2 A framework for applying the guidelines

2.1 Water quality management framework

For the long-term management of any water resource, there must be:

- a designated and clearly stated set of environmental values;
- understanding of the links between human activity (including indigenous uses and values) and environmental quality, at an acceptable level of confidence;
- unambiguous goals for management;
- appropriate water quality objectives; and
- effective management frameworks, including cooperative, regulatory, feed-back and auditing mechanisms.

Management strategies that combine prediction, acknowledgment of uncertainty, monitoring and review are sufficiently flexible to adapt as the knowledge base improves. However, before management can decide on strategies that will ensure ecologically sustainable development in the long-term, society must have a collective vision of what it wants for each water resource, and there must be a good scientific understanding of the impact of human activities on the resource.

Until recently, management of Australian and New Zealand water resources was primarily focused on protecting environmental values based on human health, such as quality of drinking water, agricultural water and water from which aquatic foods are harvested. Maintenance of water quality to protect aquatic ecosystems was often included, but based on a very deterministic view of ecosystems that assumed that factors controlling ecosystem function could be identified and managed to prevent problems. However, it is now well recognised that the relationships between key ecological processes and their components are complex and variable (probabilistic) and cannot be determined precisely. The guidelines provided in this document attempt to take these factors into consideration.

2.1.1 The broad strategy

Australia and New Zealand both have a regional or local government framework in place. The political boundaries imposed within Australia place most of the responsibility for the management of natural resources with the states and territories. In New Zealand primary responsibility for water management rests with regional councils.

Water resource management is best implemented by integrating national, state and regional powers and responsibilities, and by using complementary water quality planning and policy tools. After all available and technical information has been collated for a defined water body, the steps listed below (and shown in figure 2.1.1) could be followed to implement a broad national management strategy at a local level.

1. Identify the *environmental values* that are to be protected in a particular water body and the spatial designation of the environmental values (i.e. decide what values will apply where).

2. Identify *management goals* and then select the relevant *water quality guidelines* for measuring performance. Based on these guidelines, set *water quality objectives* that must be met to maintain the environmental values.
3. Develop statistical performance criteria to evaluate the results of the monitoring programs (e.g. statistical decision criteria for determining whether the water quality objectives have been exceeded or not).
4. Develop tactical monitoring programs focusing on the water quality objectives.
5. Initiate appropriate management responses to attain (or maintain if already achieved) the water quality objectives.

   (Note: Several of the key terms from the broad management strategy outlined above, some of them in italics, are explained in the sections below.)

Define
PRIMARY MANAGEMENT AIMS
(including environmental values, management goals and level of protection)

↓

Determine appropriate
WATER QUALITY GUIDELINES
(tailored to local environmental conditions)

↓

Define
WATER QUALITY OBJECTIVES
(specific water quality to be achieved)

- taking account of social, cultural, political and economic concerns where necessary

↓

Establish
MONITORING AND ASSESSMENT PROGRAM
(focused on water quality objectives)

- after defining acceptable performance or decision criteria

↓

Initiate appropriate
MANAGEMENT RESPONSE
(based on attaining or maintaining water quality objectives)

Figure 2.1.1 Management framework for applying the guidelines

The elements of this management strategy can be incorporated into comprehensive planning practices such as integrated (or total) catchment management plans (ICM or TCM) or can remain relatively small-scale plans for local areas. However, there must be consultation with stakeholders and the effective use and integration of a multi-disciplinary array of skills and knowledge to achieve success.

With respect to point 5 above, the management responses will depend on the issue of concern, the cause(s) of the poor water quality and the available tools, and should be negotiated and agreed upon by the local or regional stakeholders. In Australia, strategic management can be in the form of catchment management plans or state or national policies (e.g. statutory Environmental Protection Policies) and in New Zealand, in the form of Regional Policy Statements, regional plans or National Policy Statements, based on the agreed environmental values and their associated water quality objectives. Regulation could be achieved through discharge consents and codes of practice designed to ensure water quality objectives are not exceeded and taking into account cumulative impacts from all sources.

The monitoring programs identified in point 4 above should be maintained during and after implementation of the agreed management response(s), to evaluate their performance in achieving the water quality objectives and hence the management goals. This process should be iterative and on-going to ensure the environmental values continue to be sustained.

2.1.1.1 Responsibilities

The NWQMS outlines a three-tiered approach to water quality management at:

- the national level — a vision of achieving sustainable use of water resources by protecting and enhancing their quality while maintaining economic and social development together with overarching national guidelines for minimum water quality;
- state or territory level — implementation through state water quality planning and environmental policy processes, to provide a planning and management framework with goals and objectives consistent with the agreed national guidelines;
- regional or catchment level — complementary planning, with local or catchment management strategies developed and implemented by the relevant stakeholders. Regional communities are encouraged to participate in identifying the local environmental values and to monitor and report on progress and performance of the plans.

To underpin water resource management at the national, state and territory levels in Australia, a range of legislative and regulatory tools are being used. Examples include state and territory water and land resources management Acts, environment protection Acts, the development of water quality guidelines focused on state and territory water resources, and the development of national environmental protection measures. Each state or territory uses its own water quality planning and environmental policy tools to establish a framework compatible and consistent with the agreed national guidelines.

In New Zealand, these guidelines are designed to assist water managers with the implementation of the *Resource Management Act 1991* (RMA) which gives regional councils primary responsibility for water management. The RMA empowers councils to develop statutory plans and local laws for water management. The RMA also enables central government to develop national policy and standards on a statutory basis.

