PRODUCTIVITY COMMISSION

Arrangements for Setting Drinking Water Standards

International Benchmarking

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The Productivity Commission

The Productivity Commission, an independent Commonwealth agency, is the Government's principal review and advisory body on microeconomic policy and regulation. It conducts public inquiries and research into a broad range of economic and social issues affecting the welfare of Australians.

The Commission's independence is underpinned by an Act of Parliament. Its processes and outputs are open to public scrutiny and are driven by concern for the wellbeing of the community as a whole.

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Foreword

This study forms part of a continuing program of research benchmarking the performance of economic infrastructure industries. Earlier studies have focused on information about outcomes, such as prices and productivity. This study of the water sector, however, compares regulatory processes for the development and enforcement of quality standards, in Australia and overseas, against accepted best practice principles.

Consultations with governments and industry identified this as a particularly useful area for examination at this time. The urban water sector is faced with having to make large additional investments in treatment facilities if there is a rise in required water quality standards. The magnitude of the investments and the cost to consumers will be affected by the quality of regulatory decisions. What this study reveals is that there is considerable scope to improve regulatory processes, and in particular to draw on benefit-cost analysis to identify appropriate standards.

Research for the study was undertaken by the Economic Infrastructure Branch, with Dr Neil Byron as mentoring Commissioner. The Commission is grateful for the advice and assistance provided by government and industry bodies. Universally, those approached cooperated openly and constructively.

The Commission welcomes feedback on this report, consistent with its objective to improve the information base on key issues affecting Australia's economic performance and community living standards.

Gary Banks
Chairman

April 2000

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Abbreviations

AATSEIE	Australian Academy of Technological Sciences and Engineering Institute of Engineers
ABCRN	Australian Broadcasting Commision–Radio National
ABS	Australian Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
ACTEW	Australian Capital Territory Electricity and Water
ADI	Acceptable Daily Intake
AFFA	Department of Agriculture, Fisheries and Forestry (Australia)
ACPW	Advisory Committee of the Purity of Water
ANZFA	Australia and New Zealand Food Authority
ARMCANZ	Agricultural and Resource Management Council of Australia and New Zealand
AS	Australian Standard
AWWA	American Water Works Association (US)
BAT	Best Available Technology
BOOT	Build-Own-Operate-Transfer
BRTF	Better Regulation Task Force (UK)
BWSA	Bulk Water Supply Agreement
CCL	Contaminant Candidate List (US)
CCP	Critical Control Point

CDC	Centres for Disease Control and Prevention (US)
CHO	Chief Health Officer (NSW)
CMA	Catchment Management Authority
COAG	Council of Australian Governments
CRCWQT	Cooperative Research Centre for Water Quality and Treatment
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CWMB	Catchment Water Management Boards (SA)
CWW	City West Water
CWWA	Canadian Water and Wastewater Association
DASS	Direction Départementale de l'Action Sanitaire et Sociale (France)
DBP	Disinfection by-products
DETR	Department of Environment, Transport and the Regions (UK)
DG	Directorate-General (EU)
DGWS	Director-General of Water Services (UK)
DGXI	Directorate-General of the Environment, Nuclear Safety and Protection (EU)
DHHS	Department of Health and Human Services
DHS	Department of Human Services
DLWC	Department of Land and Water Conservation (NSW)
DNRE	Department of Natural Resources and Environment (Vic)
DPH	Director of Public Health (Tas)

DWC	Drinking Water Committee (US)
DWEL	Drinking Water Equivalent Level
DWI	Drinking Water Inspectorate (UK)
DWSRF	Drinking Water State Revolving Fund (US)
EA	Environment Australia
EC	European Commission
EHO	Environmental Health Officer (Tasmania)
EHU	Environmental Health Unit (DHS (Vic))
EPA	Environmental Protection Agency
ESR	Environmental Science and Research (NZ)
EU	European Union
FDA	Food and Drug Administration (US)
FPS	Federal–Provincial Subcommittee (Canada)
GAC	Granular Activated Carbon
HACCP	Hazard Analysis and Critical Control Points
HAWQ Committee	Health Aspects Water Quality Committee (SA)
HWC	Hunter Water Corporation
IARC	International Agency for Research on Cancer
IC	Industry Commission
ICR	Information Collection Rule
ICRP	International Commission on Radiological Protection
IESWTR	Interim Enhanced Surface Water Treatment Rule (US)
ILGRA	Inter-Departmental Liaison Group on Risk Assessment

IPART	Independent Pricing and Review Tribunal (NSW)
ISO	International Standards Organisation
LOAEL	Lowest Observed Adverse Effects Level
MAC	Maximum Admissible Concentration (EU)
MAV	Maximum Acceptable Value
MCL	Maximum Contaminant Level (US)
MCLG	Maximum Contaminant Level Goal (US)
MIB	Methyl isoborneol
ML	Megalitre
MMA	Melbourne Metropolitan Area
MoE	Ministry of Environment (NZ)
MoH	Ministry of Health (NZ)
MoU	Memorandum of Understanding
MWC	Melbourne Water Corporation
MWQS	Melbourne Water Quality Study
NATA	National Association of Testing Authorities
NCOD	National Contaminant Occurrence Database (US)
NDWAC	National Drinking Water Advisory Council (US)
NHMRC	National Health and Medical Research Council
NMUs	Non-Metropolitan Urbans (Victorian regional suppliers)
NOAEL	No Observed Adverse Effects Level
NPDWR	National Primary Drinking Water Regulation (US)
NRA	National Registration Authority (for Agricultural and Veterinary Chemicals)

NSDWR	National Secondary Drinking Water Regulation
NTU	Nephelometric Turbidity Unit
NZS	New Zealand Standard
OECA	Office of Environment and Compliance Assurance (US)
OFWAT	Office of Water Services (UK)
OGWDW	Office of Ground Water and Drinking Water
ONCC	OFWAT National Consumer Council (UK)
ONZPCE	Office of the New Zealand Parliamentary Commissioner for the Environment
ORD	Office of the Research and Development (US)
ORG	Office of the Regulator-General, Victoria
ORR	Office of Regulation Review
OWR	Office of Water Regulation (WA)
OXERA	Oxford Economic Research Associates Ltd (UK)
PC	Productivity Commission
pers.comm.	Personal Communication
PHS	Public Health Service (US)
PHSP	Public Health Service Provider
PHU	Public Health Unit (NSW)
PWS	Public Water Systems (US)
RFD	Reference Dose (US)
RIA	Regulatory Impact Assessment
RIS	Regulatory Impact Statement
RIU	Regulatory Impact Unit (UK)

SAB	Science Advisory Board (US)
SCA	Sydney Catchment Authority
SEQWB	South East Queensland Water Board
SEW	South East Water
STP	Sewerage Treatment Plant
SWAP	Source Water and Assessment Protection Program (US)
SWC	Sydney Water Corporation
SWTR	Surface Water Treatment Rule
TDI	Tolerable Daily Intake
THMs	Trihalomethanes
TIA	Tobacco Institute of Australia
TLA	Territorial Local Authorities (NZ)
UV	Ultraviolet
UWC	Urban Wate Cycle
VOAG	Victorian Office of the Auditor-General
WA	Western Australia
WAMC	Water Administration Ministerial Corporation (NSW)
WAWC	Western Australia Water Corporation
WTEDA	Water Treatment and Economic Development Agreement (SA)
WHO	World Health Organisation
WINZ	Water Information New Zealand
WSAA	Water Services Association of Australia
WSC	Wyong Shire Council

WTEDA	Water Treatment and Economic Development Agreement (SA)
YVW	Yarra Valley Water

Glossary

Administrative Order	Administrative orders formal enforcement actions, issued by the US EPA or the US States to address the non-compliance of a Public Water Suppliers, usually by means of a schedule with enforceable milestone dates.
Benefit-cost analysis	A systematic compliation of net social benefits and costs associated with a project or policy change.
Biofilm	Biologically active films that form on the inside of water distribution mains and which may harbour pathogenic micro-organisms.
Coliform	A group of related bacteria whose presence in drinking water may indicate contamination by disease-causing micro-organisms.
Cryptosporidiosis	The disease resulting from infection by *Cryptosporidium parvum*.
Cryptosproidium parvum	The only member of the Cryptosporidium family confirmed as pathogenic to humans.
Cysts	Lifecycle stage of a micro-organism during which it is enclosed by a cellular membrane.
Determinand	Chemical substance, microbiological organism, or some other characteristic of the water that can be measured.
Dose-response assessment	Test to determine the relationship between the amount of chemical or number of organisms consumed and the severity of the resultant health impact.
E. coli	A particular bacterium associated with diseases of the gut.
Endemic	Prevalent and ongoing.
Enteric	Pertaining to the intestines.

Epidemic	Widespread outbreak of disease, usually of limited duration.
Epidemiology	The study of diseases in populations and their causes.
Externality	The consequence of an action by either a producer or a consumer affecting other producers or consumers that is not accounted for in the market price.
Faecal coliforms	A particular bacterium indicating water contaminated with material of faecal origin.
Floc	Coalescence of finely divided precipitates into larger particles.
Genotoxic	Able to disrupt genetic material in cells.
Giardia lamblia	Disease-causing organism that affects the human gut.
Granular Activated Carbon	Carbon particles used to remove contaminants by adherence to the material.
Helminth	Parasitic worm.
Inorganic contaminants	Mineral-based compounds such as metals, nitrates and asbestos. These compounds are naturally occurring in some water, but can also occur through farming, chemical manufacturing, and other human activities.
Micro-organism	Tiny living organism or microbe that can be seen only with the aid of a microscope. Some micro-organisms cause health problems when consumed in drinking water.
Nano/ microfiltration	Membrane filtration. Pore size is smaller for nano-filtration than for microfiltration.
Oocysts	Lifecycle stage of *Cryptosproidium parvum*.
Organic polymers	Man-made chemicals with a long-chain molecular structure.
Organic contaminants	Carbon-based chemicals, such as solvents and pesticides, from cropland runoff or discharge from factories.
Oxidisation	Chemical change brought about by the addition of oxygen to the molecular structure of a chemical compound.

Ozonisation	Process of introducing ozone to disinfect drinking water — usually less harmful than chlorination.
Pathogens	Disease-carrying organisms.
pH	A measure of the acidity of a solution.
Quasi-regulatory instruments	Instruments such as operating licences that contain requirements of a regulatory nature but do not possess the legal status of regulation.
Radionuclides	Any man-made or natural element that emits radiation that may cause cancer after many years of exposure through drinking water.
Sanitary survey	An on-site review of the water sources, facilities, equipment, operation and maintenance of a public water system for the purpose of evaluating the adequace of the facilities for producing and distributing safe drinking water.
Sewage	Human effluent.
Sewerage	Infrastructure by which human effluent is transported and treated.
Thermotolerant coliforms	Bacteria that are heat-resistant that are typically associated with warm blooded animals.
Total coliforms	Collective term referring to a specified list of coliform bacteria.
Toxicology	Study of poisons, their effects, antidotes and detection.
Turbidity	The cloudy appearance of water caused by the presence of tiny particles. High levels of turbidity may interfere with proper water treatment and monitoring.

Key messages

- This study has revealed a diversity of approaches to developing, promulgating and enforcing standards, both within Australia and across the benchmarked countries.
- In Australia, as in most of the countries examined, there is considerable scope to improve processes for the development and enforcement of water standards
  - apart from the United States, benefit-cost analysis is rarely used in developing standards.
- Compared to some other countries, relatively little resources are devoted to regulatory development and enforcement activities in Australia.
- In the absence of rigorous regulatory assessment, it is difficult for authorities to fully justify existing standards, which vary across and within jurisdictions
  - it is also difficult to make sound decisions about infrastructure investments, in the face of pressures to adopt new technology.
- Any further increase in standards is likely to require significant additional investment in water treatment infrastructure, with cost implications for consumers. The cost to smaller communities would be relatively large because of scale disadvantages.
- There is a dearth of information on the quality of drinking water in different parts of Australia and the accompanying risk levels. This is an impediment to effective consultation to ascertain community preferences — a necessary part of ensuring that new standards are appropriate.
- In addition to lack of transparency, divided responsibilities for water regulation can diminish accountability.

Overview

Australia-wide, the urban water sector faces the prospect of having to make large investments in treatment technologies, because of an increase in the scope and stringency of water quality standards. Given the magnitude of potential costs and the importance of public health objectives, it is timely to explore how higher standards are developed, how risks are analysed, and how decisions are taken to implement higher standards.

Benchmarking can help improve processes.

This study was undertaken following consultations with a number of jurisdictions. Approaches to drinking water regulation in Australia and other selected countries, were compared against established 'best practice' principles of regulation making. The benchmarking is described in box 1. Benchmarking can provide insights into ways to improve institutional settings and regulatory processes with a view to achieving better health outcomes. The best practice principles used are outlined in box 2.

Box 1 **Benchmarking approach and scope**

- Regulatory arrangements and processes for establishing and enforcing drinking water standards in Australian jurisdictions were compared with those in Canada, France, New Zealand, the UK and US. The purpose was to compare regulatory process — not standards, the gap between standard requirements and actual water quality or public health outcomes, for which data are not generally obtainable.
- Information was collected on the organisations involved in developing, promulgating and enforcing drinking water standards. The information includes details of these organisations' responsibilities, processes and accountabilities.
- Differences were examined against best practice regulation making and enforcement. Widely accepted criteria for determining best practice were used.
- As a benchmarking study, there was no attempt made to develop an ideal Australian regulatory model. In any event, there is insufficient information to do so and it is unlikely that a single model would suit all jurisdictions and circumstances.
- The Commission consulted widely with relevant organisations during development of the study approach.

Box 2 **Best practice principles**

The following principles are widely recognised by Australian governments as best practice in government administration and regulation making.

Institution settings

- *Clearly defined objectives.* The success of an institution is judged by the extent to which it achieves clearly defined regulatory objectives.
- *Avoidance of shared responsibility.* Shared responsibilities can lead to confusion and a lack of accountability for regulatory outcomes.
- *Transparent processes.* Accountability requires processes that are transparent and a clear understanding of who is responsible for what.

Regulatory process

- *Adequate communication and consultation.* Community acceptance of regulation and the incorporation of design features that recognise any relevant constraints in its implementation, are best achieved if there is adequate communication and consultation with those affected by the regulation, prior to its finalisation.
- *Clearly defined regulatory objectives.* The desired objective(s) of all proposed regulation should be identified and clearly defined so that it is possible to assess how effective proposed regulation would be in the achievement of objectives.
- *Identification of regulatory alternatives*. A range of regulatory options that represent viable means of achieving the desired objectives should be identified. Regulators should look beyond regulatory approaches used in the past.
- *Benefit–cost assessment of all proposals.* Regulatory options should be subject to benefit–cost assessment. This enables alternatives to be ranked and the expected net benefits of the proposed regulation to be confirmed. Without this assessment process, resources may be wasted in developing and complying with a regulation that does not achieve its intended purpose.
- *Flexibility, provided that it is compatible with objectives*. Regulations should focus on outcomes that are consistent with the regulatory objectives, but subject to this constraint, they should be sufficiently flexible to allow different means of compliance that are cost effective.

Source: ORR 1998, Audit Office of NSW 1997.

Background

Drinking water quality guidelines and standards are set for microbiological, chemical and radiological contaminants, as well as physical characteristics such as odour, taste and clarity. Guidelines and standards are promulgated by the National Health and Medical Research Council (NHMRC) and State and Territory governments respectively. The distinction between guidelines and standards is set out in box 3.

Box 3 **Drinking water guidelines and standards**

Guidelines and standards establish quantitative limits or values for individual drinking water contaminants. In the case of chemicals, these values generally represent the concentration of a contaminant that would not result in any significant risk to health if consumed over a lifetime.

Guidelines are non-enforceable, with discretionary compliance. They may be adopted as goals to be achieved over time.

Standards have the force of law, must be complied within a specified timeframe and are usually backed by penalties for non-compliance.

Guidelines may also differ from standards in the way they are established, with no formal requirement for a Regulatory Impact Statement (RIS).

Guidelines and standards are generally set to protect the health of the population. However, not all individuals benefit equally, as some groups, particularly those who are immuno-compromised, require higher quality drinking water than others in the community.

Standards are becoming more stringent.

Over the last twenty years the stringency of drinking water standards in developed countries, including Australia, has increased considerably and their scope has widened. This has been in response to increasing contamination of source water in some areas, combined with a greater understanding of the effects of microbiological pathogens on health.

Developments in the science of detecting contaminants and improvements to technology to remove them — as well as an increase in community awareness and demand for cleaner water — have also played a role.

Water treatment costs can be expected to increase.

It is estimated that $400 million is spent annually on water treatment in Australia. If a higher level of water safety is desired, costs could be expected to increase. Any degradation of source water caused by human activity is also likely to result in higher treatment costs.

Additional treatment facilities can involve large capital expenditures. For example, it has been estimated that up to $500 million would be required to filter all of Melbourne's water.[1]

Consumer confidence may have decreased.

Industry leaders consulted by the Commission observed that consumer confidence in the safety of Australian drinking water has decreased, even though there is very little evidence of deteriorating quality or adverse health effects.[2]

Broad regulatory approach

The approach differs among countries.

There are significant differences among countries in the approaches to setting, promulgating and enforcing standards. These differences reflect a divergence in regulatory processes or philosophy (see box 4).

In Australia, a 'light-handed' regulatory approach has evolved, with water suppliers cooperating with government bodies. This approach results in lower compliance costs by providing greater flexibility to set standards according to local circumstances, particularly the cost of treatment. However, there may also be less certainty of compliance and less transparency and accountability.

1 A study of the possible health benefits of filtering Melbourne's water is currently being undertaken by the Cooperative Research Centre for Water Quality and Treatment.

2 The 1998 Sydney water crisis is likely to have contributed to a loss of confidence.

Box 4 **Key differences between countries**

The benchmarking revealed that Australia, along with most of the other countries benchmarked, is unlikely to be at best practice in the regulatory assessment of drinking water standards.

- The Australian Guidelines are based mainly on scientific assessment. In contrast, the US Environmental Protection Agency (US EPA) is required to undertake detailed benefit–cost evaluation of its regulatory proposals, which it publishes.
- Standards are promulgated in Australia using a variety of quasi-regulatory instruments, under which legal responsibilities are not always clear and rigorous assessment is lacking. In other countries, national legislation is the norm.
- In the US and EU, standards are promulgated in national legislation. In Australia, Canada and NZ, guidelines are developed at the national level and are promulgated — sometimes as standards — at a State, provincial or local level.
- The regulations in Australia are not as strictly enforced as in France, the UK and US and there is often no separation between the agencies responsible for promulgation and enforcement.
- In France, the UK and US, where private sector involvement in water supply is greater, regulators have the legal power to impose substantial penalties for non-compliance.
- Self-reporting of compliance occurs in all of the countries studied including Australia, but test results are more closely monitored overseas.

The NHMRC develops guidelines on what constitutes safe water.

The NHMRC is the expert technical body that develops Australia's Drinking Water Guidelines. The Guidelines include lists of recommended maximum values for contaminants, as well as information on water quality management practice and monitoring.

Guideline values are the maximum recommended concentration of a contaminant deemed unlikely to produce an adverse health effect.

The status of the Australian Guidelines is often misunderstood. The values listed in the Guidelines have no binding status. In practice, most suppliers try to comply with a version of the Guidelines, although not necessarily the most recent.

The need for flexibility in implementation is recognised.

The NHMRC acknowledged in the 1996 Guidelines that water quality improvement works may have to be phased in gradually over a number of years. In effect, this introduces flexibility to accommodate variations in the quality of source water, and the financial capacity of local communities to meet the costs. Similar regional variations and constraints are recognised overseas.

Implementation is a State and Territory responsibility ...

Under Australia's Constitution, water quality is a State and Territory responsibility. Consequently, those jurisdictions determine whether and how the Guidelines are to be implemented.

… which has led to differing approaches in Australia.

Most jurisdictions, consistent with the NHMRC's approach,` have viewed the Guidelines as long term goals — to be adopted as enforceable standards as quickly as possible (see box 5). This has led to considerable differences in regulation and water quality across Australia.

Versions of the Australian Guidelines have been adopted in some jurisdictions as enforceable standards without regulatory assessment, using a variety of quasi-regulatory instruments such as operating licences and memoranda of understanding (see box 5).

From a national perspective, implementation looks haphazard, but the resulting variation in water quality can be expected to reflect local circumstances and preferences to some extent. Nevertheless, differences in the quality of water across the country may prove to be contentious in the future unless the public understand the reasons.

Box 5 **Guidelines promulgated as enforceable standards**

Jurisdiction	*Supplier(s)*	*Enforceable standard* [a]	*Guidelines achieved* [b]
New South Wales	Sydney Water	NHMRC 1996	NHMRC 1996
	Hunter Water	NHMRC 1994	NHMRC 1996
	Wyong Shire Council		NHMRC 1996
	Gosford City Council		NHMRC 1996
	Non-metropolitan suppliers		NHMRC 1987 and 1996
Victoria	Melbourne Water		NHMRC 1987
	City West Water	NHMRC 1987	
	South East Water	NHMRC 1987	
	Yarra Valley Water	NHMRC 1987	
	Non-metropolitan suppliers		WHO 1984
Queensland	South East Queensland Water		NHMRC 1996
Western Australia	Water Corporation	NHMRC 1987	
South Australia	SA Water		NHMRC 1996
	United Water	NHMRC 1996	
	Riverland Water	NHMRC 1996	
Tasmania	Suppliers of potable water		NHMRC 1996
Northern Territory	Power and Water Authority		NHMRC 1987
Australian Capital Territory	ACT Electricity and Water		NHMRC 1996

[a] This is the Guideline version that is generally adopted as a standard by governments. [b] This is the Guideline version currently met by water suppliers. These are non-enforceable and there is discretion in compliance.

