses on conceptual aspects of each jurisdiction's approach to drinking-water management

2.2 Information Retrieval

Government regulatory agency, water utility and international agency websites were searched to obtain information about each country's situation and visions. We specifically searched for information about roles, responsibilities and regulations, management approaches and supporting tools, quality compliance information, current issues, visions for the future and scientific research priorities. This information is detailed in Appendix 1. The key websites searched and web pages from which information was drawn are listed in Appendix 2.

Australia, Canada and the USA have federal systems of government. Information about Australia and Canada was sought from the websites of federal or national organisations and *selected* state or provincial websites. To gather information about the USA, only websites of federal agencies or national organisations were searched.

2.3 Country Summaries

This section summarises key findings about the selected jurisdictions.

2.3.1 Singapore

Singapore is a small country and has a limited catchment to provide it with the water resources it needs and fulfil a demand for water that is expected to double in the next 50 years. To become self-sufficient in water, Singapore is turning to producing water from sources New Zealand does not need to consider at present, including secondary effluent (termed NEWater) and seawater. To achieve this, it is investing heavily in research to

develop technologies that will allow the production of safe drinking-water from these sources. To help Singapore achieve its 50-year goal, it has set quantified targets to be met in the next 10 years.

While Singapore's geographic size has contributed to problems with water scarcity, it also ensures that the political will to achieve its goal can be driven by central government and that this motivation is not dissipated among different states or provinces as is the case in some larger jurisdictions.

2.3.2 England and Wales

Water supply in England and Wales differs from the other jurisdictions considered in that it is run by private companies. As a result, the system is heavily regulated to ensure consumers' interests are protected. The UK Government's vision for water supply out to 2030 considers the water cycle as a whole, with the protection and sustainable use of water resources being important components. The Government invests heavily in water-related research because of its responsibilities for the implementation of the European Union's Water Framework Directive, which requires member states to achieve good qualitative and quantitative status of their water bodies (surface and groundwater) by 2015..

2.3.3 Australia

Australia is the driest inhabited continent. The scarcity of water is compounded by most of the continent's water draining away from the areas that demand at least half of the country's water. Climate change is expected to increase the pressures on water sources, and may already be doing so. The water industry is aware of this and systems recycling wastewater (eventually for potable use) and desalinating seawater are already in use. A water market has been established to use market forces to manage competition for water resources. The federal government has implemented initiatives providing leadership to give cohesiveness to the efforts of the states and territories in addressing water supply challenges. Water Quality Research Australia is a not-for-profit company that evolved from the Cooperative Research Centre for Water Quality and Treatment that operated for 13 years under funding from the federal government and water utilities. Its members include industry, government and universities, and it establishes its own research priorities for water quality, which include the areas of emerging contaminants, cyanobacteria/toxins, optimising treatment and the problems of remote water supplies.

2.3.4 USA

Water scarcity, exacerbated by expected climatic changes, is a major challenge in the USA. The water sector has recognised that water resources cannot sustain the growing demand for water and that there is a need for the wiser use of water. The United States Environmental Protection Agency (USEPA) and the American Water Works Association (AWWA) have taken initiatives to help make more efficient use of water. The USEPA's drinking-water strategy is primarily focused on protecting the consumer from contaminants, particularly new contaminants and contaminant mixtures. Its approach to protecting drinking-water quality is to remove contaminants as groups, rather than individual contaminants, and it aims to develop new treatment technologies to achieve this. Aging infrastructure and the cost of replacing it are major challenges for drinking-water utilities. A major contribution to research funding is made by the Water Research Foundation which has invested $US460 million in drinking-water research since it was founded in 1966.

2.3.5 Canada

Although not a dry country like Australia, Canada suffers from the same problem of catchments draining to the north while the bulk of its population is in the south. There is no unifying federal drinking-water strategy, with responsibility for drinking-water quality management resting with provincial governments. However, the federal government plays a stronger role in protecting environmental waters, which benefits drinking-water supplies by ensuring better quality source waters. The influence of the recommendations from the Walkerton incident inquiry varies across the country (particularly Ontario) in relation to provincial approaches to drinking-water quality management. The importance of multiple barriers, and particularly source water protection, is acknowledged. Like the USA, Canada has a high per capita water usage, and programmes to make water more wisely used are underway to help alleviate problems of water scarcity that climate change may compound in parts of the country.

A summary of key challenges identified for all jurisdictions is provided in Table 1 in the next section.

3. DISCUSSION: A NEW GENERATION DRINKING-WATER STRATEGY

This section does not develop a drinking-water strategy. It explores what the function of the strategy could be, ideas for steps to its development, and how the challenges facing drinking-water quality could be linked to the existing drinking-water quality management programme. It also discusses in more detail the importance of collecting science intelligence to the strategy and how this might be done.

3.1 Function of the drinking-water strategy

As noted in Section 1.1, the Ministry's strategy that has been operating for the past 15–20 years has established a drinking-water quality management programme with several components. We do not see the next generation drinking-water strategy being a new approach, rather it will continue to use the same tools to work to the goal while addressing the challenges to future-proof the strategy.

We are unaware of a stated drinking-water quality goal. To provide a reference point for this discussion we propose the following, or some variation, as a goal for New Zealand's drinking-water quality:

All New Zealanders have access to a reliable supply of safe drinking-water

Drinking-water is sourced from the environment. As a result, maintenance of drinking-water quality depends, in part, on environmental management. In New Zealand, responsibility for environmental management falls outside the jurisdiction of the Ministry of Health. Consequently, although the Ministry of Health may take prime responsibility for drinking-water quality, achievement of the drinking-water quality goal will be best achieved through co-ordinated governance by a range of organisations whose policies, activities or research affect the environment. These organisations include the Ministry for the Environment, the Ministry of Agriculture and Forestry, Local Government New Zealand, regional councils, the crown research institutes and other science providers. This group is referred to as the "stakeholders" in the following discussion.

3.2 Strategy development

To fulfil its function, the strategy would ensure that the drinking-water quality management programme is robust enough to meet the drinking-water quality goal, irrespective of the challenges to reliably safe drinking-water that may arise. Some challenges we know, while others may only become apparent in the future. As well as putting in place actions to address known challenges, the strategy would need to include processes for identifying as yet unknown challenges, in order that actions could also be taken to address them.

To help guide the development of the strategy, the risk management principles that underlie the risk management planning for individual water supplies could be used, stepwise, as follows:

1. *Identify the challenges the drinking-water quality management programme faces*

Inability to cope with the challenges could result in waterborne disease outbreaks or increased levels of illness arising from chronic exposure to contaminants. Possible challenges can be divided into two categories:

a) Those the stakeholders can address through work that is scientific in nature

   These challenges include emerging contaminants, catchment protection and the need for adaptations in response to climate change and variability. (A more complete discussion of these challenges is given in Section 3.3.)

b) Those the stakeholders may not be so readily able to address

   These challenges relate to governance, economics and social factors. For example, water suppliers are likely to face continuing pressures to "do more with less". There may also be moves to "rationalise" water supplies, that is, gain economies of scale through amalgamation.

2. *Determine the consequences of inadequately addressing a challenge*

   As resources are unlikely to be available to address all challenges at once, this information will help in deciding the order in which they should be addressed.

3. *Assess what can be done to meet the challenges and implement these measures*

   Generic approaches for addressing challenges are discussed in Section 3.3.

4. *Evaluate the success of these measures and continue to monitor the effectiveness of measures already in place*

5. *Identify what can be done to mitigate the effects of challenges being inadequately addressed and implement these measures*.

3.3 The challenges

Identifying the challenges to drinking-water quality is key to determining what the strategy would need to do to achieve the drinking-water quality goal from the basis of the existing drinking-water quality management programme.

Figure 1 visualises the links between the drinking-water quality management programme and the challenges presently facing drinking-water quality in New Zealand. There must be a sound basis from which the drinking-water strategy can operate. The upper box of the figure contains the components this foundation needs. New Zealand's existing drinking-water quality management programme essentially contains these components (although the research component is limited), namely (box numbers in the list below refer to Figure 1):

- New Zealand has scientifically-based drinking-water standards (Boxes 1, 2 and 3)
- health legislation, when it comes into force, will require community water suppliers to take all practicable steps to comply with the Standards
- a risk-based framework for the management of water supplies is required and supported (Box 4)

- a national reporting system provides feedback on how well management systems are achieving safe drinking-water (Box 7)
- there is financial support for small water suppliers (Drinking-Water Assistance Programme) (Box 9)
- suitable technology is available in New Zealand that removes known contaminants (this includes conventional processes properly operated and new technologies) (Box 8)
- regulations designed to protect source water quality are in place (Box 6)
- limited centrally-funded research is undertaken[2] (Box 5)
- resource consent processes and associated regulations ensure that water supply needs from source waters are taken into account when water allocations are decided (Box 10).

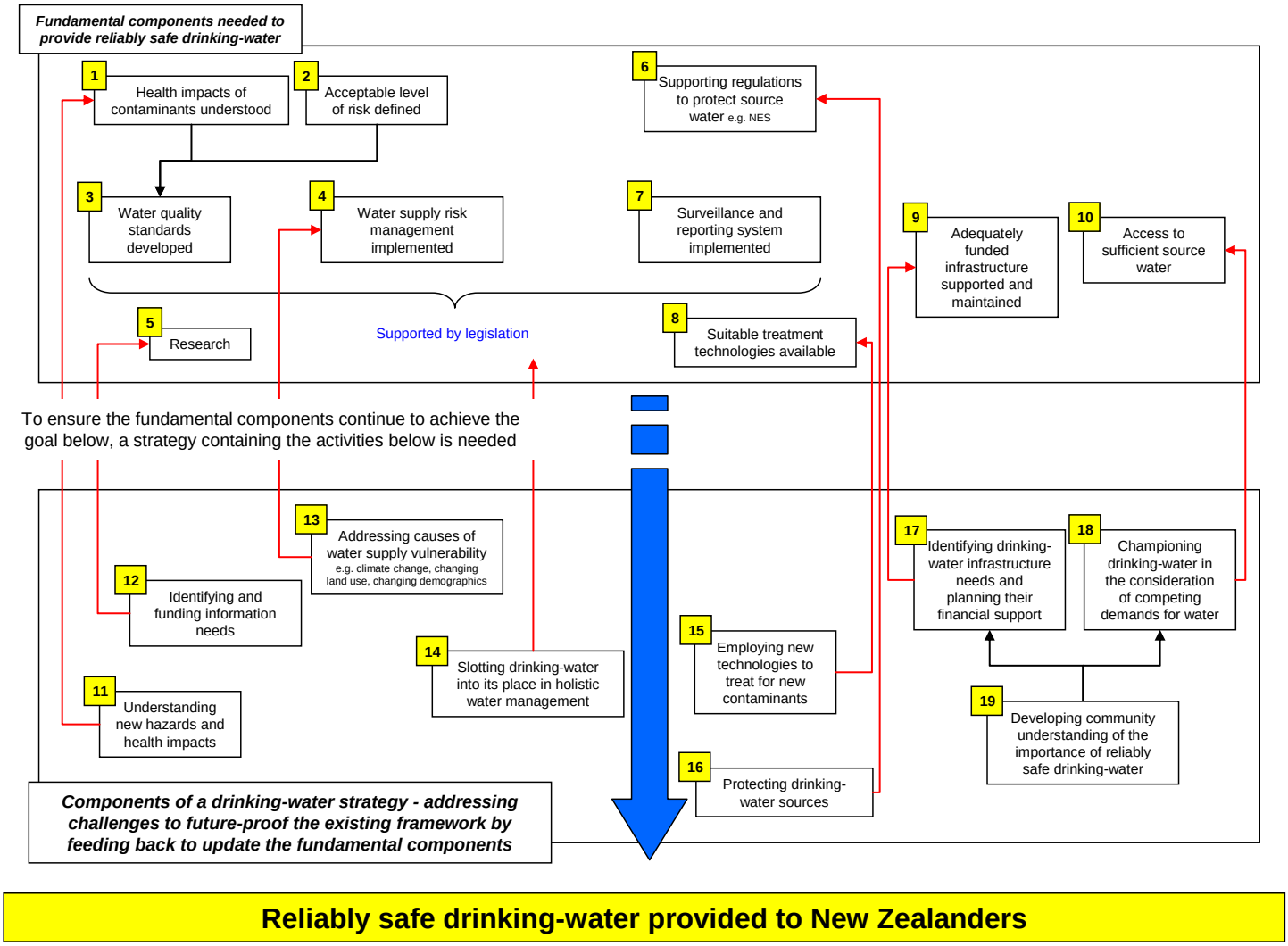

Figure 1 Key features of a drinking-water strategy

[2] Foundation for Research, Science and Technology and Ministry for the Environment. 2009. *Water Research Strategy*. Wellington: Ministry for the Environment.