Overall responsibility for water resource management rests with the community. The tools, strategies and policies developed to manage and protect environmental values should be applied in this wider context. In effect, there must ultimately be education and change in community behaviour toward a more environmentally sustainable approach.

The responsibilities for monitoring water resource quality should not always rest with government alone and ideally would be shared with the dischargers/users of the environment in question (these shared responsibilities could extend to the waters beyond the mixing zone of outfalls). Many community and catchment groups have already become involved in, or taken responsibility for, water quality monitoring programs and are developing management strategies to maintain or improve their water resources.

2.1.2 Stakeholder involvement

Stakeholders need to be actively involved in many of steps 1–5 outlined above, to help ensure that:

- community needs are accurately reflected;
- impacts on the community are well understood and incorporated into the decision-making (e.g. cultural, social, economic and political);
- the costs (financial, amenity, etc.) associated with decision making will be acceptable to the community;
- management strategies are appropriately targeted; and
- a shared ownership of catchment knowledge and commitment to action are being developed.

Relevant stakeholders include individuals and groups that directly and/or indirectly use, derive benefit from, and/or have an impact on the waterway being considered. These may include indigenous groups, community groups, government agencies and utilities, catchment and water managers, regulators, industry (urban and rural), agricultural groups, pest control groups, environmental groups, recreational users (e.g. fishers, swimmers) and individual residents.

The stakeholders can be involved at a number of different levels, depending on their interest and expertise, and the mechanisms available for their involvement. The latter in particular will vary depending on the approach taken by state, territory and local governments.

Box 2.1 shows examples of stakeholder involvement in Australia and New Zealand.

Box 2.1 Examples of stakeholder involvement in Australia and New Zealand

- New South Wales — A six month public consultation program in 1998 identified interim environmental values and objectives for various catchments in the State. The process involved written submissions, and information and discussion forums located in central and regional locations.
- Victoria — State Environment Protection Policies (SEPP) for water set out the 'beneficial uses' (or environmental values) to be protected in various parts of rivers, lakes, estuaries and bays and related environmental values. The SEPP process includes a legislative requirement for a period of at least three months for submissions to be received.
- Queensland — The Queensland Environmental Protection Policy for Water requires appropriate consultation with the community before environmental values and water quality objectives for a water are decided. Community groups can set an example on working to improve water quality, e.g. the Condamine Balonne Water Committee Inc. took responsibility for establishing and implementing a comprehensive water quality monitoring program in their catchment.
- Western Australia — In 1998, development of the proposed Environment Protection (Marine Waters) Policy involved community consultation to set the environmental values and environmental objectives of Perth's coastal waters. The process included key stakeholders, stakeholder reference groups and a two month consultation period.
- South Australia — Catchment goals, objectives and actions for the Torrens Catchment were formulated using a consultation program involving the community, local government, state and federal agencies and other stakeholders. A series of technical papers was presented as background to the catchment plan.
- Australian Capital Territory — The ACT Environment Protection Policy on Water Pollution requires public consultation with individuals, community groups, industry, government agencies and other stakeholders.
- Tasmania — Local communities and other stakeholders have a key role in identifying the water quality values for regional wetlands and waterways as part of the *State Policy on Water Quality Management 1997.* Information provided on these values assists the Board of Environmental Management and Pollution Control and local councils to finalise Protected Environmental Values (PEVs) for surface waters. The process of setting PEVs takes a minimum of 3 months. These values are reflected in management plans for the regions and in local council planning schemes. The *Water Management Act 1999* provides for enhanced stakeholder and community input into water allocation and management.
- Northern Territory — Environmental value declarations, informed by extensive public participation, have been used to establish the framework for water resource management in the territory since 1994. For example Darwin Harbour waters were declared under the *Water Act* in 1996 to have aquatic ecosystem and recreation and aesthetics values protected. This followed an extensive public consultation phase with public meetings, newspaper and other media promotions. Environmental objectives and water quality targets for harbour waters will be developed over 2000/01 through a further public consultation process steered by a committee with broad government agency and community representation.
- New Zealand — Consultation is an integral part of natural resource management under the Resource Management Act. All statutory plans require a period of consultation and a submission process. Consultation with stakeholders also frequently occurs in non-statutory management processes by government (central and local) and industry.

Possible forms of stakeholder involvement are listed below. Stakeholders could be part of:

- statutory reviews of development proposals;
- community forums or discussions to identify broad community goals and potential areas of conflict;
- specific groups that relate these broad goals to the environmental values that need to be protected in a particular water body, decide where these may apply, and evaluate the potential implications of different options;
- specific groups such as stakeholder advisory committees (as outlined in the NWQMS *Implementation Guidelines*) which would bring together all major interests in the one forum to discuss ideas, issues and proposals and provide a broad-based sounding board;
- community and industry participation in processes for developing management strategies (e.g. through catchment management planning) and assessing progress against water quality objectives and management goals (through monitoring of discharges and ambient conditions);
- public hearings, although this form of community forum is not commonly used in Australia.

(The NWQMS *Implementation Guidelines* (ARMCANZ & ANZECC 1998) provide more detail.)

2.1.3 Environmental values

Environmental values are particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and which require protection from the effects of pollution, waste discharges and deposits. They were often called ‘beneficial uses’ in the water quality literature but this term has lost favour because of its exploitative connotations. For this reason, the term ‘environmental value’ has been adopted by the NWQMS.

