



Development of interim national standards for surface water and salinity: Expert support and technical advice to Working Group on Natural Resource Management Standards

Moran C.J., Dovers S., Marcar N., Doherty M., Shaw R., Batley G., Burke J., Creighton C., Dyson P., Evans R., Jolly I., Milligan A., Veitch S., Young W.

CSIRO Land and Water, Canberra
Technical Report 42/01, September 2001

Development of interim national standards for surface water and salinity: Expert support and technical advice to Working Group on Natural Resource Management Standards

¹Moran, C.J., ²Dovers, S., ³Marcar, N., ⁴Doherty, M., ¹²Shaw, R., ⁵Batley, G., ⁶Burke, J., ⁷Creighton, C., ⁸Dyson, P., ⁹Evans, R., ¹Jolly, I., ¹⁰Milligan, A., ¹¹Veitch, S., ¹Young, W.

¹CSIRO Land and Water

²Centre for Resource and Environmental Studies Australian National University

³CSIRO Forestry and Forest Products

⁴CSIRO Sustainable Ecosystems

⁵CSIRO Energy Technology

⁶Murray-Darling Basin Commission

⁷National Land and Water Resources Audit

⁸Phil Dyson and Associates

⁹Salient Solutions

¹⁰Science Text Processors Canberra

¹¹Agriculture, Fisheries and Forests Australia Bureau of Rural Sciences

¹²Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management

Copyright

© 2001 CSIRO Land and Water.

To the extent permitted by law, all rights are reserved and no part of this publication covered by copyright may be reproduced or copied in any form or by any means except with the written permission of CSIRO Land and Water.

Important Disclaimer

To the extent permitted by law, CSIRO Land and Water (including its employees and consultants) excludes all liability to any person for any consequences, including but not limited to all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this publication (in part or in whole) and any information or material contained in it.

Table of Contents

1	Acknowledgements	4
2	Executive Summary	5
3	Structure of the Interim National Standards Framework	9
3.1	General approach.....	9
3.2	Definitions.....	10
4	National Natural Resource Outcomes	13
4.1	Outcomes statements.....	13
4.2	National natural resource guidelines	14
5	National Management Standards	18
5.1	Scope	18
5.2	Policies and legislation.....	18
5.3	Planning.....	18
5.4	Monitoring, evaluation, review and audit	18
5.5	Information base.....	19
5.6	Consultation	19
5.7	Management practices.....	19
5.8	National management guidelines	19
6	Regional Plan Development.....	21
6.1	Regional planning process	21
6.2	Assets	21
6.3	Types of targets	23
6.4	Socio-economic considerations.....	26
6.5	A target-setting process.....	26
7	Monitoring and Evaluation.....	31
8	Process for finalisation of standards.....	33
9	References and Further reading.....	35
9.1	Commonwealth Government	35
9.2	State Government.....	36
9.3	General literature.....	37
10	List of Abbreviations.....	40
	Appendix 1.National Salinity and Water Quality Action Plan — Background.....	41
	Appendix 2.Requirements for a National Standards Framework	45
	Appendix 3.Salinity and Water Quality — Contrasts and Links.....	47
	A3.01 Salinity	47
	A3.02 Water Quality	48
	A3.03 Material budgets.....	49
	A3.04 National standards for the provision of environmental flows	50
	Appendix 4.National Environmental Water Quality Guidelines	51
	Appendix 5.ANZECC State of Environment Core Indicators.....	52
	Appendix 6.National Principles for the Provision of Water for Ecosystems.....	53
	Appendix 7.A Process for Guidelines for Revegetation Using Perennials.....	56
	Appendix 8.Assessing the Condition of Australia’s Catchments at the National Scale ...	58

Appendix 9. Summary of Guidelines for Soil Salinity	60
Appendix 10. Risk assessment procedure for setting targets.....	65
Appendix 11. Management options for salinity and water quality	67
A11.01 Salinity control options	67
A11.02 Water quality control options.....	67

List of Figures

Figure 1. The components of the Framework and the relationships between them..	11
Figure 2. Interim protocol for formulating regional ICM plans.....	22
Figure 3. Proposed process for setting objectives and targets within regional plans and selecting a set of management options to achieve them.....	27
Figure 4. Detail of asset risk analysis in the context of target setting.....	28
Figure 5. Detail of trade-off analysis in the context of target setting.....	30
Figure 6. The 20 regions of Australia chosen as of highest priority for the National Action Plan.....	43
Figure 7. Trade-off analysis informed by risk assessment to determine priorities for action	66

List of Tables

Table 1. A selection of State of the Environment core indicators for land and inland waters that should be suitable for use in the national Action Plan.....	52
--	----

1 Acknowledgements

The project was led by a Steering Committee comprising the NRM Standards Working Group chaired by Mr S. Hunter from Environment Australia. Ms J. Tomkins of Environment Australia provided considerable input to the Framework specification and coordination of comments from a wide range of sections within EA and AFFA. The contents of the document have also benefited from consultation with state agency representatives in New South Wales, Queensland, South Australia, Western Australia and Victoria. A consortium of organisations involved in natural resource research, development and management prepared the document.