From our understanding of the New Zealand context, the following are the challenges to drinking-water quality that the new strategy will need to address (box numbers refer to Figure 1).

- assessing the health burden of waterborne disease and attributing its source (Box 11)
- allowing water suppliers sufficient control over their source catchment or recharge zone to properly manage their water supply (Box 16)
- increasing contamination of source waters from land-use changes, including intensification, particularly those driven by economic development, and assuming that treatment technologies will provide a sufficient barrier to the higher levels of contamination (contrary to the multi-barrier approach to risk management) (Box 16)
- managing risks associated with emerging contaminants for which safe exposure levels are unknown because infectivity or toxicity data are unavailable, and the ability of conventional treatments to remove these contaminants from water being unknown or limited (eg, pharmaceuticals and cyanotoxins) (Boxes 11 and 15)
- increasing the ability of water suppliers to protect against greater pathogen concentrations in water sources resulting from the increasing frequency of floods and droughts brought about by climate variability and change (Box 13)
- taking practical steps to reflect the national value of drinking-water and community water supplies acknowledged in the 2011 National Policy Statement on Freshwater Management (Boxes 14 and 18)
- overcoming the resistance of some water suppliers to invest in water supply improvement because they believe that waterborne illness does not occur and consequently that expenditure on improvements cannot be justified (Boxes 17 and 19)
- addressing the lack of appropriate levels of research in New Zealand to support robust provision of safe drinking-waters, noting that New Zealand research is not needed for generic information (eg, infectivity data) but is needed for New Zealand-specific questions (eg, what levels of pharmaceuticals are challenging New Zealand treatment plants, and are the conventional treatment processes in use providing a satisfactory barrier?) (Box 12). Research supports most of the information and decisions required to implement the activities identified by the boxes in the lower part of Figure 1.

The actions needed to address these challenges are contained in the lower part of Figure 1. The arrows show the links between each strategy action and a corresponding component within the drinking-water quality management programme. For example, land-use intensification leads to increased faecal contamination of source waters and requires protection of drinking-water sources (Box 16). The drinking-water quality management programme already contains a component designed for this purpose (Box 6). Thus, according to Figure 1, if drinking-water quality is threatened by faecal contamination, regulations designed to protect source waters are the component of the drinking-water quality management programme that needs to be addressed to help in meeting the drinking-water quality goal.

Figure 1 is not definitive, its intent is to provide the concepts we see as needed for strategy development. Returning to the example above, closer examination of the challenge of source water contamination may show that more than one component of the drinking-water quality management programme is required to address the challenge. The types of linkage shown in Figure 1 give broad guidance to help with implementing Steps 3 and 4 in Section 3.2.

3.4 Challenges requiring scientific solutions

Not all the actions contained in the lower box of Figure 1 require scientific input. However, most do and this section considers how the scientific data necessary for maintaining New Zealand's drinking-water quality management system could be obtained.

The new strategy needs to include a process, or processes, by which new challenges, or new facets of an existing challenge, such as emerging contaminants, are identified. Overseas jurisdictions have large active research programmes gathering information for this purpose, as well as for the purpose of developing solutions to problems already identified. New Zealand does not have a drinking-water-targeted research programme, and given its size and the commonality of challenges faced by water supplies in developed countries (see Table 1), it could be argued that significant investment in one is not needed. If this is true, sentinel activities to gather intelligence about potential challenges will be key processes within the strategy. These will help to future-proof the drinking-water quality management programme.

Table 1 Challenges for the provision of potable water identified in the various jurisdictions

	Challenge for:					
Challenge	**NZ**	**Singapore**	**England and Wales**	**Australia**	**USA**	**Canada**
Management of the water cycle as a whole	✓	✓	✓			✓
Source water protection	✓		✓	✓	✓	✓
Management of competing water demands	✓	✓	✓	✓	✓	✓
Climate variability and change	✓	✓	✓	✓	✓	✓
Affordable infrastructure (including treatment)	✓		✓	✓	✓	✓
Emerging contaminants	✓		✓	✓		✓
Wise and efficient use of water		✓	✓	✓	✓	✓
Novel water sources (eg, recycling, seawater)		✓		✓	✓	
Coordinated governance	✓			✓		✓

Table 1 summarises the challenges facing New Zealand and the overseas jurisdictions reviewed in this report. Despite the differing circumstances and different drivers affecting water quality in each country, the challenges are very similar (although prioritisations may differ). This is not unexpected. These countries were selected because of their anticipated similarity to New Zealand in the extent to which their drinking-water quality management systems have evolved. Further, the external drivers that are creating some of the challenges, such as climate change and variability, increasing demands for operation within tight financial constraints, and the increasing list of emerging contaminants, are global in scale.

Table 2 records the areas of research being undertaken in other jurisdictions to help address the challenges. It is a synthesis of the detail outlined in Appendix 1.

Table 2 Areas of research being undertaken in overseas jurisdictions that align with the challenges facing water supply in New Zealand

Challenge	Research contribution
Management of the water cycle as a whole	An outcome of meeting all of the other challenges
Source water protection	Singapore • Intelligent watershed management – aiming to predict events that may impact in water quality Australia • Pollution source tracking • Mitigation the effects of livestock access to riparian zones • Relative risks posed by sewage treatment plants • Pathogen contaminant budget models USA • Catchment risk assessment • Evaluation of best management practices for source water quality improvement • Control of pollution at the catchment scale Canada • Improved source water protection (and water allocation in catchments) through application of improved practices, technologies, monitoring and governance • Microbial source tracking
Management of competing water demands	England and Wales • Quantifying the benefits of water catchment management initiatives Canada • Risk-based cumulative effects frameworks (eg, water security index) – to help balance the demands of multiple users

Challenge	Research contribution
Climate variability and change	England and Wales • Determining the effects of climate change on algal blooms USA • Impacts of climate change on integrated resource management
Affordable infrastructure (including treatment)	USA • Understanding the potential impacts of water reuse (grey water) on human health from cross connections, improper disinfection/storage, etc. • Examining the economic costs and benefits of green infrastructure • Integrating water and wastewater management approaches to improve cost effectiveness • Educating the public about water conservation Canada • Reducing treatment operating costs • Improving treatment technology

Challenge	Research contribution
Emerging contaminants	England and Wales • Assessing emerging risks to public health – eg, lead and chromium • Enhancing the value of molecular methods • Fungi in drinking-water and implications for public health Australia • Cyanobacteria – toxin control, management, removal • Disinfection by-products (DBPs) eg, N-Nitrosodimethylamine • Pharmaceuticals and personal care products (PPCPs), endocrine disruptors, • Removal of iodide and bromide from source water • Removal of viruses and protozoa USA • Understanding the health effects of emerging pathogens, chemicals and mixtures of contaminants • Understanding the impacts on water supplies of injections into Class V wells[3] • Risk assessment of emerging contaminants • Pharmaceuticals • Improved assessment of the health effects of contaminants • Techniques for treating multiple contaminants simultaneously • Removal of emerging contaminants • Improved timeliness of analytical techniques • Pathogen infectivity – evaluation of culturing and molecular methods to address viability and infectivity Canada • Phamaceuticals • Algal toxins • Nanofibre membrane technology • DBP reduction

[3] Typically, Class V injection wells are shallow wells used to place a variety of non-hazardous fluids directly below the land surface into or above formations that contain underground sources of drinking water

Challenge	Research contribution
Wise and efficient use of water	Singapore • Water tight distribution Australia • Water footprinting Canada • Water conservation

3.5 Gathering information to support the drinking-water strategy

Section 3.4 has noted the likely importance of overseas research in supporting New Zealand's drinking-water strategy and consequently the need for sentinel activities. This section explores how these activities might work.

A possible approach to collecting supporting information is depicted in Figure 2. The first step in collecting this information would be regular monitoring of the scientific and grey literature, containing the outputs of research undertaken overseas and within New Zealand. This could include the reports on environmental health indicators produced by the Ministry of Health, because their identification of drivers and pressures with environmental impacts may warn about factors that could affect drinking-water quality. This activity would equate to Step 1 in Section 3.2. It could be assigned as one of the functions of the "Current Awareness" service presently provided to the Ministry by ESR. Rather than trying to cover all areas of research into the challenges identified in Section 3.3, the Ministry in discussion with ESR, could select areas of research on which current awareness could initially focus. The subjects that are the focus of each report could be rotated, at least initially, until enough information is gathered for the stakeholders to determine which challenge(s) is/are potentially of greatest concern to New Zealand. Broader scans of the literature should also be part of the Current Awareness service to avoid overlooking new challenges not already identified.

Having identified overseas findings that are potentially applicable to New Zealand, desk top assessments, based on an understanding of New Zealand conditions, could be undertaken to assess better the applicability of the findings to New Zealand. For example, perchlorate is an emerging contaminant of concern in groundwaters in the USA. In North America, a potentially important source of perchlorate is rocket fuel, a source of low importance in New Zealand, but there are other perchlorate sources. A desktop study would determine the need for further investigation based on perchlorate sources relevant to New Zealand. Should an assessment find that contamination of water sources by perchlorate at levels of concern is possible, surveys to provide a more accurate understanding of the exposure to the hazard through drinking-water in New Zealand would be needed to determine whether mitigating actions are required, and if so, what they should be.

The perchlorate example relates to new hazards. Overseas studies may also help in developing solutions for challenges of which we are already aware, such as the need to protect drinking-water sources. Awareness of the overseas literature, particularly the grey literature[4], may also provide ideas for addressing challenges faced by New Zealand that are not based in the biophysical sciences. Steps that can be taken to help communities reduce their vulnerability to the effects of climate variability and change are an example.

[4] This includes wide range of possible documents, but those most likely to be greatest assistance are reports from government agencies, learned societies and international bodies such as the European Union and World Health Organization.