The following environmental values are recognised in these guidelines:

- aquatic ecosystems,
- primary industries (irrigation and general water uses, stock drinking water, aquaculture and human consumption of aquatic foods),
- recreation and aesthetics,
- drinking water,
- industrial water (no water quality guidelines are provided for this environmental value), and
- cultural and spiritual values (no water quality guidelines are provided for this environmental value — see box 2.2).

Box 2.2 Cultural importance of water

Water resources have important cultural and spiritual values, particularly for indigenous peoples of New Zealand and Australia.

In *New Zealand*, water has enormous cultural importance for Maori. Water acts as a link between the spiritual and physical worlds, and many waterbodies are associated with waahi tapu (sacred sites). All elements of the natural environment (including people) are believed to possess a mauri (life force) which Maori endeavour to protect. The well-being of an iwi (tribe) is linked to the condition of the water in its rohe (territory). In addition, water provides important mahinga kai (food collected from marine and freshwater areas). Supply and exchange of mahinga kai forms part of the social fabric of Maori tribal life. The *New Zealand Resource Management Act (1991)* recognises Maori values, such as through Sections 6(e), *the relationship of Maori and their culture with their ancestral lands, water, sites, waahi tapu, and other taonga* (treasures), and Section 7(a), *Kaitiakitanga* (guardianship).

Giving effect to these values may present a considerable challenge to water managers. For example, in New Zealand, water managers require guidance on how to manage water for values associated with (i) mahinga kai, (ii) waahi tapu, and (iii) mauri. These Guidelines do not provide such guidance. The New Zealand Ministry for the Environment proposes:[1]

- preparing guidelines and case studies which develop practical methods for reflecting the values of mahinga kai, waahi tapu and mauri in the management of water;
- incorporating mahinga kai values into the relevant ecosystem outcomes and actions.

Likewise, in *Australia*, indigenous cultural and spiritual values may relate to a range of uses and issues including spiritual relationships, sacred sites, customary use, the plants and animals associated with water, drinking water or recreational activities. Native title legislation, and Commonwealth and state cultural heritage legislation, provide for recognition and management of indigenous interests in water.

At this stage no water quality guidelines have been developed for the protection of cultural and spiritual values in either New Zealand or Australia. Because of the lack of such guidelines, in the water management framework, cultural values can be taken into account through the process of establishing the specific water quality objectives for a particular water resource (see figure 2.1.1).

Until further work is undertaken to better define cultural and spiritual value for users in both Australia and New Zealand, managers in both countries, in full consultation and co-operation with indigenous peoples, will need to decide how best to account for cultural values within their own management frameworks. They will need to take account of existing legislation, regulations and guidelines.

All water resources should be subject to at least one of the above environmental values, and in most cases more than one could be expected to apply. Where two or more agreed environmental values are defined for a water body the more conservative of the associated guidelines should prevail and become the water quality objectives. It is essential that the needs and wants of the community be identified when environmental values are being defined for a particular water resource.

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1 NZ Ministry for the Environment 1999. *Making every drop count — A draft National Agenda for Sustainable Water Management.* New Zealand Ministry for the Environment, Wellington.

It should be recognised that environmental values are often interdependent. For example, all relevant environmental values need to be considered when evaluating the quality of return water for any one user to ensure that all agreed values are maintained; functioning ecosystems and ecosystem processes are essential for supporting wild fish populations and can provide some protection to water quality through chemical degradation or buffering capacity; there may also be situations where the water quality required to support downstream environmental values (e.g. lake, estuary or marine) will influence the establishment of water quality objectives upstream. This will be particularly relevant where downstream ecosystems are more sensitive to a particular contaminant (e.g. nitrogen in marine environments), where there are cumulative effects from persistent discharges (e.g. nutrients), or where persistent contaminants are accumulating in depositional areas downstream (e.g. heavy metals).

Once the environmental values for a water body have been defined by the relevant management authority, the level of environmental quality or water quality necessary to maintain each value must be determined. It may be broadly defined through the establishment of ***management goals*** that describe more precisely and in greater detail what is to be protected. As with environmental values, the management goals should be defined according to community needs and desires and therefore will involve consultation with relevant stakeholder groups. They should be structured so that they can become the key objectives to be achieved through management plans and therefore should relate to particular parts of the environment that can be measured. In particular, management goals should reflect the specific problems and/or threats to the established values, the desired levels of protection for aquatic ecosystems, and the key attributes of the resource that must be protected (e.g. endemic or key species, key agricultural or aquacultural species, primary or secondary recreation). From the management goals it should be obvious which the key water quality indicators are, and therefore which guidelines should be selected for establishing water quality objectives. The specific water quality objectives more tightly define the desired level of water quality, and are compared with the existing water quality to assess performance.

In some cases, the water quality needed to support the desired environmental value may not be attainable immediately. Where restoration is possible, there may be costs associated with restoring the level of quality that the community desires. Once full costs of restoration are known, the community may choose to accept a lower quality based on a full cost–benefit analysis. The environmental values and management goals for a particular area need to be well thought out, with full knowledge of the implications to the broader community. This is a process involving broad consultation with representatives of the whole community, with the aim of reaching a desirable, practical and agreed set of management goals, and hence water quality objectives.

Guidance on how to undertake community consultation processes is provided in the NWQMS *Implementation Guidelines* (ARMCANZ & ANZECC 1998).