In Australia and overseas, there are protocols for dealing with public health problems once they have been detected. These protocols provide a mechanism for addressing system failures. They are an acknowledgment that it is unrealistic and impracticable from a technical and economic viewpoint to ensure that standards are always met. The acceptance of possible system failures might also imply that the consequences of the residual risks are not considered to be serious.

There is an acceptance that risk cannot be eliminated entirely.

This approach means that the public bears some risk that not all drinking water hazards can be foreseen and that there may be (rare) failures in the detection and treatment of contaminants.

How standards are set

Ideally the processes followed to arrive at standards (maximum levels of contaminants) should include scientific assessment, economic evaluation and consultation. The extent to which all three processes are undertaken differs among countries.

The NHMRC is responsible for scientific assessment.

In Australia, health specialists and practitioners from government-owned water supply authorities throughout the country assist the NHMRC in the ongoing development of the Guidelines.

Risk assessment procedures are used to evaluate health hazards in drinking water. In doing so, the NHMRC sets its guidelines at levels judged to represent an 'acceptable risk'.

Most countries, including Australia, rely heavily on existing assessments by the World Health Organisation. In contrast, the US develops many of its own standards using the considerable resources of the US EPA.

No evidence of rigorous evaluation in Australia.

State and Territory governments do not appear to subject the NHMRC's guidelines to rigorous economic assessment when adopting them as standards — despite inter-governmental agreements that this should happen with all regulation making.

More extensive use is made of benefit–cost analysis in the US. Under the more stringent regulatory approach found in the US, benefit–cost evaluation is mandated.

Without economic evaluation or an appreciation of risk preferences, it is difficult to determine the level of resources that should be devoted to water quality. That said, benefit–cost analysis in this area is not straightforward, partly because of scientific uncertainty concerning the relationship between standards and health outcomes (see box 6).

Box 6 **Benefit–cost assessment under scientific uncertainty**

- The link between different drinking water standards and health outcomes is not well understood. The evidence supporting such linkages is mainly inferential — derived from animal experiments at dose rates that are unlikely to be encountered by humans in drinking water supplies.
- Uncertainty provides no excuse for not identifying and, where possible, evaluating the benefits and costs of standards; or conversely, for not implementing standard values for certain contaminants. Indeed, the evaluation of the benefits and costs within an assessment framework can make the limitations imposed by uncertainty more explicit.
- That said, taking a conservative approach to setting standard values without a benefit–cost evaluation — through the adoption of safety factors, for example — may be necessary when knowledge about events and effects is particularly limited.
- The precautionary approach to environmental health management recognises that policy must always be of a provisional nature, pending the results of further research and information. Thus, research and information should be seen as tools for reducing uncertainty and improving decision making.

Broad community consultation is relatively limited in Australia ...

Consultation helps to ensure that standards are effective and efficient. In Australia, consultation by the NHMRC is mainly with health and water quality experts. Although this is true of most of the countries studied, the US has very comprehensive processes that examine both technical and economic issues.

… as is risk communication.

Consumers have the right to information about risks. Compared with some overseas countries, Australian consumers receive relatively little information on risks, expected changes to health outcomes and costs. Consequently, there is no basis for communicating their preferences when guidelines or standards are developed.

With greater transparency, water suppliers are more effectively accountable for their performance. Also, consumers are less susceptible to 'scare campaigns' about the safety of drinking water.

New Zealand and the US were found to be leaders in providing readily understood consumer information on water quality. The NZ system of grading water quality and providing a broad indication of risks is outlined in box 7.

Promulgation and enforcement

There are many institutional models.

The institutional arrangements for promulgating and enforcing standards differ among countries. In the US, the EPA promulgates standards on a national basis, whereas in Australia and Canada, standard promulgation is the responsibility of State (and Territory) and Provincial governments respectively.

Control by central governments varies.

In France, the UK and US, central governments retain a strong role in regulation, even where enforcement functions are devolved to State or regional levels. The opposite is true in Australia, New Zealand and Canada.

There is institutional fragmentation within jurisdictions in promulgating and enforcing standards in Australia. Health departments, water resources departments and the water suppliers are all involved. This sharing of responsibility potentially lessens accountability for public health outcomes.

Moreover, drinking water standards are often established in Australia through instruments that are not scrutinised through normal parliamentary processes (see box 8).

An advantage of operating licences and memoranda of understanding is that they are easier, and less costly, to change as circumstances alter. However, there is uncertainty about the legal force of these instruments and the obligations that they impose.

In addition, the process of 'referencing' standards in operating licences or memoranda of understanding does not provide for the same level of transparency and accountability as that achieved in countries where standards are set out in regulation.

Box 7 **New Zealand's water supply grading program**

New Zealand water quality is graded by the Ministry of Health for the purpose of:

- assessing whether a particular drinking water supply consistently delivers a safe wholesome product; and
- ensuring that communities are provided with reliable information about the quality of their water supply.

The grading system assesses separately the source and treatment part of the water supply system, as well as the distribution system. A two letter grading is designated, such as Aa, Cb, Ed. The capital letter (A1, A, B, C, D or E) represents the grade of the water coming into the zone (source quality and treatment) while the lower-case letter (a, b, c, d, or e) indicates the quality of the water received at the consumer's tap.

Both gradings are presented in the *Register of Community Drinking-Water Supplies in New Zealand*, which is accessible through public libraries.

The description of the grades for source and treatment is as follows:

A1 Completely satisfactory, negligible level of risk, demonstrably high quality

A Completely satisfactory, very low level of risk

B Satisfactory – low level of risk

C Marginal – moderate level of risk

D Unsatisfactory – high level of risk

E Completely unsatisfactory – very high level of risk

The evaluation of the distribution system uses a system of demerit marks for factors in the distribution of the water supply which adversely affect, or put at risk, the quality of the distributed water.

The description of the distribution grading is similar to the source and treatment description and uses letters a to e, with the smallest number of demerit marks receiving an 'a' grade.

Source: ONZPCE (1996).

Box 8 **Regulating water quality requirements in Australia**

State and Territory governments have taken diverse approaches to committing water suppliers in their jurisdictions to the Australian Guidelines. In most cases, governments have used quasi-regulation such as operating licences, charters, memoranda of understanding and customer contracts.

The instruments employed vary not only between States and Territories, but also within some jurisdictions. Often some combination of these instruments is employed. One jurisdiction (South Australia) has commercial contracts with the private sector, while three other jurisdictions (Queensland, ACT and NT) currently have no regulatory requirements in place.[a]

Jurisdiction	*Supplier(s)*	*Instruments*
New South Wales	Sydney Water and Hunter Water	Operating licence, memorandum of understanding, customer contract
	Wyong Shire Council	Water supplier business plan
	Gosford City Council	City Management Plan
Victoria	City West Water, South East Water and Yarra Valley Water	Operating licence, *Health (Quality of Drinking Water) Regulation 1991*[b], Customer contract
	Melbourne Water	Memorandum of understanding
	Non-metropolitan suppliers	Memorandum of understanding
Queensland	South East Queensland Water	No regulatory arrangements in place.
South Australia	SA Water	Charter, performance agreement
	United Water	Commercial contract
	Riverland Water	Commercial contract
Western Australia	Water Corporation	Operating licence
Tasmania	Suppliers of potable water	*Public Health Act 1997 — Guidelines for Water Quality*
Northern Territory	Power and Water Authority	No regulatory arrangement in place.
Australian Capital Territory	ACT Electricity and Water	No regulatory arrangement in place.

a The ACT is about to introduce a Code of Practice. **b** Regulations establish monitoring arrangements only.

Australia and most of the other countries studied make provision for the enforcement of drinking water standards. However, enforcement mechanisms in the US and UK are much stricter, and larger penalties are applied when non-compliance occurs.

Enforcement is less strict in Australia.

Approaches to monitoring and enforcement usually depend on whether standards are backed by the force of law, and whether there are associated agencies responsible for enforcement. In Australia, governments typically rely on cooperation between State Health Departments and government-owned water suppliers.

Australian governments also rely on self-reporting by the industry. Although similar approaches are used in the UK and the US, in Australia there do not seem to be the processes in place to scrutinise the information provided to the same degree.

The Australian industry is self-reporting.

Suppliers in most Australian jurisdictions, and in the benchmarked countries, are required to report instances where standards are significantly exceeded. When this occurs, they are required to take action to mitigate risk.

In Australia, however, sanctions for non-compliance are generally not imposed and there is more scope for administrative discretion about compliance.

Findings and policy issues

The benchmarking revealed that the regulatory assessment of water quality standards does not satisfy important best practice criteria in most countries, including Australia. An exception is the US, which consults widely and has a very transparent process of rigorously assessing standards. The overall findings and some of the issues arising out of this study are outlined in the key messages box before the overview.

Australian regulatory processes are not at best practice.

Standards should be rigorously assessed ...

The benchmarking results suggest that there is scope to inject greater rigour into Australian regulatory processes for establishing and enforcing drinking water standards. This would be particularly important if there were proposals for new standards requiring substantial investment in new water treatment facilities.

... along with the approach …

Of particular importance is to assess whether the cooperative approach is the most effective means of achieving efficient outcomes. Also, whether the relative emphasis on output (maximum levels of contaminants) and process regulation (requirements to have quality assured risk management plans) is effective and efficient.

In Australia, compliance costs are lower and there is greater flexibility to set standards according to local circumstances. However, there is less certainty about whether compliance has been achieved and institutional responsibilities remain unclear compared with overseas regimes.

... and instruments.

The 'right' balance between specific regulation and general consumer protection law is also important. This is best resolved by assessing regulatory options as part of the regulatory assessment process.

Further industry reform will necessitate better regulation making.

Moreover, the current approach to standards setting in Australia, which appears to be predicated on government ownership, may not be sustainable if parts of the industry undergo further restructuring and commercialisation, or even privatisation. For example, the public would be likely to expect governments to take a more formal approach to regulation and monitoring with private ownership.

With greater private sector involvement, greater specificity would also be necessary. For example, the extent to which some standards are to be met over a period of time would have to be precisely specified to ensure enforceablity.

Evolving information poses new challenges.

The development of new contaminant detection techniques and treatment technologies creates a number of additional challenges. For example, there is some industry concern that extensive training would be required to upgrade competencies of staff to operate some new technologies.

Also, there are understandable commercial incentives for developers of new technology to push for more stringent standards that make use of their equipment. In the absence of information to assess whether it is cost effective to increase standards, these pressures may be hard to resist.

Institutional arrangements could be improved.

A key requirement of reform in this area, as in others, is to establish effective institutional structures and appropriate objectives.

The threshold institutional issue in Australia is the respective roles and responsibilities of the NHMRC and the State standard setting bodies.

Responsibility for drinking water regulation is effectively shared between the NHMRC and the States and Territories, when NHMRC guidelines are adopted as standards without formal regulatory assessment. Shared responsibility makes it difficult to apportion responsibility for poor outcomes.

The NHMRC's role should complement the State and Territory responsibility for setting water quality standards and administering public health. Specifically, one of the NHMRC's objectives in developing the Australian Guidelines should be to reinforce State and Territory responsibility for the rigorous assessment of standards.

The NHMRC should continue to play an important role in providing scientific advice. However, the NHMRC guidelines would be just one, albeit important, input into the regulatory assessment process undertaken by State and Territory governments.

Regulatory authorities need to be adequately resourced to maintain their independence and have powers that enable them to obtain information.

Authorities have to be resourced adequately.

A greater commitment of expertise and resources is likely to be required. Overseas agencies appear to allocate significantly more resources than is currently the case in Australia. For example, Washington State, with a comparable population to NSW, has 80 to 90 people employed in the drinking water program. The water unit of NSW Health has a staff of 4.

There is a need to ensure that health risks from contaminants are addressed in the most effective and efficient way — across all possible sources, including those from hazards other than water.

An economywide focus is required.

Above all, there is a need for a well informed public debate about how safe drinking water should be and consultation on how much consumers are willing to pay for greater safety.

Public discussion is required on safety.

1 Introduction

There has been an international trend toward increasingly stringent regulation of drinking water quality. This trend can be expected to drive up water treatment costs, even if they are offset somewhat by technological improvements.

During the last decade, there has been a shift toward commercialisation and corporatisation of Australia's water suppliers (PC 1998). Suppliers have been required to develop a stronger commercial focus and among other things, reduce their operating costs.

In view of these developments, it was decided to review existing institutions and regulatory processes and to assess the effectiveness and efficiency of drinking water regulation in Australia.[1] This decision was based on the belief that good regulatory processes would deliver more effective and efficient outcomes.

Information from benchmarking can provide tangible insights into alternative regulatory approaches and their possible application in Australia.

1.1 Purpose

The purpose of this study is to compare Australia's approach to drinking water regulation with other countries and against generally accepted criteria for good regulatory practice.

The Australian urban water sector faces the prospect of having to make large investments in treatment works because of more stringent water guidelines. For example, Melbourne Water Corporation (MWC) has indicated that if it were to filter all water supplies to Melbourne, it would cost between $430 million to $510 million depending on the process selected (MWC pers. comm., 25 January 2000).

Information from the study will be particularly relevant to the consideration of whether:

[1] Regulation is effective when the objectives of the regulation are achieved — efficiency requires that an appropriate level of resources is allocated to that end.

- existing arrangements are amenable to the establishment of effective and efficient regulation;
- the implementation of existing regulation is consistent with its intended purpose; and
- the current approach to regulation in Australia will remain appropriate if the industry undergoes further restructuring and commercialisation.

At a more detailed level, the information presented is expected to facilitate the consideration of issues that are relevant to good regulatory practices. For example, the information should assist policy developers to:

- consider the impact of evolving scientific knowledge;
- assess the appropriate role of community awareness and consultation;
- assess current benefit–cost analysis of regulatory alternatives;
- explore the interactions and coordination issues between regulation of water quality and service delivery; and
- identify the type of information and analysis required for better public health policy choices.

1.2 Terminology

The Commonwealth Government coordinates the development of drinking water guidelines through a joint committee of the National Health and Medical Research Council (NHMRC) and the Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ). The *Australian Drinking Water Guidelines* are published jointly by both organisations, but for ease of exposition, they are hereafter referred to as either the NHMRC Guidelines, the Australian Guidelines or just the Guidelines.

The Commission believes that terminology is an important source of confusion and an impediment to constructive dialogue on changes in regulatory practice. The four terms ‘regulation’, ‘standard’, ‘guideline’ and ‘code of practice’ are commonly used, sometimes interchangeably, without regard for their precise meaning.

In particular, the distinction between a ‘standard’ and a ‘guideline’ is a source of much discussion within the industry. To avoid confusion, the Commission has sought to outline its interpretation of these terms (see box 1.1).

Box 1.1 **Interpretation of regulatory terms**

- In distinguishing between the terms 'regulation', 'standard', 'guideline' and 'code of practice', emphasis is sometimes placed on the administrative ease with which these instruments can be amended. However, the definitions proposed by the Commission below focus mainly on another important distinction — whether compliance is discretionary.
- *Regulation* — The legal form of a regulation is a rule that is subordinate to and made pursuant to a provision in an Act. A penalty for non-compliance with the rule normally applies.
- Sometimes the word 'regulation' is used loosely to encompass any of the terms 'standard', 'guideline', or 'code of practice'. This report uses the term *regulatory approach* as a catch all when referring non-specifically to any or all of these terms.
- *Standard* — In the drinking water context, the term 'standard' is sometimes used to distinguish it from a 'guideline'. The most important legal distinction between these two terms is that compliance with a standard is backed by a penalty, whereas there is no penalty for non-compliance with a guideline. It is this distinction which gives a standard the status of a regulation in the legal sense — in contrast with guidelines.
- Using 'standard' and 'guideline' interchangeably ignores the distinction made above.
- *Guideline* — A guideline has no legal status, in that non-compliance is not the subject of a penalty provision. If, however, an instrument of any kind is used to impose a penalty for non-compliance with a 'guideline', then the status of that 'guideline' has been elevated to that of a 'standard', and use of the term 'guideline' is no longer appropriate.
- For example, if compliance with a 'guideline' is a legal requirement for the continuance of an Operating Licence, then the 'guideline' has assumed the status of a 'standard'. Non-compliance incurs a penalty and therefore the so-called guideline fits within the above definition of a standard.
- *Code of Practice* — Codes can be purely advisory in nature, or there may be a penalty for non-compliance with the provisions of the Code. In the latter case, a Code has also assumed the status of a standard. Similarly, if a Code refers to a set of guidelines and the Code contains a penalty for non-compliance with the guidelines, then the Code has again assumed the status of a standard and is more correctly described as such.

Source: Productivity Commission.

1.3 Approach

The approach taken is to compare the regulatory arrangements for setting drinking water guideline values and standards in Australia and overseas. The differences in regulatory approach are highlighted, and their effectiveness and efficiency discussed in terms of the criteria generally considered to be consistent with good practice. The criteria used are presented in attachment 1A to this chapter.

These criteria refer to the institutional structures and processes involved in regulation making, rather than criteria for a particular regulatory model. As generally accepted criteria for good regulatory practice, they can be thought of as recommended principles for regulation making.

The main study tasks involved collecting information on the regulatory arrangements. This included information on the organisations, their responsibilities and accountabilities, as well as the processes in developing, adopting, monitoring and reporting on compliance with drinking water regulation.

At a more specific level, information was collected on the processes adopted in regulation-making, which included:

- problem identification and reasons for having a guideline or standard;
- specification of desired objectives;
- identification of options;
- consultation;
- assessment of impacts (benefits and costs) of each option; and
- consideration of implementation and review.

Information sources mainly comprised primary sources, publications and direct contact in the case of Australia. The Internet and e-mail communication were used to gather international information.

Consultation

The Commission consulted widely with government, industry and others during development of the study approach. Advice was obtained on regulatory issues and methodology. Representatives of the Water Services Association of Australia were particularly helpful at the commencement of the study.

A list of the organisations and individuals contacted by the Commission in the course of the study is provided in appendix A.

An invitation was also issued for those with an interest in the study to formally or informally comment and provide information that would assist the Commission. A study outline was posted on the Commission's web page as a guide.

Throughout the study, comment on the accuracy of factual information on regulatory arrangements was obtained from the National Health and Medical Research Council, the Australian industry and overseas regulatory authorities. Universally, those approached cooperated openly and constructively.

A workshop was held on 14 December 1999 to discuss the study methodology and present the study findings and their interpretation. A list of organisations and academics who were invited to attend the workshop is also provided in appendix A.

Refereeing

Drafts of the report chapters were refereed by Professor Don Bursill of the Co-operative Research Centre for Water Quality Treatment. Dr Murray Raff of the Melbourne University Law School and Associate Professor Jennifer McKay of the School of International Business, University of South Australia, refereed parts of the report dealing with legal issues.

1.4 Study scope

Regulatory arrangements for determining, implementing, monitoring and enforcing water quality guidelines and standards were benchmarked in Australia and overseas. All Australian States and Territories were included. These were compared with overseas arrangements in Canada, the European Union (EU), France, New Zealand, the United States of America (US) and the United Kingdom (UK).

In some cases, the benchmarking comparisons have led to findings that some arrangements are more consistent with the criteria or recommended principles in attachment 1A. However, these findings are too general to recommend their application in a particular jurisdiction.

Drinking water regulation is complex because there are many dimensions to water quality and local supply conditions and community values differ, which may necessitate different approaches. There is also scientific uncertainty about the links between particular aspects of water quality and public health outcomes.

Promulgation and enforcement of drinking water regulation depends on the institutional and legislative arrangements in place. Accordingly, promulgation and enforcement arrangements can differ widely between jurisdictions.

A preferred regulatory model is not just about processes that conform with best practice principles — it necessarily involves judgements about social and economic values. However, it is often not possible to take into account all of the local factors and community preferences that make one approach superior to another. How the elements of an approach interact, and the tradeoffs within individual jurisdictions between quality and affordability, for example, have not been fully articulated within the scope of the study. Accordingly, there is not sufficient basis on which to recommend particular regulatory models.

The study covered arrangements for setting all quality categories — microbiological, radiological, chemical and physical.

Microbiological guideline values and standards are given particular emphasis in this report because, among drinking water quality experts, concern about microbiological quality is the major driver of new capital expenditure on drinking water treatment facilities. However, consumers may be more concerned about the colour, taste and pH of water, sometimes referred to as physical or aesthetic guidelines.

The study was concerned with drinking water only. Possible links between the cost of meeting water quality guidelines and the cost of wastewater treatment were not examined.

The relationship between the regulation of drinking water quality and other components of the regulatory framework, for instance price regulation, is only covered to a limited extent in the study.

1.5 Report Outline

The regulatory and institutional arrangements for drinking water quality differ among Australian jurisdictions, and between Australia and the other benchmarked countries.

The urban water cycle, historical trends in treatment technology and guideline values and standards in Australia and the other countries selected for this study are described in chapter 2. Current water quality guidelines and standards are outlined. There is also a brief discussion of the industry's place within the general economy, the economics of the industry and the cost of current treatment processes. This

chapter is intended to provide the context to setting water quality guidelines and standards.

In chapter 3, the institutional settings and general approach to regulation are compared. The processes for establishing safe levels for each hazard are reviewed in chapter 4.