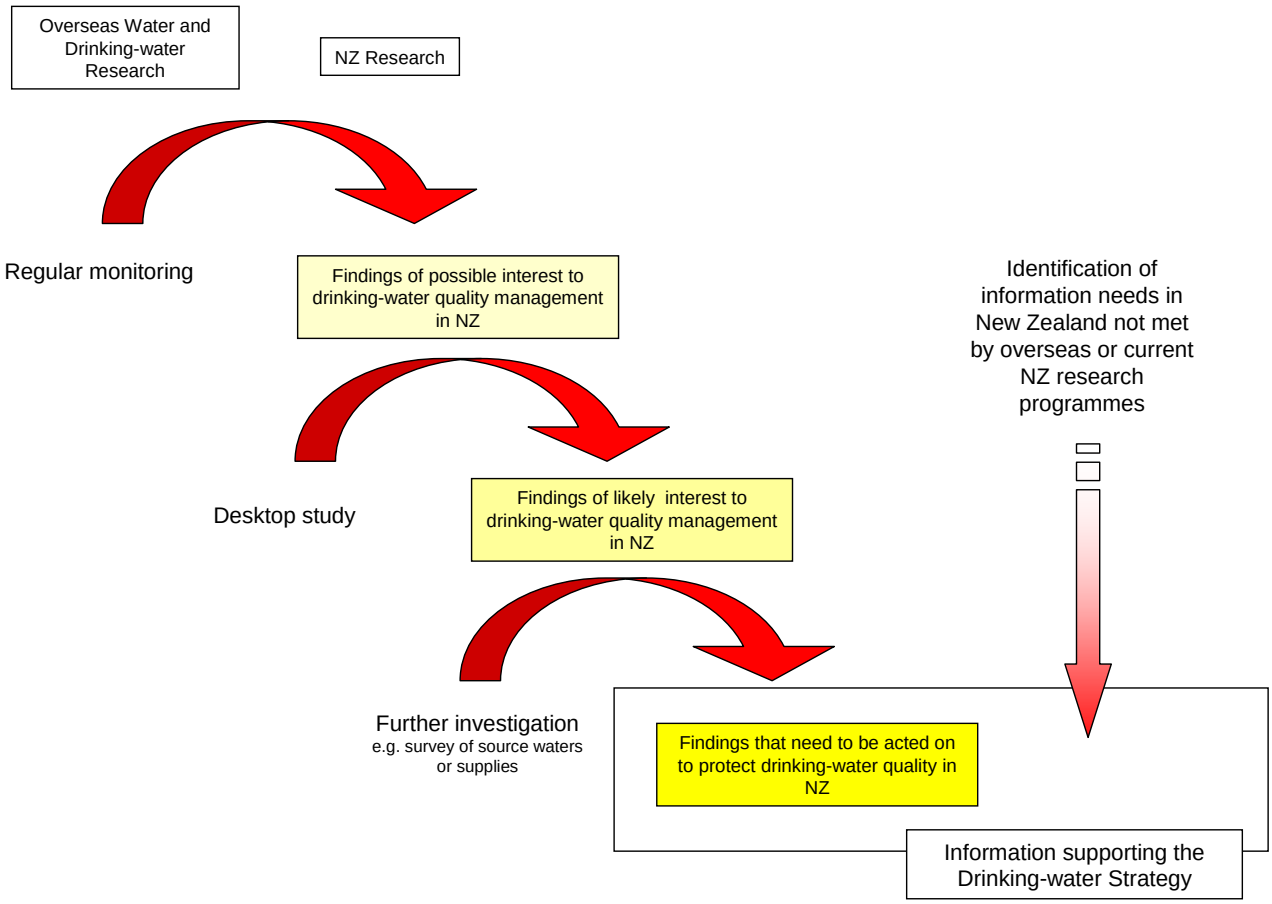

Figure 2 Possible approach to the collection of scientific information needed to support the drinking-water strategy

While the strategy needs to have an eye on overseas developments, it must also be aware of the development of needs within New Zealand for which no guidance is available from overseas work. A past example of this is the development of PHRMPs in 2000–2001. The Ministry of Health was aware of the need to encourage risk management planning by water suppliers, but the development of frameworks overseas to help water suppliers do this was in its infancy. As a consequence, the Ministry developed its own framework to help meet New Zealand's needs.

To conclude, a starting point for the collection of information to support strategy development could be to target one of the actions identified in the lower part of Figure 1 as the subject of the 2011–2012 Horizons Scanning report prepared as part of the Current Awareness service. For this year, the focus could be on addressing a cause of water supply vulnerability (Box 13).

4. CONCLUSION

Drinking-water quality management is in an evolutionary stage of development, rather than revolutionary. The information we have reviewed from other countries in preparing this report shows no indication that any jurisdiction has taken a major step forward to a new paradigm of drinking-water quality management. All continue to work within a risk management framework. Their planning is focused on meeting the new challenges they have identified.

A goal for drinking-water quality management in New Zealand is needed to focus the next generation drinking-water strategy. We propose the following, or similar, as the goal for drinking-water quality in New Zealand:

All New Zealanders have access to a reliable supply of safe drinking-water

Following the work undertaken in New Zealand over the past 15–20 years, the fundamental components required for ensuring New Zealanders are provided with reliably safe drinking-water are already in place. Consequently, the function of the strategy is to identify and implement processes to ensure the existing components of drinking-water quality management are sufficiently robust that the drinking-water quality goal can still be met despite challenges that may be encountered.

Environmental management plays a part in achieving the drinking-water goal. Consequently, organisations with environmental responsibilities, including the Ministry for the Environment, Ministry for the Environment, the Ministry of Agriculture, Forestry and Fisheries, Local Government New Zealand, regional councils, the crown research institutes and other science providers, need to be involved drinking-water quality management.

We have suggested five steps, based on risk management principles, for developing the strategy, namely:

1. *Identify the challenges the drinking-water quality management programme faces*
2. *Determine the consequences of inadequately addressing a challenge*
3. *Assess what can be done to meet the challenges and implement these measures*
4. *Evaluate the success of these measures and continue to monitor the effectiveness of measures already in place*
5. *Identify what can be done to mitigate the effects of challenges being inadequately addressed and implement these measures*.

Development of the strategy is outside the scope of this project, but a review of information available from five overseas jurisdictions has shown that the challenges to drinking-water quality in these countries are broadly similar to those New Zealand faces, and are as follows:

- management of the water cycle as a whole
- source water protection

- management of competing water demands
- climate variability and change
- affordable infrastructure (including treatment)
- emerging contaminants
- wise and efficient water use
- novel water sources
- co-ordinated governance.

This assists with Step 1 of the five steps suggested for strategy development. We have also recorded the directions of scientific research being taken in these countries in response to these challenges (assistance with Step 3). Maintaining awareness of the outputs and outcomes from these foreign research programmes will be an important mechanism by which measures to meet the challenges to drinking-water quality (Step 3) in New Zealand can be developed. Establishment of a process by which this can be done should be a key component of the next generation drinking-water strategy.

APPENDIX 1 BACKGROUND INFORMATION ON OVERSEAS JURISDICTIONS

A1.1 Singapore

A1.1.1 Country Drinking-water Landscape

Singapore is a nation of 4.9 million people, occupying a land area of 710 km^2. Singapore's challenge in ensuring it has an adequate water supply comes from its small size and limited natural resources. Water demand is expected to double in the next 50 years. In response, it has built a diverse, reliable and sustainable drinking-water supply from four different sources – local catchments including harvesting urban storm water, imported water, reclaimed water from secondary effluent, known as NEWater, and desalinated water. Two-thirds of Singapore's land area is now used to collect or store water for water supply.. Turning the entire island into a water catchment where collecting every drop of rain and keeping all water bodies clean will be crucial to meeting the demand for water. Thirty percent of the country's need can be met by NEWater and 10% by desalinated water. As of 2010, the water supply system included 19 raw water reservoirs, nine treatment works and 17 treated water reservoirs. Singapore has invested heavily in research over the last 40 years to reach its current integrated approach to solving its drinking-water supply challenges. In 2006 the government of Singapore pledged S$330 million for this research and development and training specialist personnel over the following five years.

A1.1.2 Responsibilities and Regulations

The Ministry of Environment and Water Resources manages water resources and the supply of drinking-water. Its National Environment Agency's Drinking Water Unit is responsible for regulating the quality of piped drinking-water. Officers of the unit administer the *Environmental Public Health (Quality of Piped Drinking Water) Regulations 2008* (the *Regulations*), and carry out audits and site checks. The *Regulations* include requirements for drinking-water suppliers to sample and test piped drinking-water, comply with the standards prescribed under the *Regulations,* and develop and implement drinking water safety plans (DWSPs) to minimise the likelihood of failure to comply with the water quality standards. The standards are based on World Health Organization (WHO) guidelines.

The Public Utilities Board (PUB) is the national water agency responsible for managing the supply of Singapore's drinking-water and its distribution network installed on the main island and on the offshore islands.

A1.1.3 Processes and Tools

The *Regulations* enable the issuing and approval of a code of practice that sets out requirements for water sampling plans, DWSPs and other procedural requirements for ensuring the piped water complies with the standards. The water sampling plan consists of three parts. A basic sampling plan verifies microbial quality in the distribution system throughout the year. A comprehensive monitoring plan includes all parameters specified in the *Regulations* sampled at least once a year from the finished water. The samples should be representative of the water quality produced from that source. Lower sampling frequencies can be proposed for parameters unlikely to be present in the water or present at very low levels. A sampling plan for operational monitoring is part of the DWSP. DWSP development follows the WHO approach, namely carry out a system assessment, identify

control measures and operational measures, prepare management plans, make improvements and take remedial actions, and review plans.

A1.1.4 Reporting and Performance

PUB reports that the tap water quality in Singapore is well within the WHO drinking-water guidelines and the United States Environmental Protection Agency (USEPA) drinking-water standards.

A1.1.5 Vision

Singapore's drinking-water management is driven by a 50-year vision of what it takes to be sustainable in water.

By 2020, Singapore aims to have met the following targets:

- 40% of water demand to be met by NEWater
- 25% of water demand to be met by desalinated water
- cut daily per capita consumption to 147 litres
- 820 ha of reservoirs and 90 km of waterways to be used for recreation
- research and development focused on energy efficiencies, water quality monitoring and reducing evaporation losses.

Singapore plans that by 2060 NEWater will meet 50% of future water demand. By 2060 it expects 30% of its need to be met by desalination. As agreements with Malaysia expire (2011 and 2061), imported water will cease.

A1.1.6 Challenges

Singapore's overwhelming challenge, towards which everything else is focused, is having an adequate supply of water. Ensuring the security of their water supply is judged to be key to national survival. Singapore accepts the need to produce drinking-water from poor quality sources, such as recycled grey water or wastewater, and substantial financial resources are made available to meet this challenge. Singapore also sees the importance of an holistic approach to water management and addressing this challenge is supported through national regulations.

Singapore's small geographical scale helps it in addressing its drinking-water challenges, as the strategy development of water supplies and their operation are more readily directed at a national level.

A1.1.7 Scientific Research Priorities

PUB's research and development work is centred on 'closing the water loop' and focuses on six technology areas: intelligent watershed management, membrane technology, network management, used water treatment, water quality and water treatment.

The intelligent watershed management research programme aims to enhance capability in managing water resources and flood control, for example, being able to predict and plan for future events that might impact on water quality and quantity. The membrane technology research programme supports the development of NEWater and ways of applying and

optimising membrane processes and ultraviolet technologies for water and used water treatment. Network management research supports water-tight distribution of clean water and collection of all used water for reclamation purposes. Research in the used water treatment area covers cost effective and efficient processes, sludge minimisation, biogas utilisation and odour destruction. The aim of the water quality research programme is to ensure high quality drinking-water. Real-time sampling methodology, contaminant detection method development and online data analysis are important so that emerging contaminants can be dealt with. The water treatment research programme supports the development and optimisation of innovative drinking-water treatment processes and desalination technologies.

A1.2 England and Wales

A1.2.1 Country Drinking-water Landscape

England is a nation of 50 million people, occupying a land area of 130,000 km^2. About 5% of the freshwater resources of England and Wales are abstracted by water companies. The companies use about two-thirds surface water and one-third groundwater to meet the needs of the people. The Government privatised the public water authorities in 1989. In England and Wales, water and sewerage services are now provided by 10 private regional water and sewerage companies and 16 smaller private "water only" companies. The companies own and operate approximately 1000 reservoirs and over 2500 drinking-water treatment plants. About 1% of the population of England and Wales have private water supplies to their homes (ie, not provided by a water company), mostly in remote and rural parts of the country.