In the absence of a clear and agreed set of environmental values for a particular water resource, managers should take a conservative approach and assume that all *appropriate* environmental values apply to the resource, by default. For example in the case of a coastal marine embayment, ‘drinking water’ would not apply by default, but ‘ecosystem protection’, ‘recreation and aesthetics’, and ‘primary industries — aquaculture’ would apply.

2.1.4 Water quality guidelines

A water quality guideline is a numerical concentration limit or narrative statement recommended to support and maintain a designated water use. This document includes guidelines for chemical and physical parameters in water and sediment, as well as biological indicators. The guidelines are used as a general tool for assessing water quality and are the key to determining water quality objectives that protect and support the designated environmental values of our water resources, and against which performance can be measured.

Water quality parameters can be divided into those that have direct toxic effects on organisms and animals (e.g. insecticides, herbicides, heavy metals and temperature) and those that indirectly affect ecosystems causing a problem for a specified environmental value (e.g. nutrients, turbidity and enrichment with organic matter). Whether the effects are direct or indirect has important implications for management, and perhaps for how a guideline might be derived. Some physical and chemical stressors can also indirectly modify the toxicity of other contaminants. While specific guidelines are not provided for this mode of action, guidance is provided in each relevant section on how it can be taken into account.

The guidelines have been derived with the intention of providing some confidence that there will be no significant impact on the environmental values if they are achieved. Exceedance of the guidelines indicates that there is potential for an impact to occur (or to have occurred), but does not provide any certainty that an impact will occur (or has occurred). In areas where protection of aquatic ecosystems is a designated environmental value, the Guidelines recommend direct assessment of the biological community to assess whether ecosystem integrity is being maintained, threatened or compromised to a level that causes pollution. Biological indicators should therefore be used to complement the use of physical and chemical indicators for this value. These Guidelines describe indicators for biological assessment and give guidance for determining an acceptable level of change so that the relative condition of the ecosystem can be estimated.

a See Section 3.1.3

For some environmental values it may not be feasible to protect all water resources to the same level, and the community may wish to aim for different levels of protection for different resources. Whatever the level of protection, it should be reflected in the management goals and the water quality objectives determined for a particular resource. In this document three levels of protection, based on ecosystem condition, are recognised for aquatic ecosystems.[a] For aquatic ecosystems the guidelines in this document have mainly been developed for use at the second and third levels of protection: *slightly to moderately disturbed ecosystems* and *highly disturbed ecosystems*. The highest level of protection is for *high conservation/ecological value* systems where management would be expected to ensure there is no change[2] in biological diversity, relative to a suitable reference

2 ‘No change’: In practice and in the absence of information that would define the thresholds of ecological change, refers to statistically conservative changes from a baseline mean or median value, e.g. change of 10% or one standard deviation from a baseline mean — see sections 3.2.4.2 and 7.2.3.3 (Stage 1).

a See Section 3.1.4

condition.[a] For highly disturbed ecosystems that cannot feasibly be returned to a slightly to moderately disturbed condition, these Guidelines provide advice to assist managers to derive alternative guidelines that give lower levels of protection.

The earlier guidelines (ANZECC 1992) acknowledge there is such inherent variability within the environment that 'site-specific' environmental information needs to be used to develop appropriate guidelines and indices of environmental quality. For example, light availability is a key factor controlling the growth and survival of benthic plants. In naturally turbid waters the biomass of a particular species may decrease with depth to a limit beyond which there is insufficient light. This limit would be deeper in less turbid waters. Thus the selection of a water clarity guideline value (e.g. light attenuation coefficient) would need to take into account these site-specific considerations.

Guideline numbers and decision frameworks

b Sections 2.2.1.4 & 3.1.5

These Guidelines have adopted an innovative risk-based approach that is intended to improve the application of guidelines to all Australian and New Zealand aquatic environments. It uses decision frameworks (particularly for the protection of aquatic ecosystems) that help users to tailor water quality guidelines to local environmental conditions.[b] In this approach the old 'single number' guidelines (see ANZECC 1992) are regarded as *guideline trigger values* that can be modified into regional, local or site-specific guidelines by taking into account factors such as the variability of the particular ecosystem or environment, soil type, rainfall and level of exposure to contaminants. Trigger values are concentrations that, if exceeded, would indicate a *potential* environmental problem, and so 'trigger' a management response, e.g. further investigation and subsequent refinement of the guidelines according to local conditions. Thus these Guidelines have moved away from promoting single-number guidelines that are applied universally, towards guidelines that can be determined individually according to local environmental conditions.

It is not mandatory to use decision frameworks, but they can reduce the amount of conservatism necessarily incorporated in the guideline trigger values, and so produce values more appropriate to a particular water resource. Decision frameworks or tools also allow more flexibility and scope for water managers. Hence guidelines that are more relevant to a specific water resource and environmental value can be developed where considered appropriate. However, it may take more time, expertise or resources to implement the risk-based decision frameworks, particularly where additional data collection is required to augment the data already collated.

Which stakeholder(s) are responsible for data collection and implementation of the decision frameworks will depend on the issue (e.g. environmental impact assessment process or management strategy development) and the jurisdictions' legislative and regulatory tools, and should therefore be decided on a case-by-case basis. Management agencies with responsibility for a number of water resources may need to prioritise their water resources based on factors such as condition of the system, increasing land use pressures, data availability, public concern, conservation issues and the outcomes of risk and cost-benefit analyses, so that limited resources can be appropriately allocated.