The promulgation and enforcement of standards in Australia and overseas is presented in chapter 5. Also included is a discussion of the approaches to monitoring.

Issues of systems management, cost recovery and risk communication are discussed in chapter 6. The issues examined include operator training and certification, cost recovery for investments made to achieve compliance with guidelines and standards and the benefits of effectively communicating risks.

Finally, the benchmarking findings and a number of overarching issues to be addressed in evaluating current and future effectiveness and efficiency of water quality guidelines and standards, are covered in chapter 7.

Attachment 1A Criteria used to assess the efficacy of arrangements

Criteria were developed as a basis for discussing the efficacy of current regulation making arrangements for drinking water. They are generic criteria that could also be applied to other areas of regulation making.

Institutional settings

The following criteria, consistent with effective governance, were used to discuss the strengths and weaknesses of current institutional settings.

Objectives

Clearly delineated responsibility and jurisdictional scope — responsibilities for outcomes are unambiguously defined and fall within jurisdictional function.

Non-conflicting objectives — ideally, objectives are not conflicting and allow the agency to take an economy-wide perspective to achieve the most effective and efficient outcomes for the community as a whole.

Accountability

Avoidance of shared responsibility — where responsibilities are shared, authority to act and accountability can become confused.

Effective review and appeals mechanisms — the agency is subject to the discipline of review and appeal.

Single-point accountability — ideally, the agency is accountable to a single higher authority.

Resource sufficiency — the agency is adequately resourced so that it cannot avoid accountability for performance deficiencies.

Requirement to report outcomes — requirement to report outcomes against statement of corporate intent and the achievement of objectives in the case of regulation.

Transparency

Clearly enunciated basis for decisions — where there are competing objectives, the tradeoffs made in program decisions should be published.

Open processes — decision-making processes should be open to participation and scrutiny.

Measurable performance — agency performance is readily measurable.

Responsiveness

Receptive to changing demands and needs — the agency actively assesses the need to review its regulation to ensure that it remains effective and efficient, given changes in need and preferences.

Regulatory process

The following elements of Regulatory Impact Statements were used in considering the current regulatory processes and their relative merit.

Identification of problems and issues — the nature of the problem is identified so that it is clear what the regulation is to address. In the case of water quality guidelines and standards, this involves a rigorous assessment of risks.

Objectives are transparent — the objectives of the proposed regulation are defined as desired outcomes and published.

Identification of options — all of the viable options are identified. This should include options outside water quality regulations.

In considering regulatory options and their codification, the following criteria were considered to be relevant.

Compliance flexibility — ideally, regulations focus on outcomes and maximise flexibility in the means by which these outcomes are achieved. However, output, input, or process forms of regulation may be specified in circumstances where their use is demonstrated to be the most cost-effective option.

Pro-competitive impacts — the regulation does not represent an impediment to neutral competition.

Impacts are assessed — a rigorous assessment of compliance costs and the impacts on consumers, business, government and the community is undertaken.

Consultation — consultation is undertaken throughout the regulation-making process.

Enforcement

The following criteria, consistent with effective enforcement, were used to discuss the strengths and weaknesses of current enforcement practice.

Legal instruments

Effectiveness — the instrument used provides the necessary force of law and accountabilities.

Transparency

Powers and sanctions — regulations clearly outline enforcement powers, appeal mechanisms and sanctions. Administrative procedures setting out the enforcement policy and strategies of the regulatory agency are published.

Industry consultation — mechanisms are in place to ensure that enforcement policy and procedures are understood, effective, and minimise the burden on industry of the proposed regulation.

Enforcement record — details of enforcement action and penalties are publicly available to provide information on how enforcement is being exercised and the outcomes for those not meeting standards.

Enforcement strategies

Legal action as a measure of last resort — enforcement strategies are consistent with minimising disputes and legal remedies.

Cost effectiveness — the benefits of better health outcomes from enforcement outweigh the cost of the enforcement effort and the compliance burden on industry.

Flexibility — the strategy is sufficiently flexible to accommodate new risks and changes to compliance response.

Penalties — penalties provide an effective disincentive to non-compliance.

Consistency — enforcement is consistently applied and is competitively neutral.

Monitoring

Indicators — the purpose of monitoring and the rationale for particular indicators is clear.

Cost effectiveness — the benefits of monitoring outweigh the cost burden on industry in providing information.

Acceptance — ideally, indicators are chosen after consultation with industry to ensure that they are widely used and there is agreement on their interpretation.

Implementation

The following criteria were used to assess compliance approaches.

Integrated approach — authorities have regard for the overall resource implications of meeting the guidelines or standards, taking a system-wide management approach as appropriate.

Productive efficiency — the most cost effective technology is used to meet the guidelines or standards.

Risk management — in identifying the best technical solution external risks are identified, assessed and managed.

Quality assurance — the systems in place to comply with guidelines or standards are quality assured to minimise systemic risks.

Evaluation and review — mechanisms are in place to evaluate and improve implementation.

2 The drinking water sector

Provision of safe drinking water in developed countries is seen as an essential requirement. This is because of the linkages between drinking water and health outcomes.

Drinking water quality depends on the quality of source water and the treatment processes undertaken prior to its consumption by the consumer. Its delivery is a significant economic activity.

2.1 Urban water cycle

Drinking water is one part of a complex physical system know as the urban water cycle (UWC). The UWC refers to the flow of water for consumption and other purposes, taken from and eventually returned to the environment (see figure 2.1).

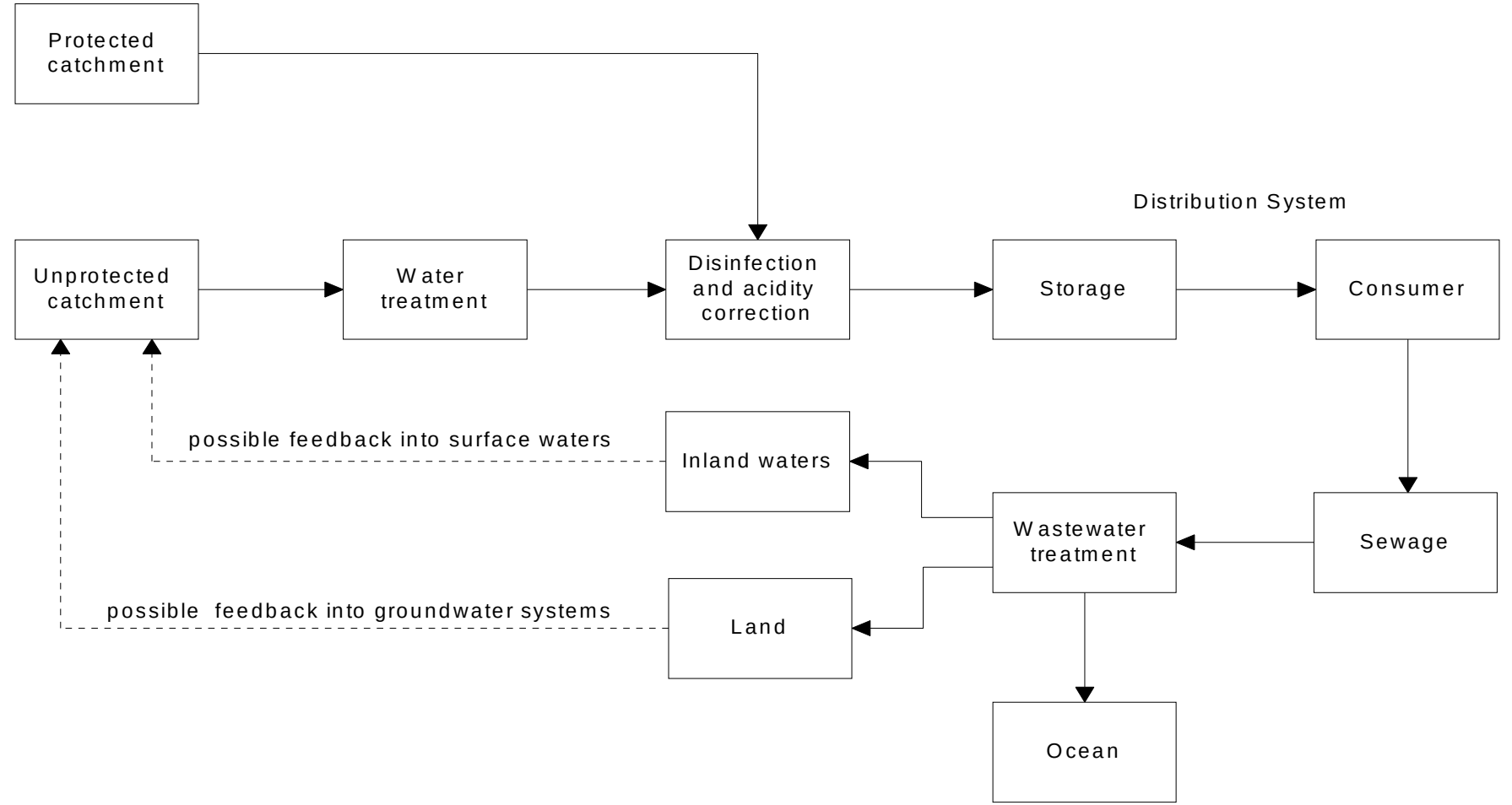
Water is harvested from rivers, streams, lakes and underground systems and stored in dams and reservoirs until needed. It is then transported to the population through a network of pipes and pumping stations.

Prior to, and during distribution, drinking water is treated to make it safe for human consumption. The level of treatment required is dependent on the quality of source water. Source water from a protected catchment is likely to be of a better quality because it is less likely to be subject to contamination.

Most properties in metropolitan areas are connected to a reticulated drinking water supply. The same reticulated supply is used to flush the sewerage system. Wastewater is returned to the environment through the sewerage system and its regulation is usually the responsibility of environment protection agencies. [1]

[1] The level of treatment of wastewater depends on whether it is to be re-used or disposed of on land or at sea.

Figure 2.1 **The urban water cycle**



2.2 Historical evolution of drinking water guidelines and standards

Water quality became an issue with the urbanisation that occurred during the Industrial Revolution. Cities were using the same water sources for both consumption purposes and waste disposal, causing the quality of drinking water and public health to deteriorate. This led to a series of developments in treatment processes aimed at improving drinking water quality (see box 2.1).

Setting guidelines and standards has had a significant effect on the drinking water treatment processes undertaken in developed countries. Filtration, together with chlorination, was a major breakthrough when introduced in the 1930s and reduced the risk of diseases such as typhoid and cholera.

Box 2.1 **Historical evolution of water treatment guidelines and standards over the past 200 years**

- In the 1820s, James Simpson pioneered the sand filter in the United Kingdom. It was the first treatment process used to clarify water supplies for consumption.
- It was not until 1852, when a law requiring all water to be filtered in London was introduced, that any standards or requirements concerning water quality were established.
- In the mid-1850s, the link between health and water quality was made. Dr. John Snow and William Farr released reports empirically linking cholera outbreaks to the quality of the water supplied at this time.
- In the 1880s, studies by Louis Pasteur on bacteriology, demonstrated the causal link between water quality and disease.
- In 1914, the first formal review of drinking water concerns occurred in the United States. Following this review, standards were established and it was agreed that they were to be re-evaluated on a regular basis.
- In the 1930s and 1940s chlorination was introduced almost universally throughout developed countries, when it became clear that filtration and disinfection with chlorine had a major impact on drinking water quality, preventing outbreaks of cholera and typhoid fever.

Source: AWWA (1990); Barty-King (1992).

Over the past fifty years, the World Health Organisation (WHO) and the United States Environmental Protection Agency (US EPA) have been the world leaders in setting guidelines and standards respectively (see section 1.2 for the distinction between guidelines and standards). Most developed nations, including Australia, have adopted or modified the WHO guidelines to suit local conditions.[2]

Despite the widespread development and acceptance of drinking water guidelines and standards over the last century, the processes by which standards are set, promulgated and enforced have been very different. These differences tend to reflect the history and unique characteristics of the countries in which the guidelines and standards have been developed.

Development of the US system of regulating drinking water started with a review of drinking water quality in 1914. Subsequently, drinking water guidelines were developed in 1925, 1942 and 1962 by the United States Public Health Services (USPHS).

The passing of the *Safe Drinking Water Act 1974* (SDWA) required the US EPA to set enforceable standards for health-related drinking water contaminants to apply to all drinking water systems (see appendix D3). The US EPA was established in 1970 out of the Federal Government's attempt to reduce cancer in the US by the regulatory control of carcinogens in the general environment (Albert 1994). The dissolution of the USPHS and other regulatory bodies saw Federal regulatory programs in air, water, radiation, pesticides, and drinking water reassembled under the US EPA.

The European Union (EU) first established standards for the quality of drinking water in 1980, with the Drinking Water Directive 80/778/EEC, applying to all water intended for human consumption. Revision of the Directive as part of the restructuring of European water policy, saw it replaced in 1998 by the Drinking Water Directive 98/83/EC (see appendix D1).

The current system that applies in Australia evolved in an *ad hoc* fragmented way through a series of historical developments. At the Commonwealth level, the National Health and Medical Research Council (NHMRC) is responsible for developing national drinking water guidelines and these are implemented at the State and Territory level. The first water quality guidelines for Australia were produced in 1972. They have subsequently been updated in 1980, 1987 and 1996.

2 The World Health Organisation (WHO) was created in 1948 as an agency of the United Nations with responsibility in international health matters and public health, including issues relating to safe drinking water supplies.

Australia's principal research and development body on drinking water quality is the Cooperative Research Centre for Water Quality and Treatment (CRCWQT). It was established in 1995 under the Australian Government's Cooperative Research Centres Program (see box 2.2).

Box 2.2 **The Cooperative Research Centre for Water Quality and Treatment (CRCWQT)**

- The CRCWQT's role is to look at issues relating to water quality management and health risk reduction, from catchment management to the distribution of drinking water to consumers' taps and to provide advice to the government regarding water supply policy and regulatory issues.
- The CRCWQT is funded through in-kind contributions made by participants who come from the Australian water industry, research organisations, universities and other relevant government organisations. External research grants are also important in supporting key projects.

Source: CRCWQT (1998, 1999a).

As drinking water standards have evolved, there have been ebbs and flows in the level of interest shown in particular contaminants. Water quality literature routinely contains assertions like the following:

> … water quality issues that concern developed countries have changed from a focus on infectious agents, which are largely under control, to a concern with chemical contaminants (Spear 1991).

This statement is only partly correct when viewed in the context of the full span of the twentieth century. In the early part of the century, diseases such as cholera and typhoid killed large numbers of people in developed countries, but these diseases have been largely brought under control.

In recent years guidelines and standards have been developed for radiological and chemical contaminants — largely in response to concerns about carcinogens — and the ability to detect them.

Despite the reduction of diseases through disinfection, concerns have arisen over the last twenty years about the by-products produced by disinfectants such as chlorine, chloramine and ozone.[3] In response to these concerns the US EPA promulgated a Total Trihalomethane Rule in 1979. Subsequently, a more

3 Chlorination and chloramination produce halogenated organics such as Trihalomethanes, chlorine dioxide produces chlorite and chlorate, while ozone produces bromate aldehydes, keytones and inorganic by-products.

comprehensive Disinfection By-products Rule was promulgated in 1998. This rule contains maximum contaminant level goals for four trihalomethanes and two haloacetic acids as well as a maximum residual disinfectant level goal for chlorine, chloramines and chlorine dioxide (US EPA 1998g).

In the 1970s and 1980s, there was considerable interest in chemical contaminants. At the same time, gastrointestinal diseases were regarded as less serious and not life threatening. However, experience in developed countries in the 1980s and 1990s has shown that some microbiological contaminants can have serious, and even life threatening consequences for more vulnerable sub-populations within the community.

Waterborne disease emerged as a major public health issue with outbreaks of illness from protozoa such as *Cryptosporidium parvum* and *Giardia lamblia*. In 1993, up to 100 people died and 400 000 were affected by an outbreak of *Cryptosporidium* in the US city of Milwaukee. In mid-1998 *Cryptosporidium* was detected in Sydney's water supplies. Although no illness of any kind was linked to the incident, 'boil water' alerts were issued over a period of three months.

Thus, a number of microbiological pathogens, some of whose properties are poorly understood, have assumed greater importance in the 1990s.

Escalation of guidelines and standards over time

Over the last twenty years, the scope and stringency of drinking water guidelines and standards in developed countries, including Australia, has increased. Developments in the science of detecting contaminants and the technology to remove them, as well as an increase in community awareness and demand for high quality water, have seen guidelines and standards become more comprehensive.

Australia and the benchmarked countries periodically adjust and update their guidelines and standards in an uncoordinated way. New rules, guideline and standard values are established at different times in different countries, such that they often supercede those existing elsewhere. However, countries often adopt or adapt the latest developments, even though they were conceived in another country. This creates a certain element of commonality in guidelines and standards for drinking water throughout developed countries.

In Australia, the number of contaminants for which values are listed in the *1996 Australian Drinking Water Guidelines* (referred to from here on as the Guidelines) has risen from 29 in 1980 to 125. This was most notably due to an increase in the

number of pesticides and other organic compounds included in the Guidelines (see table 2.1).

Table 2.1 **Comparison between 1980, 1987, 1996 Drinking Water Guidelines**

Guideline category	*1980*[a] *No. of Values*	*1987* *No. of Values*	*No. of values more stringent*	*No. of values less stringent*	*1996* *No. of Values*	*No. of values more stringent*	*No. of values less stringent*
Physical	4	4	3	0	8	2	0
Inorganic Chemicals	23	17	1	1	39	9	2
Organic Disinfection By-products	0	3	**na**	**na**	20	2	1
Other Organic Compounds	0	9	**na**	**na**	30	1	3
Pesticides	0	6[b]	**na**	**na**	21 (100)[c]	5	1
Radiological	2	2	1	0	7	0	1
Total	**29**	**41**	**5**	**1**	**125**	**19**	**8**

a The 1980 guidelines provide three different categories of values — 'desirable current criteria', 'long term objectives' and 'health investigation levels'. The desirable current criteria is used for the purpose of comparison with subsequent guideline values. **b** The 1987 Guidelines contain an appendix listing the values for pesticides that degrade rapidly in the environment and are therefore non-toxic. They are included only as a guide for situations where there is accidental direct contamination of drinking water. However, the non-toxic pesticides in this list are not included among these six pesticides. **c** The figure in parenthesis is the number of pesticides for which guideline values are listed in the 1996 Guidelines, but are not likely to be found in Australian water systems. **na** not applicable.

Source: NHMRC (1980, 1987 and 1996).

Increases in the number of organic compounds and pesticides included in the Guidelines are not a true reflection of the increase in the scope or stringency of the Guidelines. A number of these compounds are only included as a precautionary measure and do not require monitoring.[4]

The scope of the Guidelines may be extended further in the future to include pharmaceutical residuals such as hormones. Research, although still formative, has shown that minuscule concentrations of these residuals in water supplies may be enough to threaten reproductive health, posing an environmental health problem (Fisher 1999).

The stringency of drinking water guideline values is also increasing. This is evident in Australia, with the alteration of recommended concentration in guideline values,

4 Many of the pesticides, for example, are not currently used in Australia and are listed in case they are used at some time in the future.

where the number that have become more stringent outweighs the number of guideline values that have been relaxed (see table 2.1).

Monitoring regimes have also become more rigorous, with the required frequency of testing for some contaminants increasing (see table 2.2). Further, developments in science and technology have allowed the detection of contaminants that were previously unknown.

Table 2.2 **Comparison of monitoring frequency for microbiological quality**

Population serviced	*1987: Minimum number of samples*	*1996: Minimum number of samples*
Above 100 000	13 samples per month plus one sample per 10,000 people.	Six samples per week, plus one additional sample per month for each 10,000 above 100,000 people.

Source: NHMRC (1987 and 1996).

2.3 Current concerns

Current guidelines and standards have arisen in response to concerns about disease and the toxic impact of chemicals, pesticides and radiological compounds. The expansion in the number and stringency of guideline parameters over time is, in part, due to the development of new technology in detecting contaminants and from research linking contaminants with adverse health outcomes. As noted previously, water treatment, the establishment of guidelines and regulation arose in response to concerns about waterborne diseases.

Waterborne diseases

Waterborne diseases, such as cholera and dysentery, continue to be a major health problem in many developing countries. Between 1991 and 1993, a cholera epidemic spread from Peru north up the coast to Mexico — killing 7000 people and infecting over 800 000 (Putnam and Wiener 1995).

Cholera and dysentery occur only rarely in developed countries, with most waterborne disease outbreaks exhibiting as non life-threatening gastroenteritis of undefined cause. However, these disease outbreaks have the potential to spread and impose costs not just on those initially infected, but on other community members as well.

Many waterborne disease outbreaks come and go before the causal organism can be identified because of the difficulty in sampling and culturing organisms. Between

1971 and 1985, the causal organism was not identified in approximately half of the disease outbreaks recorded in the US over the period, despite improved sampling and analytical techniques (Tate and Arnold 1990).

In the US between 1971 and 1988, there were nearly 137 000 cases of waterborne disease reported. When unreported cases are included, it is believed that there may have been as many as 900 000 cases and 900 deaths (Putnam and Wiener 1995).

Waterborne diseases result from a variety of micro-organisms (see table 2.3).

While bacterial diseases such as cholera and typhoid have largely been brought under control in developed countries, other micro-organisms are constantly being identified and connected to waterborne illness.