England invests heavily in water-related research because of the UK Government's responsibility as the designated competent authority for implementation of EU Water Directives. Around £900,000 is spent annually on research and development in drinking-water quality issues, which have included, *Cryptosporidium*, other hazards to health such as *Mycobacterium avium*, monitoring, materials and their testing, and water supply within consumer presmises.

A1.2.2 Responsibilities and Regulations

In England, the Government sets the regulatory framework for drinking-water, and since privatisation in 1989 the regulations have been delivered through three agencies. The Water Services Regulatory Authority (Ofwat) is the economic regulator with responsibility to protect consumers' interests, including setting water prices and standards of service. The Drinking Water Inspectorate (DWI) is the independent regulator of drinking-water for England and Wales. It ensures consumers receive safe and acceptable drinking-water from water companies. The DWI also has an advisory role in relation to private water supplies. The Environment Agency monitors river and environmental pollution, and regulates to ensure water abstractions and discharges are undertaken in ways that protect the environment.

The powers and duties of regulators and water suppliers are set out in the *Water Industry Act 1991*, updated by the *Water Act 2003* to improve how water abstraction and impoundment is managed. The Act requires water companies to prepare and publicise drought plans, agree and publicise water resource management plans and advance water conservation.

The legal drinking-water quality standards in England are the *Water Supply (Water Quality) Regulations 2000* (and amendments). These are consistent with the *Drinking Water Directive 98/83/EC* that apply to all member states of the European Union. The regulation requires the water supplier to define annually the areas that are to be water supply zones for the year, not exceeding 100,000 people. The regulation prescribes standards of wholesomeness through maximum (and in some cases, minimum) concentrations and values specified for various organisms, chemicals, substances and properties. The health-based standards are based on expert global opinion documented in WHO guidelines. The regulation prescribes monitoring regimes (purposes, number of samples and sampling locations), and quality assurance requirements on analytical laboratories. Good record keeping and public access to records are required. The 2007 amendment to the regulation requires water suppliers to carry out and keep under review, a risk assessment of each of its treatment works and connected supply systems to establish whether there is a significant risk to human health. It is the supplier's responsibility to notify the Secretary of State of significant risks and measures taken or planned and provide a report on each risk assessment and review.

A1.2.3 Processes and Tools

As the independent regulator of drinking-water for England and Wales, the DWI has developed a range of tools to support its legal obligations and its aim of helping to protect public health and maintain public confidence in drinking-water. The DWI is organised into three groups – operations, regulations, and science and strategy. Drawing across the expertise base of these groups, a range of guidance notes for regulations and procedures and codes of practice have been produced, and training courses are provided periodically. The DWI uses an automatic mailing list of water industry stakeholders to communicate any changes in regulatory matters, guidance or procedures. These information letters are also available on the DWI's website.

The DWI promotes the use of the WHO Water Safety Plan approach for risk assessment and management to meet the requirements of Regulation 28 of the 2007 amendment to the *Water Supply (Water Quality) Regulations 2000*. There is a formal paper trail of check lists and assessment sheets for each risk assessment report. A database holds the information about and status of, the improvement programme for each water supply.

The DWI undertakes regular technical audits of water suppliers to examine water quality, treatment and monitoring.

A1.2.4 Reporting and Performance

The DWI produce an annual report that provides an overview of the quality of public water supplies, and comprises a Chief Inspector's Letter to Ministers (a high-level overview), regional reports (summaries of the testing and results, public confidence in drinking-water, events and technical audit activity), company look-up tables, tables of significant drinking-water quality events, and prosecutions and cautions.

A1.2.5 Vision

Future Water is the Government's water strategy for England through until 2030. It considers the water cycle as a whole, from rainfall and drainage through to discharge and treatment, and every aspect of water use. It sets a vision for sustainable delivery of secure

water supplies and an improved and protected water environment. More specifically, it is a vision that values and protects its water resources, ensures sustainable use of water resources, continues to provide high levels of drinking-water quality from taps, delivers water to customers through fair, affordable and cost-reflective charges, addresses flood risk with good surface water management, cuts water industry greenhouse gas emissions, and embeds continuous adaptation to climate change, population growth and other pressures across the water industry and water users. There are specific visions and actions for the eight identified themes: water demand, water supply, water quality in the natural environment, surface water drainage, river control and flooding, greenhouse gas emissions, charging for water and regulatory framework, and competition and innovation. Some relevant vision statements are:

- consumers using water wisely, appreciating its value and the consequences of wasting it
- a water sector contributing to the protection and enhancement of the natural environment with abstraction management consistent with habitats conservation
- a water sector planning for the long-term and medium-term needs of the environment and the community, including resilience and emergency response
- major improvements achieved from tackling problems of nutrient pollution, chemical pollution, water resources, litter and microbial contamination
- modern, effective and risk-based regulation.

The DWI outlines its short-term vision in its 2010–2015 strategic document, *Securing safe, clean drinking water for all*. Five strategic objectives contribute to this vision, as follows:

- water suppliers deliver water that is safe and clean
- the public have confidence in their drinking-water
- drinking-water legislation that is fit for purpose and implemented in the public interest
- a progressive and trusted organisation
- accessible and globally recognised technical experts in drinking-water regulation.

A1.2.6 Challenges

A major factor making the situation in England and Wales different from that of the other countries considered in this report is that water is provided to the public by companies. A consequence of this, perhaps exacerbated by the additional level of regulation imposed by the European Union, is that it is a very heavily regulated system, a fact emphasised by the number of prosecutions recorded in the DWI's annual reports.

The operation of private water supply companies may also explain why, at least as far as government agencies are concerned, the financial burden of having to replace aging infrastructure is not noted as a challenge.

The challenges England and Wales face are:

- adapting to climate change and variability

- wise and efficient use of water
- source water protection
- emerging contaminants
- planning for medium- and long- term needs of communities (possibly a consequence of private ownership of water supplies).

A1.2.7 Scientific Research Priorities

The DWI has access to research funds (through the Department of Environment, Food and Rural Affairs (DEFRA)) to gather the scientific evidence to support regulatory activity because of the UK Government's responsibility as the designated competent authority for implementation of the EU Drinking Water Directive. The research programme covers the following objectives:

- develop and implement national and European legislation
- assess emerging risks to public health via drinking-water
- contribute to and influence the international evidence base
- ensure evidence-based support to the operation and development of the UK water industry.

Examples of current research interests are:

- quantifying the benefits of water quality catchment management initiatives
- enhancing the value of molecular methods to the water industry, an Escherichia coli case study
- identifying meaningful opportunities for health risk reduction
- a review of fungi in drinking-water and the implications for human health
- understanding the significance of chromium in drinking-water
- a review of the latest evidence on lead and an estimation of intake via drinking-water
- the effects climate change might have on algal blooms and hence water treatment.

A1.3 Australia

A1.3.1 Country Drinking-water Landscape

Australia's land area is approximately 7.6 million km^2 containing an estimated 22.5 million people, 88% of whom live in urban areas. Water availability is Australia's greatest concern. To compound the problem of being the driest inhabited continent, it has been estimated that 60% of the continent's water drains to the north, while only 6% drains into the Murray-Darling catchment which has to meet 50% of the country's water demand.

To meet the demand for water and to address increasing vulnerability to droughts (which may be the initial indicators of climate change), desalination plants have been constructed (the first being a reverse osmosis plant in Perth) or are being constructed. Wastewater recycling is also being planned. The Western Corridor Recycled Water Project on the Gold

Coast will allow the recycling of wastewater for drinking-water systems, should it become necessary. The purified recycled water being produced presently is being used for industrial and agricultural applications.

Surface water resources are well known and understood, and provide most of Australia's urban water.

A1.3.2 Responsibilities and Regulations

A1.3.2.1 Federal Responsibilities and Regulations

At the federal level, the Minister for Sustainability, Environment, Water, Population and Communities has responsibility for water policy and for developing a National Water Quality Management Strategy. The process of developing the strategy, which has been underway since 1992, has involved cooperation with state and territorial governments.

There are three elements to federal water legislation.

- Water Act 2007
- Water Amendment Act 2008
- Water Regulations

Both the Water Act 2007 and the Water Amendment Act 2008 are primarily concerned with the management of the Murray-Darling Basin and the role of the Australian Competition and Consumer Commission in developing and enforcing rules of water charges and water market rules. The Water Regulations are linked to both acts. Consequently, although these pieces of legislation have an influence on those drinking-water systems that draw from water sources in the Murray-Darling basin, they do not deal directly with drinking-water.

The National Water Commission (NWC) is a federal agency which "is responsible for driving progress towards the sustainable management and use of Australia's water resources". This is being achieved through a National Water Initiative (NWI), which is described as "Australia's enduring blueprint for water reform." The NWI aims to:

- provide healthy, safe and reliable water supplies
- increase water use efficiency in domestic and commercial settings
- encourage the re-use and recycling of wastewater where cost effective
- facilitate water trading between and within the urban and rural sectors
- encourage innovation in water supply sourcing, treatment, storage and discharge
- improve pricing for metropolitan water.

The National Health and Medical Research Council (NHMRC) has responsibility for the development of the Australian Drinking Water Guidelines.

A1.3.2.2 State Responsibilities and Regulations

Individual states and territories have responsibility for natural resources, including water. State or territorial governments, through state-owned companies, provide drinking-water in Western Australia, the Northern Territories and South Australia. In Tasmania and parts of Queensland, water services are provided by companies owned by local authorities. In the remaining states, and south-eastern Queensland, state-owned services provide bulk water to local government-owned utilities.

Victoria

Victoria's Safe Drinking Water Act 2003, which took effect in 2004, was the first piece of legislation in the state to regulate water supplies. The Act requires water suppliers to provide safe, good quality drinking-water. It establishes a risk management framework from source to tap, standards for key water criteria, information disclosure requirements for water businesses, and systematic community consultation processes. The Victorian Department of Health administers the legislation. The state's Safe Drinking Water Regulations 2005, amongst other things, state what must be addressed in risk management plans, sets drinking-water quality standards, defines monitoring protocols, requires samples to be analysed by an approved analyst and requires water suppliers to provide an annual water quality report to the state.

New South Wales

In New South Wales, the Office of Water is the state agency with responsibility for environmental waters. The two key pieces of legislation it administers are the Water Act 1912 and the Water Management Act 2000. The Water Act 1912 is gradually being phased out by the Water Management Act 2000. This Act is designed to ensure the sustainable and integrated management of the state's water resources for the benefit of present and future generations.

New South Wales Health is responsible for drinking-water in the state. This entails developing standards for water quality (including for purposes other than drinking) and developing primary drinking-water standards and drinking-water quality monitoring programmes, and monitoring water supplies in the state with respect to the Australian Drinking Water Guidelines. The state endorses the Australian Drinking Water Guidelines, but there is no legislation underpinning the department's responsibilities. Part 2B of the Public Health Act 1991, appears to be the only legislation concerning drinking-water.

Western Australia

Three state departments have responsibility for aspects of drinking-water in Western Australia. The Department of Health advises on the appropriate standards for drinking-water and regulates the Water Corporation's drinking-water quality. (The Water Corporation is the water supplier to Perth and the surrounding areas, and is the primary drinking-water provider in the state.) The Economic Regulation Authority issues operational licences that specify drinking-water quality standards to water supply providers. The Department of Water's responsibility relates to water sources, in particular identifying and protecting public drinking-water source areas, preparing drinking-water source protection assessments and preparing drinking-water source protection plans.

Several pieces of legislation, or policy, support these responsibilities: the Country Areas Water Supply Act 1947, State Planning Policy 2.7, which relates to public drinking-water

sources, and the Water Services Licensing Act 2005, which provides for the issuing of operational licences.