Alternatively, where resources, data and/or time are significant constraints, users can take a more conservative approach and initiate an appropriate management response when either the initial trigger value or a partly modified trigger value (only part of the decision framework applied) is exceeded. The availability of data, expertise, resources and time will determine which steps in the frameworks are used.

a See Section 3.4.2

b Section 3.1.5

Note: it is emphasised here, and elsewhere throughout the document, that the use of the term 'risk-based' does not imply the need for a full (quantitative) risk assessment. For example, the aquatic ecosystem guideline trigger values for toxicants are risk-based in the sense that they are calculated to protect a pre-determined percentage of species with a specified level of confidence,[a] while the decision frameworks simply provide a site-specific estimate of whether low, possible or high risk exists.[b]

2.1.5 Water quality objectives

A water quality guideline was defined above as a numerical concentration limit or descriptive statement *recommended* for the support and maintenance of a designated water use. Water quality objectives take this a step further. They are the specific water quality targets agreed between stakeholders, or set by local jurisdictions, that become the indicators of management performance. Normally, only those indicators considered relevant to the environmental issues or problems facing the resource are selected for deriving water quality objectives. They serve to protect the designated environmental values of a resource and would normally be based on the information from these Guidelines.

A water quality objective is a numerical concentration limit or descriptive statement to be measured and reported back on. It is based on scientific water quality criteria or water quality guidelines but may be modified by other inputs such as social, cultural, economic or political constraints. Some of these inputs may be intangible and therefore hard to quantify, but nevertheless they are valid inputs to the management process. The relative weighting or importance placed on the water quality guidelines and these other, potentially very important but less tangible, considerations would be area specific, and therefore would be determined on a case by case basis. The process of modifying guidelines to establish water quality objectives would normally be carried out through cost–benefit analysis programs involving input from stakeholders or local jurisdictions.

An additional consideration when setting water quality objectives in rivers and streams is the water quality required to meet management goals and hence protect the environmental values established further downstream, including estuaries and coastal marine environments. The water quality required to support local environmental values may not be sufficient to support downstream environmental values, particularly for chemicals that persist in the environment or where downstream ecosystems are more sensitive to the contaminant (e.g. heavy metals or nutrients).

2.2 Application of the guidelines for water quality management

A primary aim of this document is to help users to develop management frameworks for protecting the environmental values of Australian and New Zealand natural and semi-natural water resources, and to derive appropriate water and sediment quality guidelines for the ambient waters that will protect their designated values.

The guidelines can:

- provide water resource managers with information that helps them identify and prioritise key environmental issues (such as the loss of seagrass beds if light intensity decreases below a critical level) and hence determine the management goals;
- assist managers to establish management goals and water quality objectives (preferably with appropriate baseline data);
- provide information that helps resource managers decide on the types of management actions they need for achieving the desired goals and targets;
- provide a basis upon which to assess whether the management actions are achieving the targets set for the management unit.

The preferred approach is to use the guidelines in a proactive way (where management focuses on preventing change beyond some pre-determined level), although in already degraded systems this may not be an option.

The purpose of a water quality management program should be to ensure that environmental values will be supported through the management goals and by meeting the agreed water quality objectives. It is recommended that this should be done through a process of cooperative best management (involving all stakeholders), and based on sound environmental arguments. Where the environmental values are not being supported because the associated management goals are not being met, remedial management programs, with appropriate performance indicators and associated time frames, should be developed and implemented to ensure the management goals will be met.

2.2.1 Philosophical approach to applying the guidelines

New ways of managing water quality have developed to match growing scientific understanding of ecosystem complexity. Traditional scientific and management approaches are now often inappropriate; instead there must be increasing reliance on holistic best-practice approaches to ensuring sustainable use of water resources. Key issues underpinning the new philosophy espoused in these Guidelines are outlined below. Some of them were also fundamental to the previous (ANZECC 1992) Guidelines.

2.2.1.1 Sustainable use

The fundamental aims of the NWQMS in Australia and the Resource Management Act in New Zealand are the sustainable use and management of each nation's water resources in environmental, economic and social contexts. To achieve these aims, the concept of integrated catchment management[3] (ICM) is promoted today. The concept is consistent with the management framework outlined in these Guidelines, and encompasses all aspects of environmental management within a catchment, including water quality. Within the ICM framework, environmental values are identified by all stakeholders of individual resources, namely landowners and the community, in partnership with relevant government agencies.

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3 Under section 30/1/a of the *New Zealand Resource Management Act (1991)* all regional councils are required 'to achieve integrated management of the natural and physical resources of the region'.

2.2.1.2 Cooperative best management

Formerly, deterioration in water quality was largely controlled by regulation and management. While these command and control approaches successfully deal with the obvious point source problems, they have produced an end-of-pipe and minimum compliance culture. It is now also clear that a regulatory approach is generally not an appropriate tool for resolving the problems of diffuse sources of contamination which have just as much or more of an impact on water quality than point sources.

Environmental regulation and management in Australia and New Zealand are currently undergoing major change, adopting a more holistic and integrated pollution-prevention approach to environment protection. This involves a shift from control to prevention, from end-of-pipe regulation to cleaner production, from a focus on prescriptive regulation to a focus on outcomes and on cooperation rather than direction. This new approach is being increasingly adopted in formulating water resource management policies and strategies. It requires the commitment of industry and government and the involvement of the community to establish cooperative best management and overall responsibilities for maintaining and improving water resources. The NWQMS *Implementation Guidelines* (ARMCANZ & ANZECC 1998) outlines a framework for involving all stakeholders in the management of water resources.