In the US, the microbial agent most commonly identified in outbreaks of waterborne disease between 1971 and 1985 was the protozoan cyst *Giardia lamblia* (Tate and Arnold 1990). This observation is not surprising given that 26 to 43 per cent of US water supplies are said to be contaminated with *Giardia* cysts, ranging in concentration from 0.3 to 100 cysts per one hundred litres (Putnam and Wiener 1995).

In developed countries, the diseases listed in table 2.3 are not for the most part fatal for people with normal immune systems and their symptoms are usually reversible. However, these diseases can be a serious health threat to those whose immune systems are incapable of dealing with them. Further, diarrhoea and dehydration due to poor water quality kill millions of children each year in developing countries.

The treatment and disinfection of drinking water has dramatically lowered the incidence of waterborne disease outbreaks since the early part of this century. More recently, however, there is some evidence of an increase in the number of reported outbreaks from the US (Tate and Arnold 1990). This is presumed to be the result of increased public awareness and the associated increase in the reporting of disease outbreaks.

Epidemic and endemic disease

Disease can exhibit as an epidemic or it may be endemic. In the case of an epidemic, the disease is likely to be readily observed and it will usually be well documented. Alternatively, disease may be endemic in that it appears relatively frequently, but is confined to a smaller number of individuals on any one occasion. Because its occurrence is sporadic, it frequently goes undetected or unreported. Accordingly, its impact is not documented and the relevant authorities may not even be made aware of its existence, let alone its cause.

Table 2.3 **Waterborne diseases**

Waterborne disease[a]	*Causative organism*[b]	*Source of organism in water*	*Symptom*
Gastroenteritis	Multiple potentially causative organisms	Animal or human faeces	Acute diarrhoea and vomiting
Typhoid	*Salmonella typhosa* (bacterial)	Human faeces	Inflamed intestine, enlarged spleen, high temperature; can be fatal
Dysentery	*Shigella* (bacterial)	Human faeces	Diarrhoea; rarely fatal
Cholera	*Vibrio cholerae* (bacterial)	Human faeces	Vomiting, severe diarrhoea, rapid dehydration, mineral loss; often fatal
Infectious hepatitis	Virus	Human faeces, shellfish grown in polluted waters	Yellowed skin, enlarged liver, abdominal pain; lasts up to 4 months, seldom fatal
Amoebic dysentery	*Entamoeba histolytica* (protozoa)	Human faeces	Mild diarrhoea, chronic dysentery
Cryptosporidiosis	*C.parvum* (protozoa)	Animal or human faeces	Diarrhoea, abdominal discomfort, possibly fatal
Giardiosis	*Giardia lamblia* (protozoa)	Animal or human faeces	Diarrhoea, cramps, nausea and general weakness; lasts 1 week to 30 weeks, not fatal

a All of the diseases listed can also be transmitted by means other than water. **b** Not all of the organisms listed cause the associated waterborne disease.

Source: American Water Works Association, reproduced in Putnam and Wiener (1995) and US EPA (1993).

The contribution of waterborne micro-organisms is particularly unclear in the case of endemic disease. A pivotal Canadian study suggested that tap water was responsible for about 30 per cent of gastrointestinal illness, even though the water was free of *total coliforms* and was compliant with Canadian water quality guidelines (Payment et al 1991). However, the absence of 'double blind' methodology used in this Canadian study has been criticised, and further research effort attempted to establish whether drinking water that meets accepted microbiological guidelines, can still cause gastroenteritis.[5]

5 'Double blind' methodology is designed to prevent reporting bias which can occur if those being tested already know the status of the water they are being given in the study.

In Australia, the CRCWQT is undertaking a large epidemiological study similar to that undertaken in Canada. The study objective is to determine whether additional treatment of Melbourne's drinking water supply is required on public health grounds (see box 2.3).

Box 2.3 **Melbourne water quality study**

The Melbourne Water Quality Study (MWQS) is a large scale household study designed to investigate the level of endemic disease attributable to drinking water at its present level of quality. The MWQS has been designed as a 'double blind' study to overcome the methodological criticisms of a similar study conducted in Canada. The results are expected to be available in April 2000.

The study recorded illness among two population groups, each comprising approximately 300 households. One group consumed normal tap water and the other consumed water that was filtered and disinfected with ultraviolet radiation.

The study objective is to test whether the baseline group drinking normal tap water experience a higher level of gastrointestinal illness than the group drinking filtered water. If there is a difference, then it is anticipated that the difference can be used to estimate the public health benefit from further treating Melbourne's water supply. The cost of further treatment would depend on the organism(s) responsible for the difference.

If on the other hand there is no difference between the two groups, then the study will not necessarily mean that there is no endemic waterborne gastroenteritis. Rather, if it exists at all, it may be too small to measure. The study team has suggested that a randomised clinical trial like the MWQS is unable to rule out endemic waterborne gastroenteritis if it represents less than 15 per cent of all community gastroenteritis.

Source: Fairley and Sinclair (1999).

Chlorine resistant organisms

Disinfection is the major means of guaranteeing the microbiological quality of drinking water. However, *Cryptosporidium* is immune to chlorine at concentrations normally used for drinking water disinfection. This has prompted greater interest in advanced technologies capable of removing *Cryptosporidium*. About one per cent of the general population contracting *Cryptosporidiosis* require hospitalisation, but severely immuno-compromised individuals may suffer a mortality rate of 50 per cent because no effective drug treatment currently exists (Baudish and Merz 1999). Nevertheless, the links between *Cryptosporidium* and health outcomes are not clear.

Disinfection by-products

Disinfection by-products are the most commonly found organic contaminant in Australian drinking water supplies according to the Guidelines. Disinfection by-products result from the interaction between disinfectants, particularly chlorine, and naturally occurring organic material resulting from the decay of animal and vegetable matter. Of these disinfection by-products, the trihalomethanes (THMs) are produced in the highest concentrations.

THMs have been the source of international concern for some time. A difficult aspect to the regulation of THMs is the risk tradeoff between the use of disinfecting chemicals that result in their production, and the risk from minimising chemical use to the point where it jeopardises the effectiveness of disinfection. In this context, the Australian Guidelines contain the following caution:

> Action to reduce the concentration of disinfection by-products is encouraged, but disinfection itself must not be compromised: the risk posed by disinfection by-products is considerably smaller than the risk posed by the presence of pathogenic micro-organisms in water which has not been disinfected (NHMRC 1996, pp. 3–4).

2.4 Treatment technologies

Drinking water treatment processes encompass the management and protection of raw water sources, through to the protection of treated water in the distribution system before it reaches the consumer's tap. Water treatment is undergoing rapid change, driven by advances in technology, a greater understanding of the contaminants present in water and their health risks, as well as rising public expectations and the need to develop cost effective processes.

Effect of source water quality on treatment approaches

The level of risk of hazardous contamination in drinking water supplies is determined by source water quality and by catchment conditions. Both these factors affect the level of treatment required to satisfy quality standards and hence the technology required to remove hazardous contaminants.

Water collected from catchments that are isolated from human and agricultural contamination, is usually of better quality, and therefore may require less treatment for drinking purposes. These catchments may be protected catchments, where the

likelihood of human pathogens being transmitted is very low, particularly in terms of protozoa and viruses.[6]

Conventional and alternative treatment processes

Conventional treatment of drinking water is a combined process of screening, coagulation, sedimentation, filtration and disinfection (see figure 2.2 and box 2.4). Conventional treatment processes have been effective over the past century in eliminating outbreaks of waterborne disease such as cholera and typhoid in developed countries.

Currently in Australia, all major urban water suppliers (Water Services Association of Australia (WSAA) members) at least filter and disinfect most of their water supplies, with the exception of Melbourne Water which only filters a small proportion taken from sources outside their protected catchments.[7] A survey of non-metropolitan water suppliers found that 76 per cent filtered and disinfected and at least 97 per cent disinfected drinking water supplies (AFFA 1999).[8]

In most cases conventional treatment will provide safe drinking water. However, there are limits to the extent which conventional treatments can remove harmful organisms such as *Cryptosporidium*. Accordingly these deficiencies have renewed interest in the multiple barrier approach, involving processes other than disinfection, and the development of alternative treatment technologies (see box 2.5).

These technologies all have advantages and disadvantages and there is no single water treatment process that is at present regarded as superior in all circumstances.

The high capital cost of new technologies, high energy consumption and, in some cases, very large waste streams, can make their application uneconomic. Their use has been restricted to relatively small scale plants needed to deal with special situations, but larger scale plants are now appearing.

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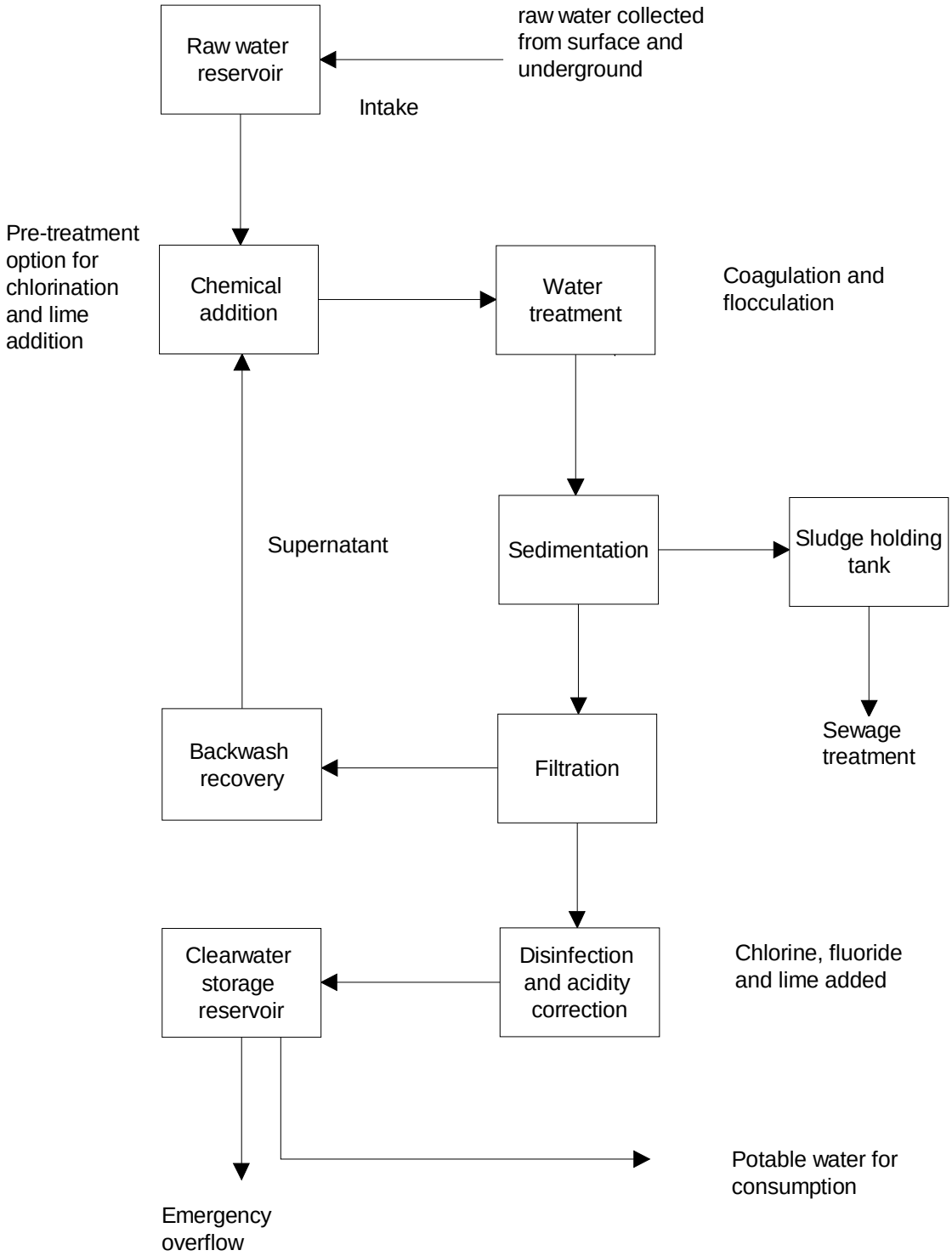
6 Despite the isolation of protected catchments, there is still some risk of contamination from birds and native animals (NHRMC 1999).

7 Currently, most of Melbourne's water supply does not undergo full treatment as around 90 per cent of its water is sourced from protected catchments (MWC 1999, p. 5).

8 A non-metropolitan water supplier is defined in *The Non-Major Water Utilities 1998 Performance Measurement Report* as a water utility in Australia supplying water to 10 000 – 50 000 properties.

Figure 2.2 **Conventional water treatment process**



Source: AWWA (1990).

Box 2.4 **Conventional treatment processes**

Intake is the process of taking water from its natural source and transferring it to a holding water reservoir in preparation for treatment. Screens are used to remove floating material and prevent large clumps of organic material from entering the holding reservoir.

Storage of water in open reservoirs reduces the number of pathogenic micro-organisms through a combination of settling, ultraviolet (UV) radiation and natural die off.

Water is often transferred from a reservoir to an enclosed tank, where acidity levels of the water may be adjusted before treatment. This prevents corrosion and enhances the effectiveness of disinfection.

Alum and iron salts or synthetic organic polymers (alone, or in combination with metal salts) are added to promote coagulation of fine organic matter and pathogenic organisms in the water into a 'floc'.

The water and floc then passes into clarifiers, where the floc settles to the bottom of the tanks. The clear water then flows into the filtration tanks and the sediment at the bottom of the clarifiers is removed.

Filters, made of layers of sand and gravel, remove remaining flocculated particles and micro-organisms, enhancing the effectiveness of subsequent disinfection. These filters rely on chemical pre-treatment of the incoming water to be effective in removing the remaining particles and micro-organisms.

Disinfection is the last stage in the treatment process. Chlorine (or some other disinfectant such as chloramine) is added to inactivate any remaining microbiological contaminants which have passed through the filters. The treated water is finally stored in a closed tank or reservoir, before being distributed to consumers. Residual amounts of chlorine are left in the water to prevent infection from bacterial regrowth and provide protection against contaminants in the distribution system.

After disinfection, water may have more chemicals added to make it suitable for drinking. For example, lime may be added to adjust the pH level. Some governments have legislated for fluoride to be added to drinking water supplies.

Source: AWWA (1990).

It has been claimed that water treatment plants in the future will use more sophisticated treatments, such as membrane filtration processes (Brignall and Bayley 1999). Improvements have been made in the past decade or so in the quality, robustness, longevity and operating requirements of membranes while their price has been reduced. Thus, membranes are expected to become more widely applied in the treatment of water:

> In the past five years, there has been a significant increase in the use of membrane filtration processes for the production of drinking water. At one time, membrane

processes were considered inappropriate or too costly for municipal water treatment … However, the recent commercialisation of back washable hollow fibre membrane systems (that is, microfiltration and ultrafiltration) has resulted in a fundamental change as to how utilities, engineers and regulatory agencies approach water treatment (Pirnie et al 1998, p. 705).

Box 2.5 **New and alternative treatment processes**

Raw water sources that are high risk, will generally require treatment other than by conventional means. Alternative water treatment processes include *Granular Activated Carbon (GAC),* disinfection with *Ozone* or *ultraviolet (uv) radiation*, and *membrane filtration.*

GAC removes residual tastes and odours, and reduces the concentration of dissolved organic material which cannot be removed by sand filters. It does this through an absorption process, causing compounds to stick to the surface of the GAC, protecting treated water from particle penetration. *Powder Activated Carbon* is also used for this purpose, but is generally not as effective in removing these contaminants.

Ozone used as a disinfectant in conjunction with *GAC,* is particularly effective in reducing tastes and odours. However, it is not effective in controlling biological contaminants in the distribution system, as residuals cannot be sustained long enough to keep the water free from re-infection before reaching the consumer's tap. Also, ozone is a very powerful oxidising agent, capable of generating carcinogenic by-products such as bromates and aldehydes. Current conventional and advanced water treatment processes do not remove either bromide or bromate.

Ultraviolet treatment usually requires the prior removal of particulate matter to allow the clear passage of UV radiation. Some bacteria have the ability to repair damage caused by UV irradiation, and thus may potentially 'reactivate'.

Membrane filtration, in the form of microfiltration and nanofiltration, is being used more frequently for treating drinking water. These technologies remove particles the size of *Cryptosporidium* and *Giardia* cysts. However, only nanofiltration removes viruses and colour.

Source: Baudish and Merz (1999); Brignall and Bayley (1999); AWWA (1990).

2.5 Economics of the industry and water quality regulation

Water supply in Australia is a significant activity, with an estimated gross value of output over $6 billion (AATSEIE 1999). It is estimated that 20 million megalitres of water was supplied for consumption and production uses in both rural and urban areas in 1995–96.

Metropolitan urban suppliers service approximately 70 per cent of Australia's population. In 1997–98, their total turnover was around $4.6 billion. Total operating costs were around $3 billion (WSAA 1998).

In 1997–98 WSAA members controlled fixed assets with a total written down value of approximately $20 billion (WSAA 1998).

Of the total amount of water used in Australia, 17.5 per cent is treated for urban uses, including residential, industrial and commercial (AATSEIE 1999). The average annual volume of water supplied per property in 1997–98 was 423 kilolitres, with residential users accounting for 59 per cent of urban water use (WSAA 1998).

Despite accounting for 17.5 per cent of total water use, urban water accounts for about 80 per cent of supply costs (AATSEIE 1999). This is mainly because of the treatment processes that urban water must undergo and the capital cost of the extensive reticulation systems used.

The percentage of treated water used for drinking purposes is estimated to be less than one per cent.[9] In contrast, garden use accounts for approximately 34 per cent of annual domestic use.

Demand characteristics

Water is a basic necessity with few substitutes (such as bottled water and fruit juices) available. The structure of the industry, with only one supplier for each property, makes it susceptible to monopoly pricing. This helps to explain the provision or regulatory supervision of water services by governments in many developed nations.

Preferences in a market are important in determining an efficient allocation of resources. Governments, in cooperation with the water industry, are trying to improve signals concerning community preferences in relation to the *quantity* of water supplied, through the introduction of user pays pricing.

When there are many customers in a network, one customer's unexpectedly high demand may be offset by another's low demand. Any residual volatility in aggregate demand can be addressed with less reserve capacity, where a network of inter-connected local storages can be drawn upon.

9 Based on average household consumption of six litres per day.

With only one supplier, consumers have no practical choice but to buy water from that supplier. It might be expected that demand for higher quality water would increase with income. However, there are information problems and no ready price mechanism to determine the effect of water *quality* on consumption.

Drinking water does not need to be treated to high quality levels for the majority of consumers. However, reducing current guidelines or standards could prove fatal for immuno-compromised people in a community.

Supply characteristics

The cost of establishing a metropolitan water treatment and distribution system is substantial. Once set up though, operating costs that vary with the level of output are relatively low. This is characteristic of a natural monopoly with economies of scale and scope (see box 2.6).

Box 2.6 **Economies of scale and scope**

The fixed costs of setting up a distribution system also result in economies of density in distribution — a special form of scale economy related to the throughput in a given geographical area. These economies arise because the costs of supplying water per litre decrease as more water is supplied through a given mains distribution system.

Suppliers of major urban areas in Australia have cost advantages compared with suppliers of smaller areas, as there can be almost twice as many 'customers per kilometre of main'. However, any such advantages may be offset to some extent by the high cost of replacement and repairs in high-density urban areas.

Economies of scope exist in supplying water for urban uses. This is because the same supply infrastructure is used to deliver water to residential and commercial properties. Economies of scope are also present in household consumption. Residents use water from the same pipes for many purposes such as cooking, bathing, washing clothes and watering gardens as well as drinking.

Source: Productivity Commission.

Water is supplied for many purposes that do not require high levels of treatment (see box 2.6). For example, water for garden purposes, does not need to be of high quality. The economies of supplying water are such that there is only one system of dual reticulation in Australia in which water of different standards is supplied.[10]

10 Dual reticulation is also used to refer to systems with a re-use component. This would involve the treatment of effluent to a non-potable standard for re-use.

The cost of duplicating reticulation in this way is generally considered to outweigh the cost of treating all water to the same high standard.

The New South Wales government is currently undertaking a project at Rouse Hill which is experimenting with the viability of dual reticulation, to test whether or not the costs do outweigh the benefits of such a system (see box 2.7). The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is also undertaking research into alternatives for a coordinated approach to urban drinking water supply and effluent disposal.

Box 2.7 **Dual reticulation at Rouse Hill**

In the early 1990s, Rouse Hill was one of the areas designated to accommodate projected population growth in Sydney. A dual reticulation system was provided for at the planning stage.

Rouse Hill has its own Sewage Treatment Plant (STP), which was opened in May 1994 for the purpose of supplying water for non-potable uses after extensive treatment. To date only fresh water has been used in the Rouse Hill dual reticulation scheme supply, as initial sewerage treatment processes were unable to meet required guideline values. Additional treatment is being installed so that the dual water supply system can be used for a range of non-drinking purposes such as lawn watering, gardening and toilet flushing.

Rouse Hill is served by the first STP in Australia to be designed to produce effluent of a sufficiently high quality for use as a domestic non-potable water supply.

Source: EA (1999) and NSW Health (pers. comm., 17 February 2000).

Treatment costs

Treatment costs are just one component of total operating costs.