Unlicensed small community water supplies are often managed by a local authority or a private agency.

A1.3.3 Processes and Tools

The federal government's "Water for the Future" initiative aims to provide national leadership in dealing with the challenges that face Australia in maintaining a sustainable water supply. The initiative has four key priorities, as follows:

- taking action on climate change
- using water wisely
- securing water supplies
- supporting healthy rivers.

Installing rainwater tanks is encouraged at the federal and state levels as part of the wise use of water priority.

At the national level, the NWC has undertaken a review of urban water regulations (PwC Australia 2011, *Review of urban water quality regulation in Australia*, Waterlines report, National Water Commission, Canberra). The report noted that although water quality is high, best practice is not reflected in the broader regulation of water quality. In particular, the following concerns were noted:

Governance

- Governance arrangements and policy drivers for urban water quality are complex and lack clarity.

Regulatory requirements

- Inconsistent application of best practice regulatory requirements by states or territories when adopting/legislating in respect of existing National Water Quality Management Strategy (NWQMS) guidelines.
- The NWQMS guidelines require more frequent and regular reviews and updating. Concerns have been raised that the NWQMS package is guidelines only.

Administration of requirements

- Numerous bodies are responsible for regulation of urban water quality at state and territory and local government levels.
- Diversity of guidelines results in a lack of certainty in the application of specific values. Applicability of the NWQMS guidelines can be challenging for proponents of on-site and decentralised systems.
- There is a lack of coordination in the development of tools to support the Australian Guidelines for Water Recycling (AGWR). Similarly, there are no formal arrangements for sharing information and coordinating mutual recognition of

process barriers and preventive measures that have been validated in other jurisdictions.

It also importantly noted that with an increasing range of water sources being considered for drinking-water, there are increased challenges from emerging contaminants and complex new treatment technologies.

Australia has established water markets for the water resource in general, not drinking-water specifically. These allow trading of water entitlements and allocations. The establishment of efficient water markets is seen as a key objective in Australia's water reforms. To achieve efficient markets, states and territories have agreed that water markets should:

- "facilitate opportunities for trade within and between jurisdictions where river systems are physically connected
- minimise transaction costs on water trades achieved through good information flows in the market, and compatible water access entitlement, registry, and regulatory arrangements
- develop an appropriate mix of water products based on water access entitlements (these can be traded either in whole or in part, and either temporarily or permanently, or through lease arrangements or other trading options that may evolve over time)
- recognise and protect the needs of the environment
- provide appropriate protection of third-party interests, for example, the interests of financiers."

The Victorian Department of Health provides a series of guidance documents to assist the various players in understanding the Safe Drinking Water Act 2003 and the Safe Drinking Water Regulations 2005. For example, there are guidance documents explaining, "regulated water", "undertakings" and the "approval of water analysts".

The New South Wales Department of Health also provides guidance, including fact sheets. The Department of Health has drawn up Memoranda of Understanding (MoU) with the Sydney Water Corporation, the Sydney Catchment Authority and the Hunter Water Corporation. The intentions of these documents are to establish the terms of a cooperative relationship that will allow each party to fulfil its function in protecting public health. For example, the stated purpose of the MoU between the authority and NSW Health is to provide:

- the framework for a co-operative relationship between the agencies
- consultation processes for considering shared operational and public health issues
- exchange of information
- dispute resolution
- agreed areas of research.

A1.3.4 Reporting and Performance

In Victoria, the Department of Health produces an annual report on the state's drinking-water supplies. In addition to drinking-water quality the report covers other aspects of the whole drinking-water supply framework, such as auditor certification, competency of operators, approving analysts, expenditure and water safety plan audits. The extent of non-compliance for a series of determinands at various locations within the state is listed, with specific supplies being identified.

The Public Health Act 1991 in New South Wales does not require the Department of Health to report on the quality of drinking-water supplies in the state. However, Sydney Water provides online updates of its test results from three water filtration stations for *Giardia* and *Cryptosporidium.*

In Western Australia, the Department of Health requires large water suppliers to report their monitoring results to the department.

A1.3.5 Vision

The *National Water Quality Management Strategy - policies and principles: a reference document* prepared in 1994 stated a national vision "of achieving sustainable use of water resources by protecting and enhancing their quality while maintaining economic and social development".

A national vision statement pertaining specifically to drinking-water is unlikely to have been made given the responsibility for drinking-water lies primarily with the states and territories. However, a vision statement could not be found from any of the health departments in Victoria, New South Wales or Western Australia.

A1.3.6 Challenges

As the driest continent, Australia's greatest challenge is an adequate supply of water from which drinking-water can be produced. The problem of overall dryness is compounded by a very large percentage of its water requirements having to be supplied by the Murray-Darling basin and a relatively small fraction of its water resource draining through this one catchment. Climatic conditions leading to extended periods of drought are further adding to the difficulty of having sufficient water.

Wiser use of available water will alleviate water shortages to some degree. In addition, re-use and recycling of wastewater, and desalination are also being employed. Turning to a range of novel water sources brings with it the challenge of emerging contaminants and the associated need to master new treatment technologies that offer protection from these contaminants.

The demand for a scarce resource inevitably produces conflicts over which users are to have priority use. Australia is using market forces, through its water market, to help manage competing demands for water.

Australia's geographical size, which has contributed to water management responsibilities being split between federal and state agencies, potentially complicates the national coordination of initiatives to manage water, particularly drinking-water.

The challenges Australia faces are:

- water availability
- adapting to climate change and variability
- wise and efficient use of water resources
- recycling and reuse of water and its acceptance by consumers
- sustainable infrastructure
- source water protection
- competing demands for water
- emerging contaminants.

A1.3.7 Scientific Research Priorities

Water Quality Research Australia (WQRA), which is the successor organisation to the Cooperative Research Centre for Water Quality and Treatment, with the membership of the main players in the water industry including, utilities, research organisations, federal and local government and consultants, has the following key research interests:

Drinking-water

- Chemical and microbiological contaminants in water supplies
- Cyanobacteria
- Optimisation of treatment processes and distribution systems
- Regional and remote water supplies
- Novel treatment steps to improve water supply quality
- Studying public perceptions of water supply

Recycled water and wastewater

- Membrane and treatment technologies
- Chemical contaminants
- Waste stream disposal and reuse
- Fit for purpose technologies
- Risk assessment

WQRA supports research projects that are fully funded by it, and projects jointly funded by other national bodies including others NWC, NHMRC and the Australian Research Council, as well as overseas organisations. Its research priorities are established through a member voting process.

The WQRA projects, completed and underway, are listed in Table A1 and provide a more detailed indication of the type of work being undertaken within the interest areas noted above. The list of supported projects ranges from those with an applied focus to those

looking at fundamental science, such as aiming to understand cyanotoxin production at the molecular level.

Table A1 Water Quality Research Australia's research projects complete and current

Project
Guidelines for Water Supply in Remote Communities
Drinking Water Risk Management Manual
Integrated Membranes for Toxin Control
Health Based Targets for Microbial Water Quality
Innovative Methods for Management of Algae
Are there More Toxingenes than Toxic Cyanobacteria?'
Methods for Measuring Toxins in Finished Waters
Optimal Water Quality to Minimise Distribution System Problems
Physico-chemical Controls for Cyanobacteria in Reservoirs
Coal Tar Pipes Project
Health effects of Drinking Water from Rainwater Tanks
Remote Technology Transfer Officer
Water Chemical Database
Novel Treatment Methods for Reduction of Bromide and Iodide in Drinking Water Sources
Occurrence and Management of NDMA in Drinking and Recycled Water
Scale Formation and Prevention in Small Water Supplies Reliant on Groundwater
Use of On-line Surrogate Parameters for Rapid Hazard Detection and Improved System Performance
The Biological Filtration Project
Australian Cyanosurvey
Public Perception Project
CDI for Desalination of Brackish Water Supplies
Using Fluoroescence for Monitoring Organic Matter in Drinking Water Systems
Ultrasound for Control of Cyanobacteria
Optimum Control of Chloramine in Water Distribution Systems
Optimizing Conventional Treatment for the Removal of Cyanobacteria and their Toxins
Molecular Detection and Identification of Microorganisms in Water
Treatment Requirements for Australian Source Waters to Meet Health Based targets
Literature Review: *Cryptopsoridium* and *Giardia* in Catchments
NDMA in Australian Drinking Waters

Project
POE/POU Management and Costing Study
Characterisation of Trihalomethane Formation - Stage 1
Using MT-PCR for Toxin Gene Detection
Investigation into the Cause of Low Recovery of *Cryptosporidium* oocysts and *Giardia* cysts
Applying Capacitative Deionisation to Inland Brackish Water Desalination
THM Formation - Stage 2
Water Footprinting
Transformation Chemistry of Endorchrine Disrupting Chemicals and Pharmceuticals and Personal Care Products Resulting in Disinfection of Drinking Water
WaterRiskNet
Pathogen Removal by Activated Sludge
Chemical Risk Assessment, Communication and Management in Recycled Water
Ecotoxicity Toolbox
Management of Odour and Corrosion in Sewers
Ecotoxicity Toolbox: Phase 2
Membrane Integrity for Virus Particle Removal
Pathogens and Organic Contaminants in Biosolids
Predictive Tools for Membrane Ageing
Chemical Pretreatment for High Pressure Membranes
Endocrine Disruption in Australian Aquatic Environments
Submerged Membrane Bioreactor Treatment of Wastewaters
Monitoring Membrane Integrity for Virus Removal
Tools for Analysing Hormone Activity in Water
Inactivation of *Cryptosporidium* across the Wastewater Treatment Train
Membrane Distillation
Pathogen Removal by Activated Sludge: Part 2
Real Time Integrity Monitoring for High Pressure Membranes
Removing Chemicals of Concern using Advanced Oxidation Processes
Deworming Wastewater
Bioassays and Risk Communication
Cross Connections: Stage 2
Exposure Assessment using Tracer Chemicals
Dissolved Organic Matter in Recycled Water

Project
Thirsty Mouse
Microbial Control in RW using HACCP
Health Risks of Grey Water Use
NatVal
GWRC - Guidance Manual on Toxic Cyanobacteria

The Sydney Catchment Authority recorded research projects in its 2009–2010 Annual Report that included:

- pathogens
    - access of livestock to riparian zones
    - relative risks posed by sewage treatment plants
    - developing pathogen contaminant budget models
- cyanobacteria
    - causes of a 2007 blue-green bloom
    - role of nutrients in bloom development
    - mechanisms for the degradation of toxins, and taste and odour compounds in the Warragamba Dam
    - environmental factors that turn toxin genes off and on
    - the fate of toxins and taste and odour compounds in reservoirs.

A1.4 USA

A1.4.1 Country Drinking-water Landscape

The USA's land area is 9.8 million km^2, with a population of approximately 308 million people. Approximately 90% of public water supplies draw from groundwater sources, but as these are mainly small water systems, only 34% of the population is supplied with treated groundwater. An estimated 66% of publically supplied water is utilised for residential use, and 58% of this is used outdoors.

The primary concerns for water supply in the USA have been identified as:

- water scarcity and climate change
- water pollution – from combined sewer overflows and from contaminants such as lead, pharmaceuticals, disinfection by-products and Cryptosporidium
- a backlog of investment in infrastructure
- access to complete plumbing facilities (hot and cold running water, bath or shower and flush toilet
- affordability of infrastructure

- retiring workforce
- fluoridation.

In the USA the response to the problem of water shortage has typically been to tap into more distant water sources. However, this approach has now been recognised as unsustainable with the result that non-conventional sources are being turned to, and efforts are being made to conserve water (see below). Average water losses are 10–15%, which is less than parts of the European Union. However, they can exceed 25% in some older systems.