The success of cooperative best management relies on negotiated agreements developed through processes involving the entire community; they set boundaries within which business can maintain the defined environmental values. Cooperative best management provides a framework through which many sources of pollution may be addressed in an equitable and effective manner. Sharing of responsibility, cooperative action, and effective monitoring and reporting arrangements are key aspects. Also important is the emphasis on flexibility and integrated management to achieve the best feasible environmental outcomes. In practice there may be issues over which stakeholders are unable to reach agreement. Local jurisdictions may therefore need to consider establishing conflict resolution mechanisms to facilitate the decision making process.

It is also important that communication networks be developed across whole catchments to address broad-scale issues cooperatively. For example, when setting the water quality objectives for upstream riverine ecosystems, effects on downstream environmental values, including cumulative effects, must also be considered.

Cooperative best management focuses on attaining goals of environmental quality rather than on compliance *per se*. For example, licence conditions or agreed levels of unacceptable environmental change in monitoring programs would be negotiated between all the stakeholders, with the overriding objective of attaining the established management goals for a water resource (and hence protecting its environmental values), rather than simply regulating to meet individual water quality parameters. The process would consider best management practices and the ability of the industry to achieve adequate effluent quality within a reasonable time frame. Where the agreed licence conditions were not met, or a trend toward a significant change in ambient water quality was detected, there would be an attempt to resolve the problem cooperatively before using a regulatory approach as a last resort. To complement their cooperative approach, jurisdictions might need to introduce a number of tools for controlling diffuse and point source pollution (e.g. economic incentives, emissions trading).

Cooperative best management involves monitoring and impact assessment. Although risk assessment concepts are familiar to many water resource managers, analogous concepts of the potential for errors in statistical inferences based on monitoring data are often poorly understood, or neglected. An alternative approach to statistical decision making (Mapstone 1995, 1996) is suggested (see box 2.3) that should jointly involve all stakeholders. As mentioned above, even where water quality meets the agreed water quality objectives and is 'acceptable' in a statistical sense, stakeholders should work cooperatively to develop a clear understanding of the issues associated with, and consequences of, water quality that is trending towards the established objectives. In this way, intervention, including changes to industry practices, can be set in place at an early stage if deemed necessary.

Box 2.3 An alternative approach to statistical decision making (Mapstone 1995, 1996)

Traditionally, statistical analysis of monitoring data has only considered minimising the probability of concluding that an environmental impact has occurred when, in fact, no impact has occurred — a Type I error. However, to maximise protection of the environment it is perhaps more important to consider Type II errors — the probability of concluding that an impact has not occurred when, in fact, it has. The first step in the suggested alternative approach is to decide on the size of effect that would cause concern (or constitute an early warning). Then, with this *critical effect size* in mind, the stakeholders consider the possibility that such an effect might either be missed (a Type II error) or inferred incorrectly (a Type I error). Monitoring and data collection are then designed to keep the risks of both Type I and Type II errors to the values agreed up-front by the stakeholders, given the stipulated critical effect size. The significance criterion used in statistical tests should be that which ensures that the agreed *ratio* of Type I and Type II errors is maintained.[a]

a Type I and II errors are explained more fully in Section 3.1.7

Consistent with the principle of cooperative best management, this approach should result in benefits to all stakeholders. All parties would be aware of the targets for monitoring, the statistical criteria by which statistical decisions will be made, what will trigger management action, the level of safeguard built into the decision making process, and the risks of expense or environmental impact arising from errors in the assessment and monitoring process. Clear knowledge of these factors should reduce the risk of wrangling or litigation when impacts have been inferred and should allow explicit planning for mitigation or restoration actions that might arise in the future, but with some known minimum probability of a wrong conclusion.

Other tools that might be considered in cooperative best management are memoranda of understanding and catchment management plans. Non-point source pollution problems, in particular, could be addressed through the development and implementation of catchment management plans by landowners and the community, in partnership with relevant government agencies. One of the main objectives of these catchment management plans would be to achieve the management goals set for the aquatic environment. Well designed and appropriately focused monitoring programs could assess the effectiveness of catchment management plans in meeting specified water quality targets.

2.2.1.3 Management focus on issues not guidelines

The philosophical approach for using these revised Guidelines is this: protect environmental values by meeting management goals that focus on concerns or potential problems, e.g. toxicity. This is in contrast to previous approaches which more often focused on simple management of individual water quality parameters, e.g. toxicant concentration, to meet respective water quality guidelines or objectives. First, identify the water quality concern (e.g. toxicity, algal blooms, soil structure degradation, loss of animal vigour, deoxygenation, loss of biodiversity), and establish and understand the environmental processes that most influence or affect the particular concern. Then select the most appropriate water quality indicators to be measured, and identify the relevant guidelines.

Usually a range of environmental problems is responsible for degradation of water resources in Australia and New Zealand and so issues typically involve a range of water quality parameters. An issue-based approach to management would focus on the overall problem, and ensure an integrated approach to addressing relevant biological, chemical and physical aspects of water quality. For example, in situations where sediment contamination is likely, water managers should not focus solely on whether the measured sediment concentrations are above or below a guideline. They should also consider the bioavailability of the contaminant, and analyse trends and consider risk factors to determine whether, under current or proposed management regimes, guideline values are likely to be exceeded in the future.