In 1997–98, capital expenditure for Melbourne Water Corporation (MWC) totalled $79.4 million. Water accounted for 16 per cent of this cost, compared with sewerage (48 per cent) and waterways and drainage (32 per cent). A majority of this 16 per cent was on supply infrastructure and not treatment technology (MWC 1998), which is to be expected given that Melbourne's water receives (and is said to require) relatively little treatment.[11]

It is the pipes in the ground that generally comprise the greater part of the cost in supplying drinking water. Nevertheless, the ongoing movement towards more

[11] There may be considerable year-to-year variation in the size and purpose of capital expenditure programs.

stringent guidelines may see treatment become an increasingly larger proportion of the overall cost base.

The average household expenditure on water services — water and sewerage — per week is 0.96 per cent of total household expenditure (ABS 1993). It can be assumed that water supply accounts for half of this expenditure, of which a fifth is attributable to treatment.[12] From this it can be estimated that total expenditure on water treatment processes in Australia is up to $400 million per annum.[13]

As water treatment costs increase as a proportion of the total, it will become more important for suppliers to separate their treatment costs from total operating costs. This will enable them to identify movements in their total cost structure, resulting from the implementation of increasing levels of treatment.

Operating costs for WSAA suppliers during 1997–98 ranged from approximately $190/ML to $560/ML (WSAA 1998). The Commission does not have a separate record of the treatment cost component for WSAA businesses.

A survey of non-metropolitan suppliers conducted in Australia, revealed that operating costs ranged from $156/ML in Fish River to $2271/ML in Kalgoorlie, averaging around $400/ML (AFFA 1999). Treatment costs that were available from the non-metropolitan suppliers surveyed, ranged from $6/ML in Ballina to $399/ML in Westernport, averaging around $50/ML, indicating that treatment costs make up approximately 10–20 per cent of total operating costs (AFFA 1999).

This information demonstrates that treatment costs vary greatly across individual suppliers — reflecting the quality of source water and hence the choice of treatment technologies and the size of water suppliers.

To illustrate the effect that more sophisticated technology and economies of scale have on treatment costs, a simulated costing exercise was conducted for various population sizes (see box 2.8).[14]

12 Melbourne Water's treatment costs average between 20-25 per cent of total operating costs as a bulk water supplier (MWC, pers. comm., 17 September 1999).

13 This is consistent with estimates of treatment costs averaging $50 per property, with approximately eight million properties in Australia.

14 Source water from protected catchments is normally of higher quality than that from semi-protected catchments and degraded rivers. As source water quality deteriorates, more sophisticated technologies are required to treat it to the required quality.

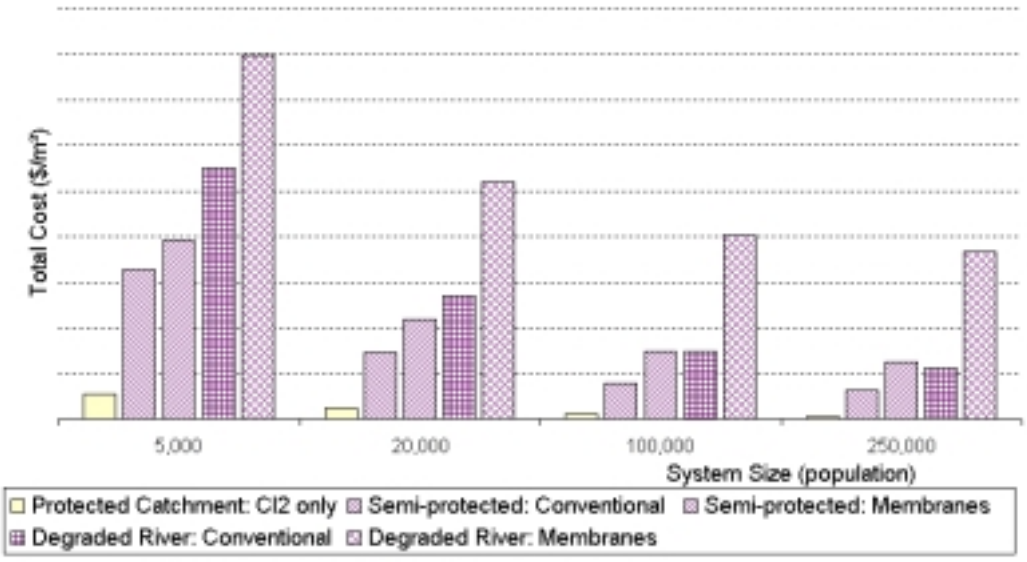
Box 2.8 **Water treatment plant costing exercise**

Water treatment costs (including sludge handling) for varying technologies and population sizes were simulated by Dr Nic Booker from CSIRO's Molecular Science Division to illustrate the cost differences between treating different quality source water and for different population sizes.

Plant sizes to cope with supplying water to 5000, 20 000, 100 000 and 250 000 people were used in the simulation.[a] The three different source water qualities and five alternative treatment technologies used in the simulations were as follows:

- *Protected catchment* with chlorination (Cl_2 only).
- *Semi-protected catchment* with chemical coagulation, sedimentation, filtration and chlorination (conventional).
- *Semi-protected catchment* with microfiltration and chlorination (membrane).
- *Degraded river system* with chemical coagulation, sedimentation, filtration, ozone/biological activated carbon and chlorination (conventional).
- *Degraded river system* with chemical coagulation, sedimentation, microfiltration, ozone/biological activated carbon and chlorination (membrane).

Water treatment costs (amortised capital and operating)



The results (expressed as $\$/m^3$) illustrate relative treatment (amortised capital and operational) costs only. They do not take into account catchment opportunity, management and reservoir costs, head works for the protected and semi-protected catchment cases, and transport. Consequently, they are not a comprehensive estimate of the total cost.

[a] Larger populations may have more than one plant per population area – this introduces more complicating factors into the analysis of treatment costs per ML for a given population.

Source: CSIRO Molecular Science, pers. comm., 20 January 2000.

The treatment costs shown in the figure in box 2.7 are illustrative of scale and technology effects — they do not reflect actual values.

The illustrative treatment costs of each scenario was derived by adding on the incremental cost of each additional stage used in the treatment process. It can be seen from the figure in box 2.7 that relative treatment costs decrease as the quality of the source water improves. In this particular simulation, the cost of treating water in all scenarios (source and type of treatment processes used) also declines as population and hence the volume of water treated increases — consistent with scale economies.

Economics of arriving at efficient standards

Government regulation and other rules are established to produce 'better' outcomes for the community. Consideration of the net gain to the community requires an assessment of the cost of administration, compliance and enforcement as well as any unintended consequences.

Why are standards set?

Market transactions may not result in an optimal level of water quality. This can occur because consumers are unable to signal the level of water quality they want — consumers are not well informed about water quality — and because disease can be transmitted beyond the area under immediate consideration.

Consumers cannot signal the level of quality that they want provided in their drinking water because a single supplier of a uniform product services them. In a normal market consumers can determine the quality of good they wish to purchase through choice and the price paid. With a natural monopoly, even if consumers could make informed judgements about the quality of water they would like to receive, they could not change to another service provider.

Information asymmetry exists in the provision of drinking water because consumers and suppliers do not have the same level of information. Consumers are unable to determine quality from direct inspection. Hence, they may receive water of different quality than if they were better informed or had greater choice.

Consumers may contract gastrointestinal illness as a direct consequence of drinking contaminated water or indirectly from someone who has.[15] The repercussions of illness in a community are potentially far reaching, in that disease can be transmitted from one person to another. Moreover, poor quality water can lead to deaths. However, it is difficult to prove the water was the cause of illness and thus that the water supplier was liable.

Guideline and standard values provide a measure against which the quality of water provided can be judged and give consumers confidence about the product they are receiving. Guidelines and standards may provide greater certainty that illness and fatalities will be prevented and they eliminate the difficulty and cost for individual consumers in seeking common law redress.

Determining an efficient standard

A structured benefit–cost approach to policy development is required to determine whether regulation meets the dual goals of 'effectiveness' and 'efficiency'. The relevant problem to be addressed and subsequent policy objective should be identified as a first step in the policy development process, followed by consideration of a range of options (including no action) for achieving the objective. The benefits of any regulation should outweigh the costs to the community (ORR 1998).

A benefit–cost assessment should take into account all benefits and costs, including the flow-on effects into other industries. For example, drinking water of a higher quality may require less treatment by the food manufacturing industry.

There are limitations with the benefit–cost assessment of water quality guidelines and standards — mainly because the causal links between water quality and health outcomes are uncertain and therefore the benefits are difficult to measure.

When identifying safe levels of contaminants in drinking water and efficient standards, the probability that exposure will occur, and the consequences of that exposure, are generally unknown. For example, in the case of pathogens such as *Cryptosporidium* and *Giardia*, there is uncertainty about what concentrations of pathogen can cause infection and it is often difficult to determine whether a micro-organism is viable.

15 Indirect effects are referred to as externalities. An externality exists when an action by either a producer or a consumer affects other producers or consumers, yet is not accounted for in the market price.

Box 2.9 **Decision making under uncertainty**

Where subjective probabilities can be assigned to outcomes

An approach to decision making under uncertainty is to assign subjective probabilities to outcomes. The approach is based on the maximisation of an individual's expected utility.

One of the limitations of this approach is that not all people have the same preferences. Also the behavioural assumptions underlying the theory do not always hold. Individuals show a preference for situations in which there is some certainty. Such behaviour has been called 'uncertainty aversion'. Behavioural studies have revealed that individuals have stronger aversions to events that are out of their control as compared to those in which they have control. Individuals generally prefer a lower level of risk when hazards are imposed through actions or events that are out of their control.

One alternative to maximising subjective utility is to base decisions on the 'maximin' approach. According to 'maximin', an action *b* should be preferred to another action *c* if and only if the worst possible consequence of *b* is better than the worst possible consequence of *c*.

Minimising the potential for the worst case still requires sufficient initial information to assign a 'worst case' value. However, even the 'worst case' is estimated with incomplete information, where the range and distribution of outcomes is unknown. It does not seem reasonable to behave in either way for non-repeatable problems or situations where there is little evidence on which to base estimates of probabilities.

Where subjective probabilities cannot be assigned

In the absence of quantifiable or subjective probabilities. the following principles have been formulated to guide decision making.

Reserved rationality: Describes the decision making process where the probability of outcomes is unknown, making it natural to proceed cautiously — to safeguard initially against the possibility of unexpectedly adverse welfare losses.

The following principles are subordinate principles.

Precautionary principle: A risk management approach that is exercised in a situation of scientific uncertainty where there is a need for action before the results of scientific research are available. For example, the UK has set a standard for the presence of *Cryptosporidium* despite the uncertainty concerning its infectivity and identification.

Burden of proof: In the absence of scientific certainty about the consequences of a decision, the body wishing to change the *status quo* is required to show that the possible risk is less than the likely benefits of the change. This principle applies also to those who wish to preserve the *status quo* — that is, not follow the precautionary principle. The 'double blind' study on the health outcomes of Melbourne's water compared to filtered water is an example of accepting the burden of proof. This study may influence whether Melbourne's water remains largely unfiltered.

Source: ECDG XXIV (1998); Kesley (1993 and 1994); Kesley and Quiggan (1992); Perrings (1991); Wills (1997); Woodward and Bishop (1997).

A consequence of the uncertain nature of the link between standards and health outcomes is that the techniques used for economic decision making under 'risk' cannot be applied. Probabilities of outcomes are measurable under risk, and decision can be made on the basis of probabilistic benefits and costs.[16] However, in the case of uncertainty, other decision making principles are followed (see box 2.9).

Governments are usually expected to make a judgement on behalf of the community — not to refuse to act because of that uncertainty. A government may choose to determine strict guidelines and standards that eliminate all risk to consumers, including those consumers that would be particularly affected by contaminated drinking water. Alternatively, governments may judge that such strict guidelines or standards are impracticable or not economically justified given the risk involved.

That said, there is a tradeoff between removing all likelihood of contamination and an 'after the event fix' approach. This tradeoff arises because compliance costs increase with the stringency of standards and the benefits at some level begin to decrease.

Consideration must also be given to the cost of enforcement. There is also a cost burden of meeting the monitoring requirements for enforcement. These monitoring and enforcement costs are additional to the cost of complying with standards.

2.6 In summary

Provision of safe drinking water is seen as an essential service in developed countries because of its importance to public health outcomes.

Over the last twenty years, the scope and stringency of quality requirements and monitoring regimes in developed countries, including Australia, has increased. This has been in response to increased awareness of the toxic impact of chemicals, pesticides and radiological compounds. Developments in the science of detecting contaminants and the technology to remove them may also have played a role.

Drinking water quality depends on the quality of the raw source water supply and the treatment processes that this raw water undergoes prior to human consumption. Both the type and level of contaminants in source water, drive the choice of treatment technologies and hence investment decisions. With the ongoing

16 A situation is said to involve *risk* if the randomness facing an economic agent can be expressed in terms of specific numerical probabilities (these probabilities may either be objectively specified, as with lottery tickets, or else reflect the individual's own subjective judgements). On the other hand, situations where the agent cannot (or does not) assign probabilities to the alternative possible occurrences, are said to involve *uncertainty* (Palgraves 1987).

movement towards higher water quality standards, the cost of treatment can be expected to increase.

Governments have responsibility for setting guidelines and standards that are practicable and economically justified, given the level of risk involved. In doing so, they should consider the cost of compliance, monitoring, and enforcement.

A benefit–cost assessment should ideally be undertaken to ensure that regulation meets the dual goals of 'effectiveness' and 'efficiency'. However, there are limitations with the benefit–cost assessment of water quality standards.

The benefits of applying a guideline or standard are uncertain because of incomplete knowledge about the links between water quality and health outcomes. Consequently, judgements are necessary — such as, whether it is appropriate to set high guidelines or standards to prevent sickness or set lower guidelines or standards and address some adverse health outcomes as they arise.

In making judgements about the level at which to set guidelines or standards, community preferences cannot be readily determined. Consumers are unable to express their preferences for a particular quality product through traditional market choice mechanisms — as they can, for example, through the purchase of fruit and vegetables.

There are also equity and public health issues to be resolved. High quality drinking water that protects all consumers, including immuno-compromised people, may not be affordable to the entire population and may require additional resources.

Given that the decisions in setting guidelines or standards involve difficult judgements, it is important that those responsible are accountable for their decisions. This can be done by ensuring that the institutional arrangements promote decision making that is in the public interest.

Institutional accountability depends on a high level of transparency and clearly defined and delineated responsibility and accountability arrangements. These attributes are discussed in the following chapter.

3 Regulatory practices and institutions

The institutions involved in developing drinking water guidelines and standards and their regulatory practices are discussed in this chapter. The arrangements vary significantly among Australian jurisdictions and the overseas countries included in this study.

The process for setting safe levels for individual contaminants is described in chapter 4. The regulatory instruments used and the enforcement and monitoring procedures in place are assessed in chapter 5.

3.1 Drinking water guidelines and standards

A regulatory approach to drinking water quality was first developed in the nineteenth century, in response to public concern about water quality (see chapter 2).

Guidelines and standards establish quantitative limits or values for individual drinking water contaminants (for the distinction between guidelines and standards see box 1.1). In the case of chemicals, these values generally represent the concentration of a contaminant that would not result in any significant risk to health if consumed over a lifetime.

Guidelines are non-enforceable with discretionary compliance. Standards have the force of law, must be complied with in a specified timeframe and are usually backed by penalties for non-compliance. Guidelines may be adopted as goals to be achieved over time.

Guidelines may differ from standards in the way they are established. There is no requirement for a Regulatory Impact Statement (RIS). However, good practice is to produce a RIS for standards.

Ideally, an assessment framework should be in place to determine whether the guidelines or standards are effective and efficient, that is, they meet the community's objectives. Such a framework would be capable of accommodating health, economic and social (including equity) objectives.

In Australia, there is no framework at the national, State or Territory level which ensures that all objectives are examined. The Commonwealth Government coordinates the development of drinking water guidelines through a joint committee of the NHMRC and ARMCANZ. However, only health objectives are considered in the process. Economic and social objectives are the responsibility of the State and Territory governments, but it is unclear to what extent they consider these objectives.

In contrast, the US Environmental Protection Agency (US EPA) is required by law to consider all these objectives. In particular, it must consider the ability of a supplier and its customers to support the cost of compliance in developing more stringent standards. Further, in recognition of the inequities between small and large suppliers, small suppliers benefit from measures to comply with higher standards.

In all of the benchmarked countries, guidelines or standards (in the absence of guidelines) are set at the national level. Many are derived from World Health Organisation (WHO) recommendations. However, it is unclear whether national guidelines or standards are designed to protect all members of the community, except in the US.

The US EPA is required by law to consider the risk to some groups such as infants, children, the elderly and those who are immuno-compromised. In the 1996 Australian Guidelines, there is no explicit reference to setting guidelines for these groups. However, the NHMRC indicate that the Guidelines may not be stringent enough for specialised purposes such as renal dialysis and some industrial uses.

A national regulatory approach is consistent with a universal right to good quality drinking water. However, national standards may not have regard for differences in local community preferences and the economic costs of compliance. In such circumstances, an approach that allows standards to be tailored to local circumstances may be warranted.

World Health Organisation

The WHO recommends drinking water guidelines for both the developed and developing world. These guidelines published, in 1984 and 1993, are based on the premise that water must be safe to drink and aesthetically acceptable.

The WHO health-based guidelines are for microbiological, chemical and radiological contaminants that may be detected in drinking water. These guidelines are based on an assessment of the risks these contaminants represent for human health.

The WHO also establishes guidelines for the physical or aesthetic characteristics of water such as colour and turbidity. In doing so, the WHO recognises that aesthetic characteristics even though they may not in themselves be of any direct consequence to health, affect consumers' acceptance of the water supply.

If the aesthetic quality of water is poor, consumers may use water from less safe sources. For example, the WHO notes that it can result in the use of bottled water and home treatment devices, some of which can have adverse effects on water quality (WHO 1993).

The WHO Guidelines are intended to be a basis for the development of national guidelines and standards. If properly implemented, they ensure the safety of drinking water supplies by eliminating or reducing the concentration of contaminants that are known to be hazardous to health (WHO 1993).

The WHO guidelines provide governments with the flexibility to undertake qualitative or quantitative assessments to establish standards to suit local conditions and economic priorities.

In establishing guidelines, the WHO has been able to draw upon the best scientific and human health advice in the world. For example, the preparation of the 1993 *Guidelines for Drinking-Water Quality* involved the participation of 200 leading scientists from nearly 40 developing and developed countries.

National Health and Medical Research Council

In Australia, the Commonwealth Government has no direct power to make laws relating to the management of water resources or the provision of drinking water, sewerage and drainage. This power rests with the State and Territory governments. However, the Commonwealth Government provides broad policy direction on drinking water quality.

Under the *National Health and Medical Research Council Act 1992* (NHMRC Act), the NHMRC is empowered by the Commonwealth Government, among other things, to foster the development of nationally consistent health standards. This includes the development of drinking water guidelines. However, the NHMRC is not required under its Act to prepare a RIS, that is, to assess the benefits and costs of proposed guidelines.

In the US, the requirement to prepare a RIS for new drinking water standards is specified in the *Safe Drinking Water Act 1974* (SDWA).

In 1997, the Australian Government endorsed *A Guide to Regulation*, which among other things, makes it mandatory for all Commonwealth departments, agencies, statutory authorities and boards making, reviewing and reforming regulations to undertake a RIS that includes a benefit–cost evaluation of regulatory alternatives (ORR 1997). This requirement does not apply to the NHMRC because water quality guidelines do not have regulatory status.

Nevertheless, during the development of the 1996 Guidelines, the NHMRC commissioned the University of Wollongong to undertake an assessment of the Guidelines (Morrison et al 1995). The assessment included consideration of the health, social, economic and environmental consequences of implementing the 1996 Guidelines. However, the assessment by Morrison et al was not as rigorous as assessments undertaken for a RIS.

The study by Morrison et al estimated the costs of implementation, but it was unable to estimate the size of the benefits in monetary terms of a life saved or an illness avoided. In contrast, such estimates are routinely included in similar studies mandated in the US under the SDWA. Without such estimates, it is impossible to determine if there are net benefits in setting particular guideline values.

Implementation of the Guidelines by the States and Territories is at the discretion of the State and Territory Health Departments, usually in consultation with water suppliers. In some jurisdictions, a range of quasi-regulatory instruments such as operating licences, incorporate the Guidelines as standards (see table 3.1). Although the 1996 Guidelines have been adopted by some suppliers, others are working to Guidelines issued in earlier years. Most suppliers aim to comply with the most recent Guidelines.

Where water supply operations have been contracted out, guideline values can be and often are more stringent than those specified in the Guidelines. For example, the contractual arrangements in place between the Sydney Water Corporation (SWC) and its water filtration plant operators go beyond the requirements specified in the 1996 Guidelines that the SWC has to meet.

The 1996 Guidelines are comprised of two elements — a description of good practice for overall systems management and sets of guideline values for contaminants in water (NHMRC 1996). The NHMRC indicate that these two elements represent an integrated package.