A1.4.2 Responsibilities and Regulations

Water supplies are regulated by both federal and state governments. At the state level, health and environmental regulations are the responsibility of the corresponding departments. The Public Utilities Commission in each state regulates the tariffs charged by private water utilities and in some states also municipal utilities.

The regulation of drinking-water at the federal level is the responsibility of the United States Environmental Protection Agency (USEPA). The two primary pieces of water legislation that influence drinking-water quality and are administered by the USEPA are the Clean Water Act 1972 and the Safe Dinking Water Act 1974 (SDWA). The former set the goal of eliminating all water pollution by 1985 and required industrial plants to improve their discharges to limit their effect on the quality of freshwater bodies.

The SDWA is the main federal legislation that ensures the quality of the country's drinking-water. Under the Act, the USEPA can set legal limits on the levels of certain contaminants in drinking-water. These limits are to be protective of human health and technically achievable. The SDWA allows states to set their own drinking-water standards, but they may not be less strict than the federal standards.

The USEPA also sets the frequency at which monitoring programmes must sample water, the testing method to be used, and suitable technologies for treating water.

The SDWA was amended in 1996. Amongst other things, this amendment allowed for the establishment of a Drinking Water State Revolving Fund to finance investment in water infrastructure to help in achieving compliance with the more stringent drinking-water quality standards. Congress has provided funds for this programme since 1997.

A1.4.3 Processes and Tools

The USEPA has a drinking-water strategy which it released in 2010. The strategy aims to find ways of strengthening public health protection against contaminants in drinking-water. The strategy identifies four principles that will protect drinking-water quality.

- Addressing groups of contaminants, rather than one at a time, to improve the cost effectiveness of treatment.
- Fostering the development of new drinking-water treatment technologies to enable the removal of a broad range of contaminants.
- Using multiple statutes to help protect drinking-water.

- Encouraging partnerships among states to achieve more complete sharing of data obtained from monitoring public water systems.

To implement the strategy, the USEPA will engage with stakeholders through:

- holding public meetings, webcasts, using the USEPA's website to seek input
- seeking advice from the National Drinking Water Advisory Council
- consulting with the Science Advisory Board's Drinking Water Committee
- hosting workshops on drinking-water technologies.

The USEPA also has a National Water Program Research Strategy, which is discussed in subsequent sections.

To assist water professionals and the public in conserving water, the American Water Works Association has established a clearing house for water conservation, efficiency and demand management – WaterWiser.

In 2006, the USEPA launched WaterSense to encourage efficiency of water use.

A1.4.4 Reporting and Performance

The SDWA specifies which contaminants water suppliers need to monitor and requires them to report any exceedence of a maximum concentration level (MCL) to their consumers.

A1.4.5 Vision

Although the term "vision" is used in relation to the USEPA's new research strategy, there appears to be no clear statement of it. The USEPA's National Water Program's goal relating to drinking-water may be the closest statement to a vision. This goal is: Ensure clean and safe water and drinking-water to protect human health.

A1.4.6 Challenges

Water availability, exacerbated by expected climatic changes and variability, is a priority challenge in the USA, as in other jurisdictions. A review published in 2002[5] considered that the USA is a relatively water abundant country. If this is so, then water shortages would appear to result from demand, and the ability to make best use of available resources will be important in the coming decades. This will require a change in attitude from that of turning to technology to allow abstraction of water from more difficult or distant locations, to one in which water conservation and efficient use of the available water are encouraged.

Economic considerations in drinking-water management are evident in the literature of other jurisdictions, but they appear more strongly emphasised in the USA. This is seen in concerns over aging infrastructure and the need to be able to treat an ever-increasing list of contaminants. Concern over the growing contaminant list is evident in the USEPA's drinking-water strategy, which focuses on being able to treat multiple contaminants simultaneously to improve cost effectiveness. The USEPA's strategy also aims to improve

[5] R.B. Levin, P.R. Epstein, T.E. Ford, W. Harrington, E. Olson, and E.G Reichard, US Drinking-water Challenges in the Twenty First Century. *Environ. Health Persp*., 2002, 110, 43-53

understanding of the risks to human health associated with new contaminants. Overly conservative evaluations of health risk contribute unnecessarily to treatment costs.

The challenges the USA faces are:

- adapting to climate change and variability
- wise and efficient use of water resources
- sustainable infrastructure – cost effective treatment and replacement of old reticulation systems
- source water protection
- competing demands for water
- emerging contaminants.

(The section of the USEPA's research strategy concerned with "healthy watersheds", shows that source water protection and managing competing demands are challenges that are not so evident in the "Safe drinking water" section of the strategy discussed in the following section.)

A1.4.7 Scientific Research Priorities

The USEPA's National Water Program Research Strategy has three objectives, to:

- ensure the National Water Program's research, science and technology needs are identified and documented in a comprehensive plan that supports its commitment to collaborative corporate planning, prioritisation and research management to meet the environmental goals of the National Water Program
- expand research partnerships and collaborations across the USEPA and the federal research family
- engage the broader research community in the investigation of water research needs.

The strategy has four themes, all of which have some aspects that could influence drinking-water supply management.

- Healthy watersheds and coastal waters research needs
- Safe drinking-water research needs
- Sustainable water infrastructure research needs
- Water security research needs

The safe drinking-water theme is probably the most important with respect to this report.

The research in each theme is divided into "Technical Tool Areas", as follows:

- aquatic life health effects
- human health effects
- method development

- occurrence and exposure
- treatment technologies and effectiveness.

The research in each tool area is further divided into three tiers, which give an indication of the urgency and the driver for the research.

- Tier 1: On a critical path to satisfy a statutory, regulatory, court ordered or agency/office strategic obligation.
- Tier 2: Supports, augments or improves existing and adequate tools, guidance or policy, or would enhance new critical path research products.
- Tier 3: Investigates potential environmental concerns of the future, or takes advantage of a serendipitous opportunity to leverage resources or an initiative.

A full listing of the research activities can be found in the strategy document. The research activities identified within "Safe drinking water research needs" are (as described in the strategy document) listed next.

- Human health effects

  Tier 1
  Understand the human health effects of known and emerging pathogens, chemicals and suites of contaminants; improve the risk assessment process for these contaminants; determine the impact of co-contaminants injected with CO_2 on drinking-water sources; reduce uncertainty in extrapolation from animals to humans and from high to low doses.

  Tier 2
  Determine the effects of short-term lead exposure on developmental processes; evaluate the potential impacts of shallow class V well[6]-injected brines and residuals on underground sources of drinking-water; assess the impacts of underground injection control Class V mine backfill wells accepting coal fly ash on drinking-waters.

  Tier 3
  Determine the impacts of injection activities and waste management associated with oil and gas production on drinking-water sources.

- Method development

  Tier 1
  Develop methods to: evaluate the appropriateness and improve the timeliness of analytical techniques; capture the risk of exposure to contaminants in support of the contaminant candidate list and unregulated contaminant monitoring rule; identify tools for longitudinal research with children; determine impacts of climate change on integrated water resource management; determine the risks of underground CO_2 injection and manage alternatives to protect drinking-water sources; determine the management and treatment practices appropriate for aquifer storage and recovery injection activities that prevent endangerment of drinking-waters.

  Tier 2

[6] Class V wells are used to inject non-hazardous substances underground

Develop methods to: evaluate human health risks from chemical mixtures; assess the vulnerabilities of drinking-water sources to contamination; develop and improve methods to detect and quantify regulated and unregulated contaminants; evaluate the ability of culture and molecular methods to address the viability and infectivity of pathogens.

Tier 3
None yet identified.

- Occurrence and exposure

  Tier 1
  Determine the national occurrence of contaminants in source water and drinking-water and the routes, frequency and duration of the public's exposure.

  Tier 2
  None yet identified.

  Tier 3
  None yet identified.

- Treatment technologies and effectiveness

  Tier 1
  Evaluate best management practices for source water quality improvement; identify treatment technologies and techniques to remediate emerging contaminants.

  Tier 2
  Optimise corrosion control treatment approaches while improving drinking-water quality; assess water resources for vulnerability to contamination; control pollution at the watershed scale.

  Tier 3
  None yet identified.

The research supported by the American Water Works Association Research Foundation (now known as the Water Research Foundation) aims to help address the needs of water utilities.

A1.5 Canada

A1.5.1 Country Drinking-water Landscape

Canada's land area of approximately 9.98 million km^2 houses a population of approximately 34.5 million people. Despite Canada containing 9% of the world's renewable freshwater resource, there is a mismatch between areas with high water demand and water availability. Canada's catchments tend to drain to the north, while 85% of the country's population is concentrated along its southern border. Climate change is expected to add to these difficulties, albeit in different ways and to different extents across the country. The interior is expected to experience increases in temperature that are larger than the average increases forecast across the country. This will result in the retreat of glaciers and a reduction in winter snow coverage, and will adversely affect the flows of glacier- and snow-melt- fed rivers and streams. Soil moisture will also decrease in these areas. In the north, winter temperatures will increase and there will be greater precipitation than occurs now.

Canadians have one of the highest rates of water consumption per capita in the world. In 1999, water consumption was estimated at approximately 343 L/person/day. In Montreal, where there is no metering, it is 1278 L/person/day. Nationally, 52% of water is used for residential purposes, 19% for commercial purposes, 16% for industrial purposes and 13% is lost through leakage, although this figure may be closer to 30% in some areas.

The Walkerton incident in 2000 focused national and international attention on risks to water supplies that had not been fully appreciated. The report of the inquiry into the incident[7] contained a raft of recommendations of steps that need to be taken to better protect water supplies. The concept of multi-barrier protection, in particular, was emphasised and this is reflected in many strategies and regulations.

A1.5.2 Responsibilities and Regulations

A1.5.2.1 Federal Responsibilities and Regulations

Federal Water Policy (1987) provides a statement of the federal government's philosophy and goals for the management of Canada's water resources and the ways in which it intends to go about achieving them. There are two key pieces of federal legislation concerning water management: the Canada Water Act 1970 and the Canadian Environmental Protection Act 1999, which is described as "an Act respecting pollution prevention and the protection of the environment and human health in order to contribute to sustainable development". Neither the federal policy nor the pieces of legislation are concerned with drinking-water quality or management, and provide no insight into how water supplies in Canada are regulated and managed. Their focus is on environmental waters. Such legislation does influence the production of safe drinking-waters through its effects on source water quantity and quality.

Although the provinces and territories have responsibility for legislation and regulation for drinking-water, there are some responsibilities that still rest at federal level. Since 1968, the federal government of Canada, represented by Health Canada, has taken joint responsibility with provincial and territorial governments for the development of guidelines for drinking-water quality. These are published as the *Guidelines for Canadian Drinking Water Quality*. They are supported by sister *Guideline Technical Documents*.

The Health Canada website notes that Health Canada has the following responsibilities:

- developing national drinking-water guidelines with provincial and territorial drinking-water authorities
- providing emergency advice in cases of drinking-water contamination when requested by another government department or agency
- developing guidelines for water used for recreational activities, such as lakes where people swim
- ensuring the safety of drinking-water on cruise ships, airlines, passenger ferries, trains and other common carriers

[7] D.R. O'Connor, 2002, *Part 1- Report of the Walkerton Inquiry: The Events of May 2000 and Related Issues*, Ontario Ministry of the Attorney General, Ontario;, and D.R. O'Connor, 2002, *Part 2- Report of the Walkerton Inquiry: A Strategy for Safe Drinking Water*, Ontario Ministry of the Attorney General, Ontario.

- working with other departments to make sure all federal government employees have access to safe drinking-water in their workplaces
- monitoring drinking-water quality on first nations reserves as part of its wider mandate to deliver public health services to these communities
- regulating the safety and quality of bottled water, pre-packaged ice and water used in food processing
- working in collaboration with partners and stakeholders on broader water quality issues, including the development of water policies and research priorities.