2.2.1.4 Tailoring guidelines for local conditions

Optimum water quality characteristics differ between regions. There is a wide range of ecosystem types and environments in Australia and New Zealand, and it is not possible to develop a universal set of specific guidelines that apply equally to all. (Some of the default guidelines, however, do now distinguish amongst several different ecosystem types and regions making these values much more focused than they were in the previous Guidelines.) Further, environmental factors can significantly alter the toxicity of physical and chemical stressors at a site and these factors can vary considerably among sites. The present Guidelines move away from single number values that are mostly conservative, and emphasise guidelines that can be determined individually, according to local environmental conditions. This is done through the use of local reference data and 'risk-based decision frameworks'.

Decision frameworks provide guideline trigger values (equivalent to the old guideline default values) that refer to the concentration of the chemical available for uptake by organisms. Guideline trigger values are concentrations that, if exceeded, will indicate a potential environmental problem, and so 'trigger' further investigation. The investigation aims to both assess whether exceedance of a trigger value will result in environmental harm and refine a guideline value, by accounting for environmental factors that can modify the effect of the chemical.[a] Although in some cases this will require more work, it will result in much more realistic goals for management and therefore has the potential to reduce both costs for industry and confrontation.

a See also Section 3.1.5

2.2.1.5 Water or environmental quality

Water (and sediment) quality is only one aspect of maintaining some environmental values. In many cases (e.g. for primary industries and aquatic ecosystems) other factors are also important, e.g. flow, habitat, soil type, animal diet, groundwater hydrology and barriers to recruitment. In many parts of Australia and New Zealand, water quality is reasonably good but management goals for maintaining aquatic ecosystems are not being met because of loss or degradation of habitat, particularly riparian vegetation. In these situations, enhancement of water quality is unlikely to result in any significant environmental benefit because improvement in *habitat* is needed to achieve management goals and protect the environmental value.

Before investing in water quality management strategies, managers need to be sure that water quality is the key issue to be addressed in the water body under consideration, and that resources would not be better spent on other aspects of the water resource, such as riparian vegetation, habitat or hydrological regime.

2.2.1.6 Integrated water quality assessment

Water quality, environmental values and the surrounding environment are all intimately connected and need integrated assessment. This should also acknowledge that ecosystems and environmental values upstream and downstream are linked and can affect each other.

a Section 3.2

b Section 3.5

These Guidelines include a substantial section on assessment of biological aspects of aquatic ecosystems,[a] to accompany physical and chemical indicators in assessing impacts on ecosystem integrity. Sediment quality guidelines are also given.[b] This is important because pollutants become partitioned between water, sediment and biota and move between them depending on prevailing environmental conditions. These Guidelines also advise on suitable environmental flows in rivers and streams.

Similarly, in assessing water quality for irrigation, the Guidelines include consideration of soil and plant aspects of the production system, as well as the off-farm implications of water use.

2.2.1.7 Continual improvement

An overriding principle that should guide management should be *continual improvement*. This is more obvious where water or sediment quality does not match the water quality objectives. In badly polluted waters it might even be necessary to set intermediate levels of water quality to be achieved in well defined stages, each subsequent target closer to the required water quality objective, until it is finally met. However, in waters that are of better quality than that set by the water quality objectives, some emphasis could still be given to reducing the level of contamination from all sources, particularly for highly modified water resources. Wherever possible, ambient water quality should not be allowed to degrade to the levels prescribed by the water quality objectives.

2.2.1.8 Guidelines not standards

The Guidelines recommend numerical and descriptive water quality guidelines to help managers establish water quality objectives that will maintain the environmental values of water resources. *They are not standards*, and should not be regarded as such. The vast range of environments, ecosystem types and food production systems in Australia and New Zealand require a critically discerning approach to setting water quality objectives.

State, territory or local jurisdictions will need to determine whether water quality objectives should be enshrined in legislation based on the particular local circumstances.

2.2.1.9 Ambient waters

The Guidelines have not been designed for direct application in activities such as discharge consents, recycled water quality or stormwater quality, nor should they be used in this way. (The exception to this may be water quality in stormwater systems that are regarded as having some conservation value.) They have been derived to apply to the ambient waters that receive effluent or stormwater discharges, and protect the environmental values they support. In this respect, the Guidelines have not been designed to deal with *mixing zones*, explicitly defined areas around an effluent discharge where the water quality may still be below that required to protect the designated environmental values. As such, the application and management of mixing zones are independent but very important processes.

2.2.2 Mixing zones

Even when stringent effluent limits are set and strict waste minimisation is practised, effluents may be of poorer quality than the receiving water. It has been accepted practice to apply the concept of the *mixing zone*, an explicitly defined area around an effluent discharge where certain environmental values are not protected (see description in box 2.4).

Box 2.4 Mixing zones adjacent to effluent outfalls

Mixing zones are often defined as explicit areas around effluent discharges where the management goals of the ambient waters do not need to be achieved and hence the designated environmental values may not be protected. In this context mixing zones are sometimes termed *exclusion zones.* Appendix 1 of Volume 2 provides some key references and further information and advice on mixing zones. The following issues are covered there:

- the nature of mixing zones;
- difficulties with mixing zones;
- the management of mixing zones;
- best-practice effluent release and mixing zone management, as a case study; and
- mixing zone models.

Effective discharge controls that consider both the concentration and the total mass of contaminants, combined with *in situ* dilution and waste treatment, should ensure that the area of a mixing zone is limited and the values of the waterbody as a whole are not jeopardised. The environmental conditions within a mixing zone, and its size, are important concerns, particularly because degraded areas around effluent discharges reduce environmental benefits. If mixing zones are to be applied, then management should ensure that impacts are effectively contained within the mixing zone, that the combined size of these zones is small and, most importantly, that the agreed and designated values and uses of the broader ecosystem are not compromised.