Table 3.1 **Regulatory practices in Australia**

State	*Water Suppliers*	*Guidelines*	*Standards*
NSW	SWC		Required by Operating Licence to comply with 1996 Guidelines
	HWC		Required by Operating Licence to comply with draft 1994 Guidelines
	Wyong Shire Council	Comply with 1996 Guidelines as set out in the Water Supply Business Plan	
	Gosford City Council	Comply with 1996 Guidelines	
	Non-metropolitan suppliers	Comply with 1987 & 1996 Guidelines	
Vic	MWC	Comply with 1987 Guidelines	
	CWW SEW YVW		Required by Operating Licence to comply with 1987 Guidelines
	Non-metropolitan suppliers	Comply with 1984 WHO Guidelines under MoU with DNRE	
SA	SA Water	Under performance agreement with SA Government, required to achieve compliance with health related 1996 Guidelines	
	United Water		Commercial contract with SA Water to comply with 1996 Guidelines
	Riverland Water		Water Treatment and Economic Development Agreement with SA Water to comply with 1996 Guidelines
WA	All water suppliers		Required by Operating Licence to comply with the 1987 Guidelines
Tas	Suppliers of potable water	Comply with the 1996 Guidelines	Required by the *Public Health Act 1997* to comply with the sampling regime for microbiological contaminants
Qld	SEQWB	Comply with 1996 Guidelines	
NT	Power and Water	Comply with 1987 Guidelines	
ACT	ACTEW	Comply with 1996 Guidelines[a]	

[a] In the ACT, it is envisaged that ACTEW will be required to comply with a Code of Practice that is enforceable and backed with substantial penalties.

Source: SWC (1998a); HWC (1995); WSC (1999); Gosford Council, NSW, pers. comm.,1999; DLWC, NSW, pers. comm., 1999; CWW (1998c); SEW (1998a); YVW (1998b); DNRE (1997); SA Water (1998); OWR (1998); *Public Health Act 1997* (Tasmania); Power and Water, NT, pers. comm., 1999.

Good practice is defined in the Guidelines to include:

- the use of effective barriers to prevent contamination of the water at source or within the distribution system;[1]
- regular inspections of catchment areas to identify the chemicals being used, and how they are applied;
- control of industrial, mining, forestry, agricultural and human activities within catchment boundaries;
- an effective maintenance program for plant and equipment used in the water supply system;
- use of appropriately skilled and trained personnel in the operation of water supply systems; and
- public awareness and education programs so that people know what is being done to protect their water supply.

The second element comprises recommended guideline values for physical, microbiological, chemical (including organic and inorganic chemicals and pesticides) and radiological contaminants which affect water quality. The guideline values are used in two separate but complementary ways — as the basis for assessing how well a water supply system is performing and as 'action levels', which trigger an incident management response when they are exceeded (see appendix B).

The incorporation of good management practices occurred for the first time in the 1996 Guidelines. Previous versions focussed on guideline values only.

In developing the current 1996 Guidelines, the NHMRC based the guideline values primarily on the recommendations of the 1993 WHO Guidelines. Specialist panels representing Australian and New Zealand suppliers, State and Commonwealth departments of health and water resources, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), universities and private industry were consulted (NHMRC 1996).

1 These may include measures that protect the source water from contamination by human or animal faeces; the pre-treatment of water by detention in reservoirs for sufficient time to allow micro-organisms to die off; protection of water storages; coagulation, settling and filtration; disinfecting the water before it enters the distribution system; maintaining an adequate disinfectant residual throughout the distribution system; and securing the distribution system against possible re-contamination which involves ensuring the integrity of the pipe system, vermin-proofing water tanks and preventing backflow.

The NHMRC, like the WHO, also recommend guideline values for the aesthetic characteristics of water.[2] The guideline values are recommended minimum concentrations for these characteristics. In contrast, the WHO approach provides a greater degree of flexibility for developed and developing countries to adopt higher or lower values for their own aesthetic characteristics.

The NHMRC and ARMCANZ Ministers are committed to re-emphasising the need for suppliers to develop and implement drinking water quality management systems of the kind outlined in the 1996 Guidelines. However, many suppliers are still working to pre-1996 Guidelines (see table 3.1).

A framework providing guidance for establishing these systems is currently being developed through the ongoing review process associated with the Guidelines. The framework builds on the quality management actions already outlined in the Guidelines. In addition, it includes Hazard Analysis and Critical Control Points (HACCP) principles, similar to those currently being introduced in the food industry (see chapter 6).

The development of a water quality management system is designed to minimise the risk of contaminated water over the entire supply chain. This is also true of the proposed regulatory approach to food regulation in Australia, which addresses health outcomes by focussing on food handling practices (see box 3.2).

The proposed national food regulations require businesses to institute programs that identify hazards, assess risks and implement measures to minimise risk as far as practicable. Suppliers are required to take measures that ensure that the concentration of contaminants should not exceed guideline or standard values. Guidelines on good risk mitigation practice are recommended, but are not mandated as specific requirements.

The United States Environmental Protection Agency

In contrast to the WHO and the NHMRC, the US EPA is required under the SDWA to set National Primary Drinking Water Standards and Secondary Drinking Water Guidelines based on a comprehensive economic evaluation and risk assessment process.

Primary standards are enforceable standards for health-related drinking water contaminants and apply to all suppliers (except those households on private wells). Suppliers can be penalised for non-compliance.

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2 The aesthetic characteristics of water include colour, turbidity, hardness, total dissolved solids, pH, temperature, taste, odour and dissolved oxygen.

Box 3.2 **Proposed food regulation mechanisms**

In May 1999, the Australia New Zealand Food Authority issued an analysis of the regulatory impact of proposed national food safety reforms. The standards proposed under the reform cover:

- programs to identify hazards;
- practice (handling, cleaning, sanitising and personal hygiene), notification, food recalls and training; and
- design and construction parameters for food premises and the equipment used.

The proposed regime is intended to unify standards. The standard requirements are minimised to just those that are effective and necessary to achieve safe food, replacing overly prescriptive and inconsistent requirements. They require producers to systematically minimise food contamination by controlling microbiological, chemical and physical hazards using a Hazard Analysis and Critical Control Points (HACCP) approach.

The proposed safety standards are claimed to be outcome-based — that is, promoting health outcomes. In their formulation it was recognised that prescription is inappropriate because the desired outcomes can be achieved by particular businesses in a variety of ways.

General requirements that are generic to all food handling and processing are specified — for example, the temperatures at which food must be maintained.

Source: ANZFA (1999).

In setting primary standards, the US EPA must first establish a non-enforceable health-related Maximum Contaminant Level Goal (MCLG) for a contaminant (see appendix D3).[3] Once the MCLG is determined, the US EPA must concurrently set, either an enforceable Maximum Contaminant Level (MCL) or a treatment technique in lieu of establishing a MCL.[4]

MCLGs are based on public health considerations. For chemicals which are non-carcinogenic, the MCLG is based on the Reference Dose (RFD). A RFD is an estimate of the amount of a chemical that a person can be exposed to on a daily basis, that is not anticipated to cause adverse health effects over a person's lifetime. The US EPA's policy is to set MCLGs for carcinogenic and microbial contaminants

3 The US EPA conducts a risk assessment for each contaminant, which determines the level at which a MCLG will be set.

4 When it is not economically or technically feasible to set a MCL for a contaminant — for example, when the contaminant cannot be easily measured — the US EPA may set a treatment technique. This is an enforceable procedure or level of technological performance which water suppliers must follow to ensure control of a contaminant.

at zero. However, zero is often not measurable nor feasible using Best Available Technology (BAT), nor is it practicable when costs constraints are severe.

The SDWA defines a feasible level as that which may be achieved with the use of BAT, treatment techniques, and other means which the US EPA finds available, taking cost into consideration.

This explicit recognition of cost as a constraint is a distinguishing feature of the US arrangements. It effectively draws together both risk analysis and benefit–cost analysis in the setting of MCLG and MCL values.

Suppliers have three years to comply with new national primary drinking water standards from the date they are promulgated. However, if capital improvements are required, the US EPA, or the administering State, may allow this period to be extended by up to two years.

As drinking water regulations have become more stringent and complex, small suppliers have found it increasingly difficult to comply and provide safe water at affordable costs. To address this situation, small suppliers receive special consideration and funding support from the US EPA and their State governments (see appendix D3).

In addition to health-related enforceable standards, the SDWA requires the US EPA to set secondary or non-enforceable national guidelines for contaminants that may adversely affect the aesthetic quality of drinking water. The States are encouraged to adopt these secondary guidelines, but may establish higher or lower values depending on local conditions, provided that public health is not adversely affected.

The 1996 SDWA amendments require each supplier to adopt a multiple barrier approach which includes systems management procedures for drinking water protection. Each supplier must assess and protect drinking water sources, protect wells and collection systems, make sure water is treated by qualified operators, ensure the integrity of distribution systems, and make information available to the public on the quality of their drinking water (see appendix D3).

In recognition of some shortcomings in the regulatory approach to setting drinking water standards in the US, the Partnership for Safe Water was formed in 1995.[5] This Partnership is a voluntary initiative between the US EPA, the American Water Works Association and several national organisations.

5 The failure to provide safe drinking water to 12 per cent of the population in 1994 combined with an outbreak of *Cryptosporidosis* in 1993, was the catalyst for the formation of the Partnership for Safe Water.

The goal of this partnership is to provide a new measure of safety by implementing prevention programs. The preventative measures are based on optimising treatment plant performance and increasing protection against microbial contamination.

Among other things, such partnerships allow suppliers to provide safe water without regulatory coercion and to solve internal problems in a cost effective manner through the free exchange of information.

Other benchmarked countries

Unlike the US, the other benchmarked countries (Canada, New Zealand, the European Union (EU), United Kingdom (UK) and France) have adopted variants of the WHO Guidelines to suit local conditions and community preferences. In some cases, the status of these variants has been elevated from guidelines to that of standards (see table 3.2).

- In Canada and New Zealand, all suppliers comply with guidelines (except in three Canadian provinces where standards apply).[6]
- In the EU, guidelines developed by the WHO have been incorporated in the Drinking Water Directive 98/83/EC and are enforced as standards under national legislation by EU member countries. Although there is a requirement under the EC Treaty to assess the benefits and costs of new environmental proposals, a RIS was not undertaken. As with the US legislation, the EU Directive specifies a date that Member States must comply with new drinking water standards.
- In the UK, the Secretary of State is required by the *Water Industry Act 1991* to set drinking water regulations based on the standards specified in the EU Drinking Water Directive.[7] The standards may exceed but must not be below the levels set by the EU. The UK does not normally prepare a RIS on legislation put in place as a result of an EU Directive. However, if the UK develops legislation over and above EU requirements, a RIS is prepared — this occurred in 1999 with the establishment of a standard for *Cryptosporidium*.
- In France, drinking water standards are specified in the Decree 89.3 (1989) and are based largely on the EU Drinking Water Directive.[8] Like the UK, France does not prepare a RIS on legislation put in place as a result of an EU Directive.

6 Although the New Zealand guidelines are referred to as standards, they are non-enforceable and are therefore classified as guidelines for the purposes of this report (see appendix D5).

7 The UK drinking water regulations are currently being amended to incorporate most of the standards established in the EU Drinking Water Directive 98/83/EC. It is envisaged that this process will be completed by December 2003.

8 The French Health Ministry is currently amending Decree 89.3 following the introduction of the EU's Drinking Water Directive 98/83/EC.

Table 3.2 **Regulatory practices in overseas benchmarked countries**

Country	*Guidelines*	*Standards*
Canada	National Guidelines (except Alberta, Quebec and British Columbia where standards apply)	
European Union		Required by the Treaty of European Union (1992) and Drinking Water Directive 98/83/EC
France		Required by the Decree 89.3 (1989)
United Kingdom		Required by the *Water Industry Act 1991* and the *Water Supply (Water Quality) Regulations 1989*
New Zealand	National Guidelines	
United States	National Guidelines for Secondary Drinking Water Regulations (optional can be enforced at the state level)	Required by the *Safe Drinking Water Act 1974* and National Primary Drinking Water Regulations

Source: *Safe Drinking Water Act 1974;* MoH (1995); *Water Industry Act 1991* (UK); EU (1998).

Forms of regulation

The regulatory forms used by governments to provide safe drinking water may include output, input, process and outcome regulation (see box 3.3).

Governments sometimes use only one of these regulatory forms but more often use a combination to achieve the desired objective. What combination governments use depends on a number of factors such as the practicalities of implementation and the costs associated with enforcement.

In Australia and all the benchmarked countries, output regulation is the most commonly used regulatory form. Output regulation is an efficient way to regulate drinking water if a contaminant is measurable and it is supported by effective enforcement mechanisms. Although the Australian Guidelines rely mainly on an output-based approach, it is not always supported by effective enforcement mechanisms.

Box 3.3 **Forms of regulation**

To achieve regulatory objectives, governments may use output, input, process or outcome regulation.

Governments use *output regulation* where they require an industry's final product to be of a certain type or meet certain quality criteria. Output regulation is the most common form of regulation used in the water industry and comprises the numerical guideline values or standards that drinking water must meet.

Governments use *input regulation* to manage the type and quality of inputs used in a production process. Within the water industry, input regulation may constitute catchment management requirements, for example. This form of input regulation aims to influence the quality of the source water used in the water treatment process.

Process regulation refers to government management of the operation of a production process. In terms of water treatment, governments may require water suppliers to use certain processes or technologies within their water treatment and distribution systems. Governments may also lay down maintenance schedules or operator certification requirements to protect the integrity of the water supply systems and ensure their effective operation. The US EPA's Interim Enhanced Surface Water Treatment Rule, which specifies a treatment technique for the removal of *Cryptosporidium*, is an example of a process regulation.

Outcome regulation frames regulatory requirements in terms of meeting an objective, defined as a measurable improvement in a performance indicator — say an upper limit on the proportion of the population made sick through contaminated drinking water. Judgements about which contaminant causes such illness, or the levels to which such contaminants should be reduced, are left to those subject to the regulation.

This form of regulation maximises compliance flexibility, in that the means of achieving the regulated outcome are left to the water supplier. However, in doing so the supplier must address the scientific uncertainties involved in selecting a means of achieving the regulated outcome. In contrast, if output regulation is used and particular contaminant levels are specified, the scientific uncertainties are borne by the regulator.

Selection of output or outcome regulatory forms is likely to be influenced by the ease to which contaminant levels or sickness respectively, can be measured. It may also be influenced by the extent to which a regulator can be held accountable for compliance with either of these two forms of regulation.

Source: Productivity Commission.

Output regulation provides suppliers with the flexibility to achieve the required output by selecting the least costly means of compliance. However, one of the criticisms of output regulation when it is universally applied, is that it does not allow for flexibility to tailor standards to meet the particular characteristics of different water systems.

Output regulation is of dubious effectiveness in the prevention of microbiological contamination such as *Cryptosporidium*, because it is very difficult to measure. Accordingly, Australia and the US have not established a guideline or standard value for *Cryptosporidium* at present.[9]

Process regulation is seen by most regulators as a more appropriate alternative to reduce the risk of *Cryptosporidium* outbreaks. For example, the US EPA has specified a treatment technique for minimising levels of *Cryptosporidium*.

In Australia, the NHMRC propose to recommend that suppliers develop and implement a water quality management system based on the approach used in the food industry. This is seen as part of a multiple barrier approach that will address water quality in situations such as *Cryptosporidium* contamination.

Regulatory forms that prescribe particular inputs and processes may impose high compliance costs, stifle innovation, prevent the evolution of best practice and continuous improvement (IC 1995).

Outcome regulation is probably the least frequently used because it is the most difficult type of regulation to implement. Outcomes are difficult to measure because the precise relationships between water quality and health outcomes is often unknown.

Status of guidelines and standards

There have been four versions of the Australian Guidelines — 1972, 1980, 1987 and 1996. Although the State Health Departments encourage their respective suppliers to comply with the latest Guidelines, in reality there is no uniform adoption of the Guidelines by suppliers within and among States and Territories in Australia (see table 3.1).

The NHMRC emphasise that the Guidelines are not legally enforceable. However, consumer protection from the risk of contaminated drinking water can be achieved in a combination of ways — a common law duty of care, a statutory duty of care, drinking water regulations, or Commonwealth legislation pursuant to the *Trade Practices Act 1974* (TPA) and complementary State and Territory legislation (see box 3.4 and appendix E).

9 The UK has established a standard value for *Cryptosporidium* but many commentators believe it is impracticable to enforce.

Measures to protect consumers can take the form of both the recovery of compensation for contaminated drinking water, or statutory rules and regulations that prescribe potential criminal offences.

Box 3.4 **Consumer protection**

A common law duty of care requires a person to exercise reasonable care in the conduct of an activity. However, under common law, there must be some damage to a person or property before a person may bring an action alleging a breach of the duty (IC 1995). The harm can be physical, serious nervous shock or economic loss. The real burden for a plaintiff in a water pollution case is proving that there was a breach of duty and that the illness came from the water. In cases related to cancer this is difficult. For some illnesses it will be easier to prove the causal link.

Where a common law duty of care exists there are high transaction costs involved when seeking redress (compensation for breach of duty) through the legal system.

Generally, a statutory duty of care is expressed in similar terms to the common law duty of care and encourages a broader view of responsibilities than those imposed by detailed regulation. A statutory duty of care is put in place to make environments safer, and to codify and formalise good practice (Reynolds 1995).

Unlike common law duty of care, if a statutory duty appears to be breached, action can be taken to enforce the Act and make drinking water safe before illness occurs — for example, failure to install a cover on a storage tank. A breach of the statutory duty does not have to be associated with an accident or illness (IC 1995).

Drinking water regulations in most cases prescribe outputs rather than how they are to be achieved. Compliance is supported by effective enforcement mechanisms. This approach is aimed at preventing contamination before it occurs.

Drinking water regulations provide a mechanism to reduce the possibility of non-compliance, and avoids the cost burden on individuals seeking legal redress. However, the costs of effective enforcement can also be high. Further, the potential compliance burden and disincentives to use efficient technologies (where a process rather than an output is prescribed) may impact on efficient service delivery.

(Continued next page)

Box 3.4 (continued) **Consumer protection**

The *Trade Practices Act* (TPA) applies to conduct involving corporations, but under certain circumstances, it can also apply to individuals.[a]

The consumer protection provisions of the TPA which are most relevant to contaminated drinking water include Part V (s. 52, s. 71(1) and (2), s. 74B, s. 74D), Part VA and Part VI (s. 87B) (see appendix E).[b]

Under Part V provisions:

- s. 52 prohibits misleading and deceptive conduct.
- Under s. 71 there is an implied condition that goods supplied under contract are of merchantable quality[c], and fit for a purpose[d] communicated by the consumer to the manufacturer. The remedy for a breach of s. 71 is to sue for breach of the implied condition of the contract rather than to proceed for remedies such as damages under s. 82. Section 71 only allows the consumer to sue the retailer for breach of contract but not the manufacturer.
- Provisions under s. 74B and s. 74D are similar to s. 71. However, consumers' rights are extended to allow consumers to sue the manufacturer and other retailers further up the chain of distribution.

In addition to Part V, the TPA also includes provisions under Part VA which relates to the liability of manufacturers and importers of defective goods. A person who is injured, or whose property is damaged by a defective product, has a right to compensation by the manufacturer of the product. Individuals can bring actions, or the Australian Competition and Consumer Commission (ACCC) can bring representative actions on behalf of one or more persons.

Further, under Part VI (s. 87B) consumer protection can take the form of enforceable undertakings provided by a water supplier to the ACCC.

[a] For example, the Act may apply (in some circumstances) to individuals such as doctors, dentists, architects, engineers, accountants, chemists, teachers, solicitors and other professional persons who, in trade or commerce in any of the Territories, engage in misleading or deceptive conduct. [b] All States and Territories have enacted their own Fair Trading legislation (covering misleading and deceptive conduct) and Sale of Goods legislation (covering merchantable quality and fitness for purpose provisions) which complements Part V of the TPA. State and Territory legislation can protect a consumer when the seller of a good or service is not a corporation. [c] Saleable and fit for the market, sound and undamaged, such as is generally sold in the market. [d] 'Fit' in this context means suitable or appropriate.

Source: Miller (1999); IC (1990).

In Australia, a common law duty of care always exists, unless explicitly over-ridden by particular statutes. These statutes can include specific provisions established in the Commonwealth TPA or in State and Territory legislation.

Irrespective of whether a jurisdiction has adopted the Guidelines or elevated the status of the Guidelines to standards, suppliers have a common law duty of care to identify hazards, minimise the risks of harmful contamination and monitor the

performance of water quality. Further, they have a duty to investigate the cause and, if appropriate, take practical steps to eliminate or reduce risk.

The duty of care need not necessarily be limited to one person or entity, it may be apportioned. For example, a contamination incident may have been averted but for the incorrect readings from a science laboratory contracted by a water supplier to carry out testing. The science laboratory may have failed because of faulty equipment received from a supplier. It is conceivable that the water supplier, the science laboratory and the equipment supplier may all be found to owe a duty of care to the consumer.

The inclusion of a statutory duty of care in legislation can strengthen consumer protection if it formalises good practice. However, the existence of a right of action depends entirely on the interpretation of the particular statute or regulation in question. A supplier will not be liable unless the statute or regulation is couched in such terms as to impose liability on the supplier (Balkin and Davis 1996).

In Australia, statutory provisions may provide consumers with additional protection from contaminated drinking water. For example, under s. 73 of the Victorian *Water Industry Act 1994*, a licensee must cause as little damage and inconvenience as possible in the performance of its functions. It is specified that a licensee is liable to compensate any person who has sustained pecuniary losses or incurred any expense as a direct, natural and reasonable consequence of the licensee's functions. A limitation of this provision is that the Act only applies to the three Melbourne water suppliers.[10]

The use of national drinking water regulations in the EU, UK and the US is supported by strong enforcement procedures including the threat of criminal prosecutions and jail terms. This can act as an effective deterrent which provides consumers with greater certainty that their drinking water will not be contaminated.