Two national bodies, other than Health Canada, have some involvement in water supplies or source water management:

- the Canadian Council of Ministers of the Environment, which consists of 14 ministers, 13 from provincial and territorial governments and the federal minister. Its role is the development of national strategies, standards and guidelines. In 2009 it produced a document setting strategic directions for water. While the document may have some indirect benefit for drinking-waters, it is primarily concerned with environmental waters (ie, waters that may be used as water supply sources).
- Environment Canada, the federal agency with responsibility for Canada's environment. This Ministry's website presents the federal government's water policy, which has two main goals:
    - to protect and enhance the quality of the water resource
    - to promote the wise and efficient management and use of water.

  It contains a section about safe drinking-water, which states:

  > "The federal government is committed to ensuring safe drinking-water within areas under its jurisdiction and to promoting and encouraging a consistent approach to protection and improvement of the nation's drinking-water by provinces, territories and local governments.

  To meet this commitment, the federal government will continue to:

    - consider legislation to ensure the safety of drinking water within federal jurisdiction and to complement provincial and territorial programs;
    - establish national drinking water quality guidelines to help all jurisdictions in setting safe drinking water standards;
    - conduct research and support technological development and transfer in drinking water treatment processes; and
    - promote public awareness and understanding of critical issues respecting drinking water safety, such as prevention of contamination of drinking water sources from land area runoff."

Federal legislation recognises concerns with the provision of drinking-water to first nations, and the Safe Drinking Water for First Nations Act was introduced into Parliament in 2010.

Provincial and territorial governments have responsibility for the development, maintenance, operation and quality assurance of drinking-water supplies. Drinking-water supplies are owned by municipalities, which have responsibility for developing and enforcing all legislation relating to municipal and public water supplies, including their construction and operation.

Another important player in water supply management is the non-government organisation, Canadian Water and Wastewater Association, which represents the municipal water suppliers and their private sector partners and suppliers.

In overview, the Canadian system appears to have the following implications for water supply management:

- there is no national body with responsibility for drinking-water regulation
- there are no national drinking-water regulations, only guidelines to be interpreted by the provinces and territories
- there is the possibility that water supply management and safety may suffer as the result of potential problems with collaboration between different levels of government.

A1.5.2.2 Provincial Responsibilities and Regulations

As the provinces/territories are primarily responsible for the regulation of drinking-water supplies, the legislation of a selection of provinces is briefly reviewed here

Ontario

In Ontario, the Ministry of the Environment has responsibility for drinking-water. The two main pieces of legislation concerning drinking-water are the:

- Safe Drinking Water Act 2002, the purposes of which are to:
    - recognise that the people of Ontario are entitled to expect their drinking-water to be safe
    - provide for the protection of human health and the prevention of drinking-water health hazards through the control and regulation of drinking-water systems and drinking-water testing.
- Clean Water Act 2006, the purpose of which is to protect drinking-water sources, existing and future.

Many of the Ministry of the Environment's clean water initiatives are based on recommendations from the report of the Walkerton inquiry[7].

British Columbia

The Ministry of Health has responsibility for drinking-water in British Columbia. It administers the Drinking Water Protection Act 2001. This Act requires water suppliers to provide potable water, where "potable water" means water provided by a domestic water system that:

- meets the standards prescribed by regulation, and

- is safe to drink and fit for domestic purposes without further treatment.

British Columbia also has a Drinking Water Protection Regulation (2003). In terms of numerical standards, this regulation is limited to setting permitted levels of total and faecal coliforms, and *Escherichia coli* only.

Alberta
Alberta's drinking-water is regulated by Alberta Environment. Its responsibilities include:

- setting standards
- approving waterworks systems
- promoting best practices and providing education
- training and certifying operators
- monitoring performance
- inspecting facilities
- enforcing facility approvals
- enforcing legislation.

The province's Environmental Protection and Enhancement Act 2000 (EPEA), requires water supplies to meet the maximum acceptable concentrations (MACs) of the federal drinking-water guidelines. "Alberta Environment's Drinking Water Program - A 'Source to Tap, Multi-Barrier' Approach" (2009) lists legislation other than the EPEA, which is related to drinking-water management and quality.

Quebec
(Commentary is limited as much of the key material is in French)

The Ministry of Sustainable Development, Environment and Parks has responsibility for drinking-water in Quebec. In 2002, the Government of Quebec implemented a water policy for the first time in its history. It has three objectives:

- to ensure the protection of this unique resource
- to manage water with a view to sustainable development
- to better protect public health and ecosystems.

The Environment Quality Act contains, amongst other things, regulations with respect to the quality of drinking-water, which define the minimum amount of treatment that waters require. Water must be filtered and receive continuous disinfection if it is a surface water or groundwater if its quality could be affected by events on the surface. Treatment must eliminate at least 99.99% of viruses, 99.9% of *Giardia* cysts and 99% of *Cryptosporidium* oocysts. However, filtration is not required if the raw water turbidity is less than or equal to 5 NTU (nephelometric turbidity units), 90% of weekly faecal coliform samples from the raw water contain fewer then 20 bacteria/100ml, the average turbidity over 30 consecutive days is less than 1 NTU, and contamination from agricultural activities or wastewater systems is unlikely.

Schedule 1 of the regulations referred to in the Act, sets out microbiological, chemical (a substantial list) and radiological quality standards, not all of which follow the WHO Guidelines for Drinking-water Quality, or the federal Canadian Guidelines. Quebec's acceptable level for arsenic, for instance, is 0.025 mg/L, compared with 0.010 mg/L in the Canadian Guidelines (2008) and the *Drinking-water Standards for New Zealand.*

Quebec's government produced a water policy in 2002 containing a small section concerned with drinking-water. The provincial government gives three undertakings in this document:

- to provide financial assistance over the next five years to bring all drinking-water supply and treatment facilities up to standard
- to develop a strategy for protecting surface water collection sources by 2004
- to increase and improve the ability of regional public health branches to intervene, investigate, and assess risks or impacts whenever water quality standards are violated or waterborne illnesses break out.

Saskatchewan
Saskatchewan Environment regulates municipal water treatment plants and privately-owned (publically accessible) plants with flow rates of 18,000 L or more/day. Saskatchewan Health regulates privately owned systems with flow rates of less than 18,000 L/day.

Saskatchewan Watershed Authority (part of Saskatchewan Environment) has responsibility for catchment and aquifer management plans, that is, stewardship of the source waters. The authority is also required to balance competing interests.

Saskwater is the Crown water utility that provides water services, including potable water, to communities, first nations and industry throughout the province. It designs, builds, owns and operates these facilities.

The Water Regulations, made under the Environment Management and Protection Act 2002, set out, amongst other things, the requirements for operation of a drinking-water system. The regulations adopt the federal drinking-water guidelines.

A1.5.3 Processes and Tools
British Columbia has a Safe Drinking Water Action Plan, published in 2002, which aims to ensure that British Columbians have access to safe drinking-water.

Water for Life – Alberta's strategy for sustainability was released in 2003 and updated in 2008. The accompanying action plan states that "ensuring safe drinking-water for all Albertans is a priority". The strategy is not dedicated to drinking-water alone, but it is an important aspect of it. It contains the following elements:

- safe, secure drinking-water
- healthy aquatic ecosystems
- reliable, quality water supplies for a sustainable economy

- knowledge and research
- partnerships
- water conservation.

In relation to drinking-water, the specific outcomes from the initiative include:

- a comprehensive strategy to protect Alberta's drinking-water
- timely access for all Albertans to information about drinking-water quality in their communities
- adherence of Alberta's drinking-water infrastructure to emerging standards and management for long-term sustainability.

Saskatchewan's Safe Drinking Water Strategy has four goals and associated objectives.

Goal 1: Waterworks systems and operations provide safe, clean and sustainable drinking-water

Objective 1 – Waterworks staff are capable and well trained

Objective 2 – Infrastructure produces water that meets the national drinking-water quality guidelines

Objective 3 – Waterworks systems and operations are financially sustainable

Goal 2: The drinking-water regulatory system is clear and effective

Objective 1 – Regulations are clear and ensure that health and drinking-water quality will be protected

Objective 2 – Professional regulatory staff have access to the tools necessary to ensure compliance

Goal 3: High quality source waters are protected now and into the future

Objective 1 – Risks to source water quality are known

Objective 2 – Watersheds are protected, natural purification and protection processes are maximised and potential for contamination is minimised

Goal 4: Citizens and consumers trust and value their drinking-water and the operations which produce it

Objective 1 – Consumers value quality water and are willing to pay for it

Objective 2 – Citizens and consumers trust the quality and reliability of their drinking-water systems and are confident in the regulatory system

Objective 3 – Citizens have meaningful access to information about the quality of their water

Objective 4 – Reduced consumption of water

Some of the challenges noted in the Performance Plan Report are specific to Saskatchewan, but several are common throughout the developed world. The listed challenges are:

- small community challenges
- meeting existing and new water and wastewater treatment standards
- municipal infrastructure funding and related challenges
- northern water quality-related needs
- legislative and regulatory gaps and challenges
- source water protection
- industrial challenges.

A1.5.4 Reporting and Performance

Canada has no drinking-water quality reporting requirements at the federal level. Reporting, where it is required, is at the provincial level.

Ontario

Ontario requires all adverse results from drinking-water supplies to be reported immediately to the Ministry for the Environment and medical officer of health by the operating authority and the laboratory that generated the result. Each year, the chief drinking-water inspector prepares a report, which relates to all water supplies regulated by the provincial government. The report is divided into two parts. The first part describes steps that have been taken to improve water supply security, and the second provides summary statistics of test results. Individual water supplies are not identified.

British Columbia

The Drinking water Protection Act 2001 in British Columbia requires water suppliers to report any threat of which they are aware that is likely to result in them being unable to provide potable water. The supplier may be required to inform their consumers of this threat. There appears to be no requirement for the Ministry of Health to provide an annual report on water quality/compliance of supplies throughout the province.

Alberta

No regular reporting of drinking-water quality at a provincial level appears to be undertaken.

Quebec

The regulations in Quebec require persons responsible for water supplies to provide quarterly reports on *E. coli* concentrations in source waters and calculated percentage removals of viruses and protozoa using free available chlorine, temperature and pH data.

Saskatchewan

Legislation in Saskatchewan requires the Ministry of Environment to report annually on the activities of ministries and other agencies involved in drinking-water and source water protection activities. This includes statistics on levels of compliance with quality requirements.

A1.5.5 Vision

Alberta's *Water for Life* initiative provides no vision statement, but its goal is to be able to assure Albertans that their drinking-water is safe. The strategy, in relation to drinking-water notes:

> "Efforts to ensure safe, secure drinking water must recognize our dependence on aquatic ecosystems as source water and the potential requirements of other uses that support our economy."

Saskatchewan's vision for drinking-water supplies, spelt out in its *Safe Drinking Water Strategy*, is: "A sustainable, reliable, safe and clean supply of drinking water that is valued by the citizens of Saskatchewan". Performance Plan Reports on progress towards meeting the plan provide statistics to demonstrate the success of the strategy.

A1.5.6 Challenges

Canada, like Australia, has a mismatch between its main sources of water, and the location of most of its population. While the availability of water is a challenge, Canada in general does not suffer from being a dry country as does Australia. Climate change forecasts predict that shortages of water in some areas will be exacerbated by the climatic changes expected to develop. Improving the wise and efficient use of water in Canada is a challenge given its high per capita usage. However, recycling of wastewater appears to play a smaller role in Canada's strategies than Australia's, and Canada has not developed a tool similar to Australia's water markets. These observations suggest that Canada's water resources are under less pressure than those in Australia.