2.2.3 Application of water quality prediction models

Development of a water quality management strategy depends on the quality of available information and a capacity to predict the effects of various actions on water quality. This can be done via conceptual models, which are often used to predict effects of discharges on the environment. Conceptual models can be very simple flow diagrams that illustrate the linkages between the components of the system or they can be more complex models built up from information arising from previous studies. They should indicate which key processes are influencing the system and highlight those processes likely to be affecting the water quality indicators that are of concern. These models may be conservative and rely on worst-case conditions of dilution and degradation of effluents, or they may attempt more complex analysis of cause and effect. Because of the unique features of each system, it has generally been found that models developed for a particular waterbody cannot be used for other waterbodies without significant modification. A more detailed discussion of conceptual models is provided in the *Australian Guidelines for Water Quality Monitoring and Reporting*, the Monitoring Guidelines (ANZECC & ARMCANZ 2000).

The preferred approach for managing persistent contaminants that have concentration-related toxicity potential is appropriately based on controlling ambient concentration in the environment. Generic guidelines for the protection of environmental values can be established for these types of contaminants, based on modelled relationships between concentration/exposure of the contaminant and the toxicity to test organisms, and applying safety margins designed to take account of the uncertainty associated with transferring laboratory-derived data to the open environment and the likelihood and pathways of bioaccumulation/ persistence/degradation. This model is suitable for managing toxicants in general, but alternative approaches are needed for managing substances such as nutrients that may stimulate rather than retard growth of particular species.

An example of a model that is raised frequently in the context of water pollution control is that of *assimilative capacity*. The underlying philosophy of this concept is that a natural system has the capacity to receive some level of human-induced nutrient input without unacceptable changes occurring. This concept has been defined using a variety of terms including: *assimilative capacity* or *environmental capacity* (GESAMP 1986, WAEPA 1990, Masini et al. 1992); *receiving capacity* or *absorptive capacity* (UNESCO 1988, WAWA 1994) and *carrying capacity* (French 1991, Jenkins 1991). Regardless of what name is used this ecosystem-based approach is now recognised as central to the principle of ecological sustainability (IUCN, UNEP & WWF 1991, Jenkins 1991, Folke et al. 1993).

This ecosystem-based approach is based on establishing linkages between total nutrient loadings to an ecosystem and the response of the most sensitive or important component of that ecosystem. Once these relationships have been quantified, and the desired management goals defined, regulatory agencies can set ecologically-based maximum nutrient loadings consistent with maintaining the desired environmental quality. An ecosystem-based approach linking nutrient loadings to environmental response has been successfully applied to Perth's coastal waters (WADEP 1996).

a See Section 3.1.2

In many freshwater and estuarine systems[a] the biological response to nutrient additions can become confounded and less predictable because plant growth and biomass may be significantly limited by factors other than nutrient availability. Light availability is the dominant limiting factor in many naturally–turbid or tannin stained waters for at least part of the year. Under these conditions nutrients can behave more conservatively and concentrations can differ between seasons. For effective management in this case, key pathways of nutrient transformation need to be known, and seasonal and interannual variation in flow regimes need to be understood. Under these circumstances, models of system behaviour employing flow-weighted concentration-based approaches can be very useful and are sometimes essential.

No matter which 'predictive' model is used, it is essential that environmental quality and the attainment of management goals are regularly assessed through monitoring to determine whether regulation or other management is necessary. Undesirable trends and the necessity for proactive management can be identified if data are collected at appropriate temporal scales. This relies on regular monitoring of indicators within some or all of the environmental media (water, sediment and biota) and assessment against appropriate guidelines or water quality objectives and reference sites. This information improves our conceptual understanding of the ecosystem being managed and in particular the pathways that underpin predictive models.

2.2.4 Deriving guidelines for compounds where no guidelines currently exist

The Guidelines focus on water quality management in Australia and New Zealand, but situations will arise where there is not enough information to address an issue. There are more than 70 000 chemicals in use around the world. It is not feasible to develop guidelines for all of them, either because there are insufficient toxicological studies available, or because the chemical is currently not available in Australia or New Zealand or not considered a risk there. There could also be situations where effluent contained a range of chemicals and complexes, and the chemical make-up might not be well understood. In this instance the complex chemistry might increase or reduce the toxicity of the overall mixture to an unknown degree and so the guidelines would be irrelevant. A third possible situation relating to the protection of aquatic ecosystems is where there is a well founded suspicion that a particular natural community may have atypical sensitivity to one or more contaminants.

Direct toxicity assessment is a useful tool that can be used in these circumstances, although it is mainly used to assess the toxicity of complex effluents and to derive guidelines for the amount of dilution required to safely discharge an effluent to aquatic environments. It can also be used as a monitoring tool, testing the ambient waters after they have received effluent discharges. The main advantage with using direct toxicity assessment is that it is not necessary to know the exact chemical make-up of the test effluent, and the interactions between the components, to determine potential impacts.

If water quality guidelines do not exist for a specific chemical, or if effluents contain a complex range of chemicals, expert advice should be sought from the relevant authorities on whether a current guideline exists or how a guideline might be derived. These sorts of situations are most likely to arise for the protection of aquatic ecosystems, and later chapters of the Guidelines give extensive guidance for addressing these problems.