In Australia, some governments have elevated the status of the Guidelines to standards for metropolitan suppliers. Where this has occurred, some consumers are also protected by an implied customer contract.[11]

Implied customer contracts provide rights and obligations to the supplier and consumer. If a supplier fails to meet its obligations under the implied customer

10 An earlier Victorian statute, the *Water Act 1989*, includes an indemnity provision for water suppliers which may negate protection from contaminated drinking water otherwise provided to consumers. However, the precise scope of this indemnity is unclear as it has not yet been judicially considered (see box E.1 and appendix E).

11 The contracts are 'implied' as they are deemed under an Act of Parliament rather than having been expressly made by the parties.

contract, consumers have legal redress for breach of an implied customer contract (see appendix E).[12]

The Sydney water incident in 1998 provides an insight into the legal obligations which have been and may be imposed on the SWC. Although consumers have been compensated under customer contracts, there are class action cases which have not been concluded (see box 3.5).

In response to this incident, the provision of water in the Sydney metropolitan area was vertically separated to create the Sydney Catchment Authority as a wholesale supplier of water to the SWC. While vertical separation may improve accountability and transparency, it can have an unintended effect of complicating legal responsibilities if contaminated drinking water is supplied to consumers in the future.[13]

Link between guidelines, standards and health outcomes

The primary objective of a guideline or standard is to minimise exposure to a drinking water contaminant that would result in a known or potential adverse effect on human health (Sidhu 1991). To achieve this objective, the link between guidelines or standards and health outcomes must be thoroughly understood.

Despite enhanced efforts to measure the health effects of drinking water, there is still a great deal of uncertainty about the causal relationship between guidelines or standards and health outcomes. This is largely because of insufficient scientific evidence and the imprecision of detection.

Although the NHMRC establish guidelines for chemical contaminants on scientifically demonstrated health effects, they indicate that values are promulgated in the face of great uncertainty. For example:

> A number of epidemiological studies have suggested an association between water chlorination by-products and various cancers. This association has been most consistent in relation to cancer of the bladder and rectum, but there are insufficient data to determine concentrations at which chlorination by-products might cause an increased risk to human health (NHMRC 1996, p. 3-3).

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12 In Australia this form of consumer protection is currently limited to the three Melbourne retail water suppliers, the SWC and the HWC.

13 This situation could equally apply in the Melbourne metropolitan area, where the Melbourne Water Corporation supplies bulk water at the wholesale level to the three retail water companies.

Box 3.5 **Sydney water incident**

In 1998, *Cryptosporidium* and *Giardia* were detected in Sydney's water supply. A number of boil water alerts were issued to consumers in the affected areas.

Despite Sydney water being declared unfit to drink, it still met the health requirements of the Australian Guidelines.

This is because *Cryptosporidium* and *Giardia* are difficult to measure and at present there is no requirement for routine monitoring. Nor is such routine monitoring recommended in the draft 1999 Guidelines on *Cryptosporidium* and *Giardia* released for public comment by the NHMRC after the Sydney water incident. Rather, the draft Guidelines rely on a multiple barrier approach to prevention, supplemented by investigative testing when contamination is suspected.

Under these circumstances, compliance with the Guidelines could be seen as all that was practicable and required of the SWC to discharge its responsibilities in 1998. However, consumers have a number of avenues to seek compensation from the SWC for failure to protect the public from the risk of contaminated drinking water.

The SWC is required by law to establish a customer contract. This contract provides for a rebate on the service availability charge and compensation if it can be demonstrated that the SWC failed to provide the services set out in the contract.

In response to the Sydney water incident, the Independent Pricing and Regulatory Tribunal of New South Wales determined that consumers should receive a A$15 rebate on their service availability charge. In addition, an increase in the water usage charge has been deferred until the relevant authorities are satisfied that the problem affecting delivery of filtered water has been satisfactorily resolved.

Consumers also have an option to seek redress through class action. First, consumers could claim a breach of contract if a supply authority agreed to supply householders and businesses with safe water and failed to do so. Second, it could be argued that the product was defective and that the SWC had engaged in misleading conduct when they implied that the product was safe under the *Trade Practices Act 1974*. Finally, it could be argued that the SWC was negligent under a common law duty of care (ABCRN 1998).

According to newspaper reports, about 9000 businesses have registered compensation claims under a class action scheme approved in December 1998 by the Federal Court. Payouts under this scheme are expected to amount to several million dollars, with claimants being mainly from the food and hospitality industries. These claims are in addition to settlements totalling about A$700 000 already paid to 3000 businesses and individuals by the SWC (CRCWQT 1999b).

Further, the International Agency for Research on Cancer has reviewed the available data and concluded:

> … that there is inadequate evidence to determine the carcinogenicity of chlorinated drinking water to humans (NHMRC 1996, p. 3-4).

Notwithstanding this uncertainty, the Australian Guidelines contain guideline values for chlorination by-products.

In Australia, guideline values for organic and inorganic compounds, including pesticides, are generally based on epidemiological or toxicological data. However, as noted in the Australian Guidelines:

> Interpreting these data and extrapolating from them to human populations can be difficult, as health effects vary with dose, route of exposure (that is ingestion, inhalation or skin absorption), frequency or duration of exposure, and the species, sex and age of the exposed population (NHMRC 1996, p. 3-6).

Historical data is normally available indicating the type of disease that results from consumption of a particular microbiological contaminant. However, there is often uncertainty about infectivity or the number of organisms required to cause disease.

Large numbers of bacteria are generally required to cause disease, but there is uncertainty about the infective dose of protozoan parasites such as *Giardia* and *Cryptosporidium*. For these micro-organisms, it is believed that small numbers of parasites may infect much of the population. However, there are many confounding factors, including immunity.

In relation to infectivity, the WHO has concluded that:

> The multifactorial natures of infection and immunity mean that experimental data from infectivity studies and epidemiology cannot be used to predict infective doses or risk precisely (WHO 1993).

In the context of such uncertainty, a judgement has to be made whether to err on the side of caution and set a guideline or standard with a higher factor of safety. However, this approach may lead to an inefficient use of resources. For example, a high level of capital expenditure may be required for no real reduction in risk.

The alternative is to set a guideline or standard with a low factor of safety, accepting that there is a possibility that some people may become ill, and adopting other health-based measures to address these problems if and when they occur.

3.2 Linkages between standards and monitoring and response

Monitoring programs and response protocols are a necessary part of implementing drinking water guidelines and standards. Monitoring programs are essential to provide the final check that guidelines and standards are being met — by ensuring that the various values are not exceeded at the time of sampling.

Operational and notification responses, such as increased chlorination or boil water alerts, depending on the nature of the problem, can be triggered if monitoring data indicate that values are exceeded.

A monitoring program should be assessed on the basis of its effectiveness and efficiency. An effective monitoring program should have clear linkages to a set of well defined objectives. The absence of a clear purpose can lead to monitoring data being collected without a definite use.[14] If a program is efficient, the benefits must outweigh the cost burden of monitoring — costs borne initially by suppliers are passed on to consumers.

A monitoring program may be undertaken for regulatory, public health and operational purposes.

- For regulatory reasons, monitoring is required to assess compliance with guideline or standard values or agreed levels of service.
- For public health reasons, monitoring is required to assess the ongoing effectiveness of catchment management and treatment processes in providing barriers to the risk of contamination in drinking water. The data generated can indicate if consumers' health is at risk and if so, be used to determine public health responses, including boil water alerts.
- For operational performance reasons, monitoring is used to check that all the key processes and equipment are working properly. The data can be used, if necessary, as a trigger for immediate short term corrective action but they are not used for assessing compliance with guidelines or standards or agreed levels of service.

Irrespective of whether monitoring is required by law or by cooperative arrangements, it typically covers nominated physical, microbiological, chemical and radiological contaminants. However, the nature of the monitoring (routine, continuous, investigative, random or event based) and its frequency (hourly, weekly, monthly, annually) varies according to the potential hazard and the probability of a system problem occurring.[15] Generally, the greater the hazard and the risk of it occurring, the higher the rate of monitoring required.

14 A situation commonly referred to as data rich but information poor.

15 Routine monitoring involves regular sampling at set sites with no specified time or termination. Continuous or real time monitoring uses instrumentation that allows continuous reading of certain values, rather than having to send samples away and wait for several days before laboratory results are available. Investigative or random monitoring has a specific information purpose related to a particular water quality problem and has a set timeframe.

Although routine monitoring may be recommended for chemical and microbiological contaminants, the frequency will vary. Brief periods of exposure at levels above established values, may be of limited public health concern in the case of chemical contaminants. This is because monitoring of chemical contaminants is set at frequency levels consistent with the objective of ensuring that a lifetime of consumption will not cause illness. Hence, frequent monitoring is generally not required.[16] There are exceptions, most notably chemicals modified by water treatment operations and which should be monitored frequently.

In contrast, even brief exposure to microbiological contaminants may be a serious public health concern and more frequent monitoring may be justified — in particular the effects of microbiological contaminants can be immediate, potentially fatal and widespread throughout the community.

Sampling protocols

Monitoring programs involve collecting water samples from identified locations throughout the water supply system, and analysing turbidity levels, chemical pollutants and microbiological indicator organisms to determine if they meet the required guideline or standard value.[17]

Sampling frequency, that is, the number of samples to be collected, is usually determined by factors such as population size, the source and quality of water, the treatment the water receives, the risks of contamination, the previous history of the supply and the knowledge of the water supply system's operation.

To be effective, the quality of the water sampled must be representative of that being delivered to the consumer. This requires identifying sampling locations that are representative of each part of the water supply system (see appendix B).

Sufficient samples must be collected over a representative period to enable the data for each contaminant to be statistically evaluated, significant trends identified, and performance against the guideline or standard value assessed. In framing the Guidelines on monitoring, the NHMRC recognised that sufficient data for statistical

16 There are few chemical contaminants that lead to acute and immediate health problems, except through massive accidental contamination of a water supply. The problems associated with chemical contaminants arise primarily from their ability to cause adverse health effects after prolonged periods of exposure — of particular concern are contaminants that have cumulative toxic properties, such as heavy metals, and substances that are carcinogenic (WHO 1993).

17 Output monitoring excludes operational monitoring to check that processes and equipment are working properly.

evaluation may take time to collect in small supplies and, therefore, reporting over a five year period (rather than annually) may be more appropriate.

Sampling frequencies for large and small suppliers tend to differ in practice. Small suppliers are less able to meet the costs of treatment and monitoring. Consequently, this often means that only untreated water can be supplied or sampling is infrequent or not conducted at all.[18]

Notwithstanding the constraints faced by small suppliers, the NHMRC emphasised that microbiological safety of drinking water should not be compromised. In such circumstances, the NHMRC recommended that small suppliers:

- undertake regular sanitary inspections of their water supply; and
- use the guideline values, and in particular the microbiological guidelines, as a goal for progressive improvement.

Limitations of monitoring for microbiological contaminants

It is impracticable to monitor for every possible microbiological contaminant such as bacteria, protozoa and viruses. Although it is now possible to detect the presence of these contaminants, the methods of isolation and enumeration are often complex, expensive, time-consuming and the laboratory results are frequently unreliable. Consequently, monitoring of microbiological quality has continued to rely on 'bacterial indicator organisms', namely *thermotolerant coliforms* (or alternatively *E. coli*) and *total coliforms,* as surrogate measures of overall microbiological water quality (see box 3.6).

As noted in the Guidelines, *total coliforms* can occur naturally in soil and vegetation and are therefore not always indicative of faecal contamination. For this reason, the guideline value for *total coliforms* was relaxed in the 1987 Guidelines for closed catchments. However, the values were subsequently restored in the 1996 Guidelines. Despite this amendment the Australian Guidelines indicate that:

> Where the health authority is satisfied that it has been demonstrated that the coliforms are not faecally derived, their persistence may be tolerated provided there is a level of microbiological monitoring sufficient to detect any change in the pattern of coliform occurrence (NHMRC 1996, p. 2-13).

At face value, some suppliers such as the Melbourne Water Corporation (MWC), appear to have difficulty in meeting the 1996 *total coliform* test and it has been estimated that the MWC might have to spend around A$500 million on filtration to comply with the 1996 Guidelines (see chapter 1). However, if the MWC can

[18] Small suppliers are defined here as those serving less than 1000 people.

demonstrate that these *total coliforms* are not faecally derived, then it seems that the Corporation would be deemed to have satisfied the 1996 Guidelines.

Box 3.6 **Bacterial indicator organisms**

- In developed countries, including all those in this study, the microbiological quality of drinking water has traditionally been measured by the concentration of two types of indicator bacteria. The indicator bacteria used are the concentration of *total coliforms* and the sub-class known as *thermotolerant coliforms*.
- *Total* and *thermotolerant coliforms* are used as indicators of faecal contamination and hence the possible presence of pathogens.
- A major output from monitoring indicator organisms is that it provides a measure of the effectiveness of disinfection, because all indicator organisms should be killed during the disinfection stage of drinking water treatment. If the indicator organisms have not been killed, then there is the possibility that other microbiological contaminants, also intended to be killed by disinfection, have passed into the distribution system. Alternatively, their detection at the consumers' tap may indicate regrowth within or penetration of the distribution system.
- In the 1996 Australian Guidelines, the NHMRC recommend that no sample should contain any *total coliforms* or *thermotolerant coliforms*. The Guidelines also contain a schedule prescribing minimum values for sampling frequency, that varies according to the population within the supply area. For assessing overall system performance during any preceding 12 month period, the Guidelines state that 95 per cent of samples tested during that period should be free of *total coliforms* and 98 per cent should be free of *thermotolerant coliforms.*
- The 1996 Australian Guidelines indicated that the system performance measure is set at 95 per cent for *total coliforms,* rather than 100 per cent, because they occur naturally in soil and vegetation and are sometimes present in the absence of faecal contamination. However, although the NHMRC conceded that *total coliforms* may occasionally be isolated from drinking water, they indicated that any persistence of *total coliforms*, even at low numbers, should trigger follow up action.
- The more stringent 98 per cent figure for *thermotolerant coliforms* reflects the greater specificity of this organism as an indicator of faecal contamination. It is also set at less than 100 per cent, to provide some allowance for sporadic contamination resulting from occasional lapses in laboratory testing procedures. However, the NHMRC also indicated that any detection of *thermotolerant coliforms* should trigger follow up action.

Source: NHMRC (1996).

The NHMRC recommend routine monitoring of the two indicator organisms as an effective means of identifying faecal contamination and where appropriate, alerting public health authorities to the possibility of disease outbreaks.

Although the presence of these indicator organisms usually confirms the breakdown of disinfection procedures, their absence does not guarantee the safety of drinking water. Research is demonstrating that *Cryptosporidium*, for example, will not be killed by doses of chlorine that can be used in drinking water, and therefore it may survive, even though indicator organisms are killed.

The risks from microbiological contaminants can never be entirely eliminated. Even with relatively frequent sampling, the passage of a brief surge in concentration of a harmful contaminant may not be detected. Therefore, monitoring traditional indicator organisms is increasingly being seen as an aid to confirming that drinking water quality is unlikely to be injurious to health.

Further, real time monitoring, which is designed to provide immediate testing results, may be technically impracticable. Monitoring is not regarded as a fully effective response to contamination by *Cryptosporidium* for example, and hence there is a greater interest in preventative measures.

In the event that it is not efficient to remove all contaminants from drinking water, it may be more cost effective to respond to health problems if and when they occur.

Cryptosporidium and *Giardia*

In contrast to the UK and the US, there have been no reported deaths from *Cryptosporidiosis* and *Giardiasis* in Australia.[19] More importantly, there have been no outbreaks of these two diseases associated with drinking water in Australia, although there have been outbreaks of *Cryptosporidiosis* attributed to swimming pool exposures.

Monitoring for specific levels of *Cryptosporidium* and *Giardia* is agreed by most scientific experts to be impracticable at present, principally because the particular organisms that are infectious to humans cannot be easily detected.

There is a trend in parts of Europe and the US toward developing more stringent measures to reduce *Cryptosporidium* oocysts to levels that can be regarded as safe, without necessarily trying to eliminate it completely.

In the UK, a number of experts have reportedly concluded that it is impossible to eradicate all risk of *Cryptosporidium* oocysts entering drinking water supplies — although technologically feasible with modern absolute barrier techniques, the costs would be prohibitive and unjustified by the magnitude of the risk (Attenborough and Campbell 1998).

19 *Cryptosporidiosis* and *Giardiasis* are the diseases that arise from *Cryptosporidium* and *Giardia*.

The UK Government has nonetheless established a standard value for *Cryptosporidium*. Legislation has also been introduced to impose compulsory monitoring for this contaminant in some water supplies, combined with heavy penalties for exceeding a standard value (see appendix D2).[20] However, with the present incomplete understanding of *Cryptosporidium*, there is some doubt about the rationale for implementing this regulation.

In contrast with the UK approach, the US EPA has established the Interim Enhanced Surface Water Treatment Rule (IESWTR) which specifies a treatment technique for *Cryptosporidium* based on a turbidity criterion,[21] which, if complied with, is expected to achieve a 2 log (99 per cent) removal of *Cryptosporidium* oocysts (US EPA 1998a).[22]

In the US, suppliers are deemed to comply with this level of *Cryptosporidium* removal, even if they are using conventional filtration methods, provided that such filtration systems satisfy strengthened rules concerning filter performance.[23] In promulgating this new rule, the US EPA has implicitly acknowledged that complete removal of *Cryptosporidium* is impracticable, even if it is technologically possible.

In Australia, a guideline value or treatment technique for *Cryptosporidium* has not been set. Also, routine monitoring for this contaminant has not been recommended 'due to the time and complexity of testing' (NHMRC 1996).

In July 1999, revised draft Guidelines for *Cryptosporidium* and *Giardia* were released for public comment. Guideline values or routine monitoring were not recommended. Rather, the draft Guidelines recommended implementation of a multiple barrier risk management strategy from catchment to tap (NHMRC 1999).

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20 The standard value must not exceed one oocyst per 10 litres of water.

21 The IESWTR specifies a turbidity level of one Nephelometric Turbidity Unit (NTU) for filtered water as a measure of process performance. In the Australian Guidelines, turbidity of less than one NTU is said to be 'desirable' for any water supply irrespective of treatment. This more relaxed Australian position is not related to *Cryptosporidium* or *Giardia per se*, but is discussed in terms of higher turbidity levels having potential to jeopardise the effectiveness of disinfection.

22 The IESWTR applies to all *Cryptosporidium* species, not only *C. parvum* (the species known to cause illness in humans), as it is recognised that detection techniques are not yet reliable enough to provide identification of particular oocyst species.

23 The US EPA observed that when the performance of traditional filtration systems is optimised to achieve compliance with the IESWTR turbidity levels, then 2 log removal of *Cryptosporidium* can be achieved. Thus, turbidity is in effect being used as a proxy measure of *Cryptosporidium* levels, because it is impracticable to routinely monitor for *Cryptosporidium* directly.

The NHMRC recommended that investigative testing should be used in response to events that increase the risks of contamination by *Cryptosporidium* and *Giardia*. Such events could include heavy rainfall leading to a marked increase in turbidity and numbers of *Cryptosporidium* and *Giardia* in source water or treatment plant failures (NHMRC 1999).[24]

The ability to effectively monitor for *Cryptosporidium* and *Giardia* in drinking water remains an unresolved issue. Consequently, routine monitoring of Australian drinking water supplies is generally confined to the traditional indicator organisms. In Australia, emphasis remains on preventing contamination and optimising water treatment operations, supported by investigative and event based testing if there are reasons to suspect contamination.

Preventing contamination

The limitations of monitoring for indicator organisms as a method of detecting and subsequently preventing certain forms of contamination, mean that other approaches assume greater importance.

A favoured approach in Australia and overseas toward preventing contamination, has been to adopt comprehensive risk management strategies. According to the WHO:

> Pathogen-free water is attainable by selection of high-quality uncontaminated sources of water, by efficient treatment and disinfection of water known to be contaminated with human or animal faeces, and by ensuring that such water remains free from contamination during distribution to the user. Such a policy creates multiple barriers to the transmission of infection (WHO 1993).

Preventing contamination as close as possible to the source water and prior to final stage disinfection is seen as a desirable strategy.

> The multiple barrier concept of water treatment requires that the removal of pathogens and of pollutants and biodegradable compounds should be as nearly complete as possible before terminal disinfection (WHO 1993, p. 21).

Source water protection and improvement can be achieved by active catchment management and by the control of human activities within catchment areas. Each stage of a water supply system is linked. For example, if a major improvement can be made in the quality of source water, less treatment may be required.

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[24] In response to the Sydney water incident in 1998, the SWC is required to undertake investigative testing for *Cryptosporidium* and *Giardia* until the NSW Health Department is convinced that there is no further threat of contamination to the public.

The MWC relies heavily on the relatively pristine state of its catchments to prevent contamination of its water supply (see appendix C2). It was not until 1978, that Melbourne's water was disinfected. This option would not have been available in other parts of Australia, or in most countries, because of the relatively poorer quality of their source water.

Preventing re-infection during distribution, and the suppression of re-growth bacteria by maintaining an effective disinfectant residual, are other common preventative strategies used in Australia and the other countries in this study.

3.3 Transparency, accountability and consultation

Drinking water objectives that are clearly and explicitly stated in legislation or regulation provide guideline or standard setters with certainty about their responsibilities.

Ideally, the process by which a drinking water guideline or standard is developed should be transparent and provide for public consultation. Specifically, a RIS which formalises the steps taken in developing a standard should be published.