Those jurisdictions that have heeded the lessons of the Walkerton incident, have grasped the importance of source water protection, as the key barrier in a multiple barrier approach to drinking-water quality protection. This is reflected in their regulations and strategies at provincial level. While there is no unified national drinking-water strategy, federal agencies working towards protecting environmental waters are helping, by default, to protect water supply source waters.

The challenges Canada faces are:

- adapting to climate change and variability
- wise and efficient use of water resources
- sustainable infrastructure
- source water protection
- co-ordinating national initiatives that will contribute to safe water supplies
- competing demands for water
- emerging contaminants.

A1.5.7 Scientific Research Priorities

The federal government has a Networks of Centres of Excellence (NCE) program, which in 2001 established the Canadian Water Network (CWN).

The CWN's purpose is to "connect Canadian and international water researchers with decision-makers engaged in priority water management issues". It is unclear what strategy or policy drives the research, but Figure A1 below shows the three intersecting research programmes that constitute its core research.

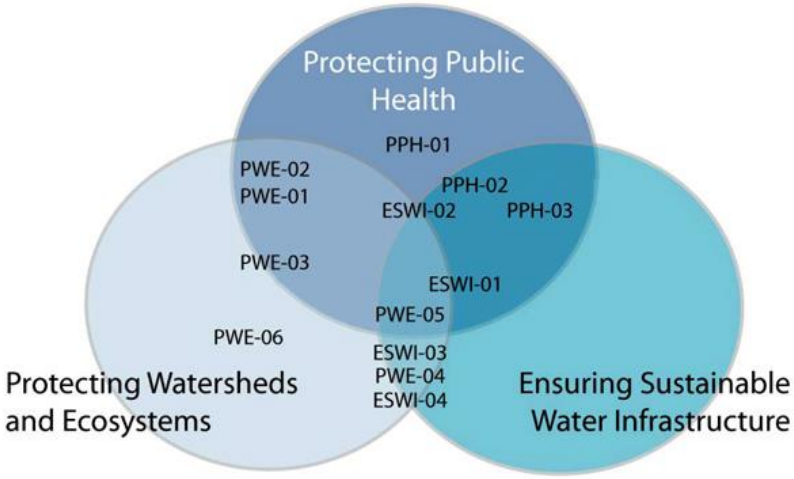

Figure A1 Diagram from the Canadian Water Network showing intersecting areas of research

Each of these programmes has two objectives as described next.

- Protecting watersheds and ecosystems

  Objective A — Increased adoption of risk-based cumulative effects frameworks that recognise changing land uses and water availability and help balance multiple water uses in watersheds across Canada

  Objective B — Improved source water protection and water allocation in watersheds across Canada through the application of improved practices, technologies, monitoring and governance

- Protecting public health

  Objective A — Reduced risks associated with waterborne pathogens and contaminants in communities across Canada, including small and remote communities, resulting in reduced health consequences and public expenditures

  Objective B — Improved risk assessment models that balance risk, cost and societal benefits, and incorporate both pathogenic and chemical risks, supporting decision-making across Canada within a multi-barrier approach

- Ensuring sustainable water infrastructure

  Objective A — Implementation of improved and expanded treatment technology and management options that enhance reliability and performance of water and wastewater systems, including those in small and remote communities

  Objective B — Reduced costs to operate and maintain water infrastructure through innovative technologies and approaches that ensure balance among costs and risks to humans and the environment

Environment Canada's National Water Research Institute (NRWI) is the largest freshwater research entity in Canada. Its work is primarily concerned with environmental waters, but the title of a 2001 report, "Threats to sources of drinking waters and aquatic ecosystem health in Canada" indicates that the importance of the quality of these waters to drinking-water supplies is recognised.

A NWRI report, "Pharmaceuticals and Personal Care Products in the Canadian Environment: Research and Policy Directions", is the proceedings of a workshop held by the NWRI in 2007 to discuss what appears to be a topic of concern in Canada. Pharmaceuticals in drinking-water are also on Health Canada's watch list.

The provinces have also identified priority areas requiring research. The Minister for the Environment's 2010 report in Ontario notes the following as emerging issues requiring research:

- water conservation
- microbial source tracking
- algal toxins
- disinfection by-product reduction
- nanofibre membrane technology
- climate change adaptation
- pharmaceuticals.

Alberta's *Water for Life* programme action plan identifies a key action highlighting a research need:
"Develop a waterborne disease surveillance system and undertake waterborne contaminant research.

- Provide on-going drinking-water quality testing and laboratory-based surveillance through the public health laboratories
- Conduct domestic well water surveys of specific contaminants in identified areas (e.g. Beaver River and North Saskatchewan River Basins, etc.)
- Undertake applied research in priority water contaminants and develop a public health risk management support system"

APPENDIX 2 SOURCES OF INFORMATION

Singapore

Singapore's Public Utilities Board
http://www.pub.gov.sg/LongTermWaterPlans/index.html
http://www.pub.gov.sg/about/Pages/default.aspx, and subpages

National Environment Agency
http://app2.nea.gov.sg/topics_dwu.aspx

International Water Association (for access to regulations)
http://www.wsportal.org/uploads/IWA%20Toolboxes/WSP/EPH%20Regulations.pdf

World Health Organization
http://www.wpro.who.int/countries/sin/2010/SIN.htm, and subpages

England

Water Industry
Meeting Future Challenges – a blueprint for policy action, June 2010
http://water.org.uk, and subpages

Department for Environment, Food and Rural Affairs
Future Water. The Government's water strategy for England, 2008.
http://archive.defra.gov.uk/environment/quality/water/strategy/pdf/future-water.pdf
http://www.defra.gov.uk/environment/quality/water/whitepaper/

Drinking Water Inspectorate
http://dwi.defra.gov.uk, and subpages

Securing safe, clean drinking water for all. Drinking Water Inspectorate, Our Strategic Objectives 2010-2015
http://dwi.defra.gov.uk/about/our-strategic-plan/Securing-safe-clean-drinking-water.pdf

Australia

Background information
http://www.nwc.gov.au/resources/documents/47_review_of_urban_water.pdf
http://www.bom.gov.au/climate/drought/livedrought.shtml
http://www.water.gov.au/WaterAvailability/WhatIsOurTotalWaterResource/index.aspx?Menu=Level1_3_1
http://www.qwc.qld.gov.au/prw/timeframes.html .

Responsibilities and Regulations

Federal

http://www.environment.gov.au/water/policy-programs/nwqms/

http://www.environment.gov.au/water/australia/water-act/index.html

National Water Commission

http://www.nwc.gov.au/www/html/7-home-page.asp

State

Victoria

http://www.health.vic.gov.au/environment/water/drinking.htm

New South Wales

http://www.health.nsw.gov.au/PublicHealth/environment/water/drinking_water.asp

Western Australia

http://www.public.health.wa.gov.au/2/640/2/drinking_water.pm

http://www.water.wa.gov.au/

http://www.erawa.com.au/1/78/51/water_licensing_.pm

Processes and Tools

"Water for the future" initiative

http://www.environment.gov.au/water/australia/index.html

Urban water reform

http://www.nwc.gov.au/www/html/185-reform-progress.asp?intSiteID=1

Water markets

http://www.nwc.gov.au/www/html/491-water-market-information.asp

Victoria Department of Health guidance documents

http://www.health.vic.gov.au/environment/water/d-guidelines.htm

New South Wales Department of Health fact sheets and MoUs

http://www.health.nsw.gov.au/PublicHealth/environment/water/drinking_water.asp.

http://www.health.nsw.gov.au/resources/publichealth/environment/water/watermou_pdf.asp

Reporting and performance

http://www.health.vic.gov.au/environment/water/d-report.htm

http://www.sydneywater.com.au/WaterQuality/DailyDrinkingWaterQualityResults/

Vision

http://www.environment.gov.au/water/policy-programs/nwqms/

Scientific research

http://www.wqra.com.au/research/research-programs/
http://www.sca.nsw.gov.au/__data/assets/pdf_file/0008/19637/SCA-Annual-Report-2009-10-Part-1.pdf

USA

Background information

http://www.epa.gov/safewater/wot/pdfs/book_waterontap_full.pdf
http://www.amwa.net/galleries/climate-change/AMWA_Climate_Change_Paper_12.13.07.pdf
http://water.nationalacademies.org/basics_part_3.shtml
http://cfpub.epa.gov/npdes/cso/demo.cfm
http://water.epa.gov/infrastructure/drinkingwater/dwns/index.cfm

Responsibiltiies and Regulations

Federal

http://water.epa.gov/lawsregs/guidance/sdwa/laws_statutes.cfm

Processes and Tools

http://water.epa.gov/scitech/swguidance/waterquality/standards/strategy/upload/strategy.pdf
http://www.epa.gov/WaterSense/pubs/indoor.html
http://www.awwa.org/Resources/Waterwiser.cfm?navItemNumber=1516

Scientific research

http://water.epa.gov/scitech/research-riskassess/researchstrategy/index.cfm
http://www.waterrf.org/Pages/WaterRFHome.aspx

Canada

Background information

http://adaptation.nrcan.gc.ca/perspective/water_1_e.php
http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=11A8CA33-1
http://www.watergovernance.ca/factsheets/pdf/FS_Water_Use.pdf

Responsibiltiies and Regulations

Federal

http://www.ec.gc.ca/eau-water/D11549FA-9FA9-443D-80A8-5ADCE35A3EFF/e_fedpol.pdf
http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=87922E3C-1
http://www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/index-eng.php

First Nations Safe Drinking Water Act

http://www.ainc-inac.gc.ca/ai/mr/nr/m-a2010/23358bg-eng.asp

Provinces and Territories

Ontario
http://www.ontario.ca/ONT/portal61/drinkingwater/General?docId=STEL01_046858&breadcrumbLevel=1&lang=en
http://www.ene.gov.on.ca/environment/en/subject/protection/index.htm

British Columbia
http://www.health.gov.bc.ca/protect/dw_index.html

Alberta
http://environment.alberta.ca/apps/RegulatedDWQ/More.aspx

Quebec
http://www.mddep.gouv.qc.ca/eau/politique/index-en.htm

Saskatchewan
http://www.saskh20.ca/about.asp

Processes and Tools

British Columbia
http://www.health.gov.bc.ca/protect/dwpublications.html

Alberta
http://www.waterforlife.alberta.ca/

Saskatchewan
http://www.environment.gov.sk.ca/Default.aspx?DN=7bede8e4-739e-4723-acc3-d9a93e1428b2

Reporting and Performance

Ontario
http://www.portal.gov.on.ca/ONT/portal61/drinkingwater/!ut/p/c5/04_SB8K8xLLM9MSSzPy8xBz9CP0os3hvi2A3F0dzE0N3b3dXA09vX0dT9yA_Q_9AU_1wkA48Kkwg8gY4gKOBvp9Hfm6qfkF2dpqjo6IiAMMr8bw!/dl3/d3/L2dJQSEvUUt3QS9ZQnZ3LzZfSzhTRkRBNzQxR0tHRTBJS01BNUdSTjFPNjY!/?lang=en

Saskatchewan
http://www.saskh20.ca/WaterInformationFactSheet_Drinking_AnnualReports.asp

Vision

Alberta (see strategy link above)

Saskatchewan (see strategy link above)

Scientific research

http://www.cwn-rce.ca/research/core/
http://www.ec.gc.ca/inre-nwri/default.asp?lang=En&n=0E7169DE-1
http://www.ec.gc.ca/inre-nwri/default.asp?lang=En&n=C00A589F-1
http://environment.gov.ab.ca/info/library/8236.pdf

APPENDIX 3 REPORT DISTRIBUTION

Copies have been made and distributed to:

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Jan Gregor (ESR)
Chris Nokes (ESR)

Further copies of this report may be obtained from:

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