A RIS helps to ensure that options to address a perceived public health risk are canvassed in a systematic, objective and transparent manner, with options ranked according to their net economic and social benefits (ORR 1998). By publishing a RIS with the rationale for a guideline or standard, and involving interested parties in the process, not only is there a more consultative and transparent process, but the quality of policy development and decision making is also likely to be improved.

Consultation allows for the injection of information on community preferences into economic decision making, as well as ensuring that proposed guidelines or standards are rigorously developed and scrutinised. In this way, it makes guideline or standard setting bodies more accountable to those affected by their decisions.

There should be clear delineation in the responsibilities of those agencies involved in the enforcement of guidelines or standards. It is clearly inappropriate to have one agency acting as both service provider and regulator. Such a dual role creates a potential conflict of interest between advancing the commercial interests of the agency and advancing wider public interests through the exercise of regulatory powers. Further, in a competitive environment, this might present opportunities for incumbents to misuse control over guidelines or standards to frustrate the actions of actual or potential competitors (Hilmer 1993).

Transparency

Decision making must be linked to clearly specified objectives and it must also be transparent for organisations to be held accountable for those decisions. In Australia, the process for setting guidelines is less transparent than in some of the benchmarked countries.

Best practice evaluation processes will help to prevent public money being wasted on the purchase of inappropriate or unnecessary water treatment technology. In the absence of a robust decision making framework, the effectiveness and efficiency of drinking water guidelines or standards cannot be adequately assessed. Further, it is more difficult to resist commercial and political pressures to adopt new treatment technologies that may not be cost effective and efficient.

Although the NHMRC is responsible for developing national drinking water guidelines, there are no clearly defined objectives in legislation concerning the quality of drinking water. The NHMRC Act only refers to generic health objectives and not drinking water quality specifically. Without nominated objectives, the effectiveness of the guidelines cannot be gauged.

Unlike Australia, in most of the benchmarked countries, drinking water objectives are clearly defined in legislation. In the case of the EU, they are defined in the Drinking Water Directive. The objective of the Directive is 'to protect human health from the adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean'. Water is wholesome and clean if it:

- is free from any micro-organisms and parasites and from any substances which, in numbers or concentrations, constitute a potential danger to human health; and
- complies with the microbiological, chemical and indicator parameters and parametric values listed in the Directive (see appendix D1).

In the US, drinking water objectives are explicitly described and defined in the SDWA. The objectives outline the responsibilities of the US EPA in setting drinking water standards and regulations. In particular, the US EPA is authorised to set a MCLG and a National Primary Drinking Water Regulation for contaminants that may 'have an adverse effect on the health of persons,' that are 'known to occur or there is a substantial likelihood that the contaminant will occur in public water systems with a frequency and at levels of public health concern' (SDWA Section 1412(b)(1)(A)).

In addition, the US EPA is required to take into consideration the effects of contaminants on infants, children, pregnant women, the elderly and individuals with

a history of serious illness, and other relevant factors (SDWA Section 1412(b)(3)(C)).

Accountability

In Australia, accountability appears to be weaker than in some of the benchmarked countries. In part this reflects a failure to clearly delineate and define the roles and responsibilities of those involved in the development of drinking water guidelines.

Accountability is further weakened when standards are not specific concerning their requirements.

The NHMRC is only responsible for developing, not implementing the Guidelines. The development of drinking water guidelines involves rigorous scientific assessments and consultation with stakeholder groups. However, the NHMRC and the ARMCANZ have limited accountability for their decision making processes or for the compliance costs which the Guidelines potentially impose when subsequently adopted by the States as standards.

Any decision to recommend more stringent guidelines is not supported by a published assessment of the public health benefits and costs. Nor are they explicitly assessed in relation to their priority *vis-a-vis* other public health priorities.

At the State level, responsibilities are often shared between agencies implementing guidelines or standards. Although the Health Departments in most States and Territories are responsible for recommending new or more stringent drinking water guidelines or standards, there is often divided responsibility for implementation. For example, in Victoria, the Health Department, the Office of the Regulator General, the Water Agencies Branch and suppliers, all have a role in setting drinking water standards.[25]

In recommending new or more stringent guidelines or standards, there are benefits and costs of complying with them. However, it is not clear how or whether most Australian Health Departments undertake an evaluation of compliance costs. In these circumstances, Health Departments cannot be held accountable for the compliance costs which they impose. Nor is there evidence to suggest that State and Territory governments have prepared a RIS when promulgating quasi-regulatory instruments such as operating licences, which incorporate the Guidelines as

[25] The Water Agencies Branch is part of the Department of Natural Resources and Environment.

standards.[26] In bypassing a RIS, standards are not subject to a detailed and formal review to determine whether they are effective and efficient.

In the US, there are much stronger accountability mechanisms in place for the organisation responsible for imposing standards. In particular, in developing more stringent standards, the US EPA is required by the SDWA to consider the ability of a supplier and its customers to support the cost of compliance.

There are several steps in the US accountability mechanism. For example, the 1996 SDWA amendments directed the US EPA to conduct a survey of the infrastructure needs facing suppliers if they were to satisfy more stringent standards. The first survey, released in 1997, estimated that suppliers would need to invest US$138.4 billion over a 20 year period to ensure the provision of safe drinking water consistent with US EPA standards. However, only a portion of these funds are required for compliance with the SDWA (US EPA 1999a).[27]

In recognition of the compliance costs imposed by the US EPA's standards, there is a provision in the 1996 SDWA amendments for financial assistance. This is done through the Drinking Water State Revolving Fund (DWSRF) to assist suppliers to make improvements that allow them to comply with revised standards. Between 1994 and 2003, the SDWA authorises US$9.6 billion for the DWSRF program and related programs (see appendix D3).

Of the other benchmarked countries, stronger accountability has become an issue in the UK. The EU is not directly accountable for the cost implications of its recommendations. The OFWAT National Consumer Council (ONCC) is pressing for the full assessment of benefits and costs of the EU's proposals for higher standards, prior to their implementation. ONCC is pressing for the establishment of an affordable program and an assurance that customers' interests are taken into account, alongside those of environmental and other interest groups (ONCC 1998).

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26 The preparation of a RIS is mandatory for all reviews of existing regulation, proposed new or amended regulation and proposed treaties involving regulation which will directly affect business, have a significant indirect effect on business, or restrict competition (ORR 1998).

27 SDWA projects often include components that are not required for compliance but are undertaken at the same time to realise efficiencies in operation as well as savings in design and building costs. For example, a state-of-the-art computerised system for monitoring and control of operations in the entire system may be included in a project for a new filter system. Only the filter plant and the component of the computer system used for the filter plant is a SDWA need, but the Needs Survey is likely to have recorded the need for both as one SDWA project.

Consultation

Consultation improves decision making by gathering input from a range of interested parties. It also facilitates the gathering of information on community preferences and addresses the right of individuals affected by decisions to have a say in those decisions.

In Australia, there are some safeguards in the guideline setting process at the national and State level, that provide for public consultation. The process used by the NHMRC to develop the Guidelines involves public and ministerial consultation prior to finalising the Guidelines. Given that State and Territory jurisdictions have input to the process and translate these guidelines into their own requirements, it could be argued that the guideline values have also received scrutiny by State and Territory governments.

Section 12 of the NHMRC Act provides that, whenever the NHMRC proposes to develop guidelines or recommendations, it must publish a notice to that effect, seek submissions from the public and interested bodies on the matter, publish draft recommendations, and seek further submissions before issuing a definitive report.

Specification of consultative procedures in legislation can improve accountability for effective consultation, by ensuring procedures are followed. Legislative provisions for consultation safeguard 'due process'. However, if these provisions are not adhered to, court action is possible. For example, in 1996, the NHMRC was subjected to a Court challenge by the tobacco industry, claiming that the Council had not followed the procedures specified in its Act (see box 3.7).

Box 3.7 **Tobacco industry challenge**

In 1996, the Tobacco Institute of Australia (TIA) Ltd initiated court action against the NHMRC, claiming deficiencies in discharge of procedures specified in the NHMRC Act.

The court decided that the NHMRC Working Party on Passive Smoking had erred significantly in the consultative procedure it used. Early in its deliberations the Working Party had decided that, in responding to its terms of reference requiring it 'to review the relevant scientific evidence linking passive smoking to disease in adults and children', it would only consider evidence that had been published in the peer-reviewed scientific literature. The submission received from the TIA was not considered to be peer reviewed material.

Justice Finn ruled that the Working Party 'failed to have regard to the submission received' from the TIA, in that it was obliged to but failed 'to give positive consideration to their contents as a fundamental element in its decision making'. Justice Finn also found that the NHMRC Act did not provide for the Working Party to dismiss a submission on the basis that the material contained therein was not peer reviewed.

Source: Jamrozik et al (1997).

In contrast to Australia, the US has a more formalised consultative process (see box 3.8). One of the formal means by which the US EPA solicits the assistance of its stakeholders is the National Drinking Water Advisory Council (NDWAC). The NDWAC advises the US EPA's Administrator on all of the agency's activities relating to drinking water. The Science Advisory Board is also mandated by the SDWA to comment on drinking water regulations prior to promulgation.

The US EPA also encourages public input into its decision making process by seeking comments on the US EPA's proposed regulations and encouraging participation in public meetings. Proposed regulations are published in the *Federal Register* and can be accessed on the US EPA's web site.

Box 3.8 **US EPA consultative procedures**

Throughout the standard setting process the US EPA considers input from many diverse sources. These include:

- The National Drinking Water Advisory Council (NDWAC) created in 1974 by the SDWA. The 15 member committee comprises members of the general public, State and local agencies, and private organisations and groups (including two members who are associated with small rural suppliers).
- To receive more formal input from stakeholders, the US EPA has increased the scope of the Council. NDWAC working groups have been formed that will make recommendations to the full Council, which in turn will advise the US EPA on individual regulations, guidances and policy matters. These NDWAC working groups consist of approximately 20 members with a variety of viewpoints. All NDWAC working group meetings and full NDWAC meetings are open to the public.
- The Science Advisory Board (SAB) was mandated by the 1996 SDWA amendments. The SAB provides independent scientific and engineering advice to the US EPA's Administrator on the technical basis for US EPA regulations.
- The US EPA also consults with the Secretary of the Federal Department of Health and Human Services (DHHS). The US EPA may use information provided by the DHHS, or may ask for input from the DHHS when developing a regulation (or when an already final regulation comes into question).
- In addition to the NDWAC, SAB and DHHS, representatives from water suppliers, environmental groups, public interest groups, States, Indian tribes and the general public are all encouraged to take an active role in shaping the regulations, by participating in public meetings and commenting on proposed rules. Special meetings are also held to obtain input from minority and low-income communities, as well as representatives of small business.

Source: US EPA (1997a, 1998b).

3.4 Incident plans and response protocols

Incident plans and response protocols are both important elements of overall risk management. They are developed in recognition that the risks of supplying contaminated drinking water cannot be eliminated entirely, despite the measures put in place to protect public health (by monitoring and treatment) — that is, some residual risk has to be borne by the consumer.

Incident plans are developed by suppliers to address an incident or event, or a series of events, when the quality of water deteriorates. They may be as simple as setting out the procedures for notifying a health authority that the quality of water is, or is likely to become, a threat to public health. Alternatively, an incident plan may be a comprehensive document covering a range of management responsibilities including communication, coordination and emergency training protocols.

Response protocols are generally developed by government agencies and set out procedures for addressing a notifiable incident that has already occurred. These incidents may relate to a fault or breakdown in preventative measures such as catchment protection, filtration and disinfection, that could present a risk to the general population.

Incident plans

The NHMRC recommended in the 1996 Guidelines that suppliers develop incident plans for emergency situations, including procedures for notification when water quality poses a health risk. More specifically, they recommended that these plans should specify coordination responsibilities, communication and notification plans, and plans for providing emergency water supplies (NHMRC 1996).

In Australia, the development of incident plans by suppliers varies significantly across State and Territory jurisdictions. Tasmania, Victoria and South Australia are the only jurisdictions where incident plans are supported by legal obligations. In NSW, incident plans have been developed by the SWC and the HWC.

In Tasmania, suppliers are required by the *Public Health Act 1997* to:

- notify the Director of Health that the quality of water is, or is likely to become, a threat to public health;
- develop in consultation with the Director of Health, a protocol for advising the users of water under their control on water quality issues; and
- prepare an incident plan for public reticulated potable water as part of its management responsibility.

In Victoria, only the three retail suppliers are required by their respective operating licences to have in place a plan to effectively and efficiently respond to potential emergencies.

In South Australia, United Water and Riverland Water are required by their contracts to prepare emergency response and contingency plans for management of operational incidents, including water quality incidents.

In NSW, the SWC and the HWC have developed incident plans under the umbrella of a Memorandum of Understanding (MoU) with NSW Health.[28] The MoU, among other things, establishes the responsibilities of each party in dealing with events of public health significance.

The SWC's Drinking Water Quality Incident Management Plan contains procedures and protocols for the coordinated management of incidents, including the notification of public health advice to customers and media communication of public health information. The protocol requires the SWC to notify NSW Health immediately on the detection of contamination and provide information about the concentration and the likely affected areas.

In the benchmarked countries, particularly the UK and the US, incident procedures are set out in legislation.

UK suppliers are required by the *Water Industry Act 1991* to develop and implement incident management procedures. It is also mandatory for suppliers to notify the relevant authorities of events and incidents. This notification rule applies to any event that is likely to give rise to a significant risk to consumers, but also to events that may be of national significance, have attracted publicity, or may have caused significant concern to consumers (McClellan 1998).

In the US, the SDWA outlines public notification requirements relating to violations of the national primary drinking water regulations. Suppliers are required to inform consumers, the US EPA Administrator, or the head of the State agency that has primary enforcement responsibility for violations of drinking water standards.

28 With recent amendments to the *Public Health Act 1991*, NSW Health has the powers under its own legislation and the *Sydney Water Act 1994* to enforce the MoU obligations. The HWC is not required by law to enter into a MoU with NSW Health — this is a voluntary procedure and hence the contents may not be enforceable.

Response protocols

In Australia, health authorities in each State and Territory are responsible for addressing a notifiable incident. In doing so, they are usually guided by an established response protocol. In NSW, Victoria, Tasmania and South Australia, response protocols have been established in legislation and regulation.

A response protocol outlines action procedures which must be communicated to both the supplier and the community. These procedures may include issuing a boil water alert.

In some jurisdictions the responsibility for advising the community to boil water is delegated to the supplier. For example, in Victoria, if the health department is satisfied that the water supplied may be contaminated, and that there is a substantial risk to public health, it may:

- direct the supplier to issue a boil water alert; and
- direct the supplier to purify the water supply to a standard that is acceptable to the health department.

In South Australia, the government has endorsed a Water and Wastewater Incident Notification and Communication Protocol. The Protocol prescribes water quality criteria for notification (determined by the Health Aspects Water Quality Committee) and time frames for that notification by suppliers to the Department of Human Services (DHS(SA)).[29]

In addition, the Protocol describes duties of a Water Incident Coordinator (located in the DHS(SA)) who acts as a single point of contact for communication of all water and wastewater incidents and the duties of the Lead Minister (when required). The Lead Minister is responsible for managing communication of serious incidents to the public and the Government. In the event of incidents designated as having potential human health effects, the Lead Minister would be the Minister for Human Services.

In NSW, the Chief Health Officer (CHO) has the sole responsibility for determining whether a boil water notice should be issued in the case of the SWC and the HWC. However, in doing so, the CHO may direct the SWC or the HWC to issue the

[29] Type I incidents (serious incidents that could cause risk to human health) require immediate reporting to the DHS(SA) by telephone with a hard copy report to follow within 24 hours. Such incidents are also reported to concerned Ministers. Type II incidents (incidents that represent a low risk to human health) generally require reporting to DHS(SA) within one business day. Persistent minor operational problems in distribution systems are reported monthly to the DHS(SA).

notice. Recommendations have been given to non-metropolitan suppliers to contact their regional Public Health Unit (PHU) when a real or potential health risk exists. The PHU is required to advise the Water Unit of NSW Health to help determine the necessity for a boil water notice.

In the US, suppliers are responsible for issuing boil water alerts in consultation with the health authority when a drinking water regulation is violated. A boil water alert is announced through the media as well as details of the violation, the potential adverse effects on human health, and the steps the supplier is taking to correct the violation.

In NSW, Queensland, Victoria, South Australia and the ACT, the health departments have established response protocols to deal specifically with actual and potential outbreaks of *Cryptosporidium* and *Giardia* in drinking water. These protocols define responsibilities and include criteria to guide decisions on public health action. In particular, NSW and Queensland Health consider that any positive *Cryptosporidium* and *Giardia* result constitutes an incident and warrants further investigation.

3.5 Regulation review process

In Australia and most of the benchmarked countries, drinking water guidelines and standards are to be reviewed on a rolling basis rather than as one comprehensive review.

The EU is required to review drinking water parameters and parametric values, the monitoring of parameters, and specifications for the analysis of parameters at least every five years.

The UK and France do not undertake a rolling review of their standards but rely on the outcome of EU reviews and make the necessary amendments to existing legislation.

In the US, the EPA is required to review existing regulations every six years to determine if they are appropriate. In addition, the US EPA has a list of unregulated contaminants from which it must examine at least five contaminants every five years.

The advantage of a rolling review over a comprehensive review is that it is less resource intensive because it does not require all guideline or standard values to be reviewed at the same time. It also provides greater opportunity for a guideline or standard setter to act in a more timely and efficient manner. For example, a rolling

revision approach provides greater scope to respond to emerging contamination problems and to amend existing guideline and standard values as new scientific evidence emerges.

3.6 In summary

Guidelines and standards establish quantitative limits or values for individual drinking water contaminants. Their regulatory status depends on their legal form — standards have the force of law and are usually backed by penalties for non-compliance, whereas guidelines are discretionary and non-enforceable.

Internationally, there is great scientific uncertainty about the link between guideline or standard values and health outcomes. In particular, health benefits, although real, are difficult to substantiate and quantify.

In Australia, the NHMRC Guidelines comprise sets of guideline values and a description of good practice for overall systems management. Their content is largely drawn from the WHO Guidelines.

Most suppliers in Australia aim to meet the 1996 Guidelines or earlier versions. In some jurisdictions, a range of quasi-regulatory instruments have been used to upgrade the status of the Guidelines to that of standards without undertaking a regulatory impact assessment. The variety of instruments used means that there is a lack of consistency in implementation.

Guidelines are not always set independently of the suppliers. Where MoUs are used for example, the agreed implementation processes are established by mutual consent between the supplier and a regulatory agency.

In Australia, irrespective of whether a jurisdiction has adopted the Guidelines or elevated the status of the Guidelines to standards, suppliers have a common law duty of care to take practicable measures to identify hazards, minimise the risks of harmful contamination and monitor the performance of water quality.

In addition to a common law duty of care, consumers may also be protected from the risk of contaminated drinking water by a statutory duty of care, Commonwealth legislation pursuant to the *Trade Practices Act 1974* and complementary State and Territory legislation. Where the status of Guidelines have been elevated to standards, some consumers are also protected by an implied customer contract.

In contrast with Australia, suppliers in the US, EU, UK and France must comply with national drinking water regulations which are supported by strong enforcement

mechanisms. This approach provides consumers with more certainty that their drinking water will not be contaminated.

Provision of safe drinking water in the US is covered by specific safe drinking water legislation (SDWA). The SDWA provides a mechanism for explicitly linking health risk assessment and economic evaluation by providing for goals (MCLGs) as well as standards (MCLs). MCLGs are goal levels for what is ideal in public health terms, whereas MCLs are tempered by what is scientifically practicable and affordable. In Australia, risk assessment is undertaken. However, economic evaluation, if done at all, is at best implicit.

Water quality monitoring is a key risk management strategy and necessary to fulfil the duty of care and to operate systems properly.

Monitoring traditional indicator organisms is a form of output regulation that has limitations. Consequently, preventative measures involving risk management and quality assurance have assumed greater importance. These approaches necessitate the adoption of comprehensive catchment to tap strategies.

Cryptosporidium and *Giardia* are the two contaminants of greatest contemporary concern. *Cryptosporidium* in particular, has the potential to produce life-threatening illness in immuno-compromised persons. It is not possible to reliably monitor *Cryptosporidium* and knowledge of the organism is incomplete. Consequently, the policy response to its possible presence in drinking water supplies is still emerging. At issue, is whether it is practicable to eradicate all risk of *Cryptosporidium* and to do so at a cost that is justified by the magnitude of the risk.

There are differences between countries in whether a RIS is prepared and an associated benefit–cost analysis undertaken and hence the transparency with which drinking water regulations are developed. Without transparency, accountability is diminished and proper consultation is unlikely to occur.

Of the countries studied, the US seems to have the most transparent and robust regulation-making process. By comparison, there is less rigour in Australia. In particular, there is little evidence to suggest that State and Territory governments have prepared a RIS, despite a mandatory requirement to do so when proposing new or amending regulation. Further, there is no framework at the national, State or Territory level which requires a comprehensive assessment of health, economic and social (equity) objectives to ensure that the recommended guidelines are effective and efficient.

The process for reviewing and updating drinking water guidelines and standards varies between countries, with Australia adopting the practice of a rolling review to

take account of new scientific information as it becomes available. However, the NHMRC may have insufficient resources to undertake such reviews and this may jeopardise their ability to review standards independently of other countries. At the State and Territory level, there is no evidence of a formal regulatory review process to comprehensively assess the ongoing appropriateness of standards.