- CSIRO (Divisions: Land and Water (CLW) — Co-ordinator Dr C.J. Moran; Energy Technology (CET) — Dr G. Batley; Sustainable Ecosystems (CSE) — Dr M. Doherty; Forestry and Forest Products (CFFP) — Dr N. Marcar).
- Australian National University Centre for Resource and Environmental Studies (ANU-CRES) — Dr S. Dovers.
- Cooperative Research Centre for Catchment Hydrology (CRCCH) — Dr T. Ladson.
- Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management (CRCCZ) — Dr R. Shaw.
- Murray-Darling Basin Commission (MDBC) — Mr S. Keyworth, Ms Julie Burke.
- National Land and Water Resources Audit (NLWRA) — Mr C. Creighton.
- Bureau of Rural Sciences — Agriculture Forestry and Fisheries Australia (BRS) — Mr S. Veitch.
- University of Canberra — Dr W. Maher.
- Salient Solutions — Dr Ray Evans.
- Phil Dyson and Associates — Dr P. Dyson.
- Science Text Processors Canberra — Ann Milligan.

2 Executive Summary

This interim National Standards Framework is a central part of The National Salinity and Water Quality Action Plan (known as the National Action Plan) that was proposed in 2000 in response to Australia's poor inland water quality and worsening salinisation problems. The Framework brings together key elements of the currently available information on salinity, water quality and environmental flows.

The Framework lists the national natural resources outcomes that the National Action Plan is intended to achieve (Section 3). It discusses the need for national management standards and proposes sets of required guidelines for resource conditions and aspects of management (Sections 4&3). The Framework also proposes a process for devising regional plans which takes into account existing plans, and emphasises the need for consistent and continual monitoring and evaluation of natural resources and natural resource outcomes (Sections 5&6). Conflicts between people who may be disadvantaged in the short-term by aspects of the National Action Plan could delay the progress of the Plan. Therefore, this Framework sets out a proposal for evaluating assets that will be affected by the Plan, assessing the risks involved, and negotiating trade-offs to keep the Plan active (Section 5). Being an interim Framework, this document also lists steps that will be necessary for a final version of the National Standards Framework to be produced by December 2001 (Section 7). Eleven appendixes briefly describe salinisation and salinity guidelines, 'material budgets' for water, salt and nutrients, risk assessment, and the philosophies of recent documents concerned with water quality, environmental indices, revegetation and catchment health.

Natural resources outcomes

For natural resources, the National Action Plan aims for three outcomes. First, rivers, ecosystems and catchments need to be in sufficiently good condition to meet the needs of current and future generations. Second, industries (rural and urban) in their general practices should contribute to human and environmental well-being in both the short and long terms. Third, regional communities should be able to live with environmental amenity commensurate with that available to the majority of Australians. The National Action Plan and this National Standards Framework presume that communities, industries and investors will be working in partnership with all levels of government to achieve these national outcomes.

As stated in this Framework, it is important to restore a more natural balance between land, vegetation and water. Among many possible actions, revegetation and engineering solutions will help adjust the material budgets for water and salts above and below ground, reducing influx of water to the soil and groundwater. From another point of view, managers of rural and urban industries will need to minimise their industries' effects on surface and groundwater across Australia by intensifying

their input/output controls. To achieve the goals of the National Action Plan, industries will need to speed up their move to improved management standards, if they are not already using them. Salinity and water quality action will engender industry innovation resulting in new industries to capitalise upon opportunities.

Need for many guidelines

To achieve the national natural resources outcomes, nationally agreed guidelines are needed for determining and establishing resource condition levels. This Framework suggests that there will be guidelines for assessing and controlling water quality, salt loads in water bodies, land degradation, and engineering interventions. We cannot improve water quality, for example, unless there is sufficient monitoring of variables that indicate the quality and unless the required levels are specified. Guidelines will also be required for managing the expected volume of information and data that will be generated by monitoring and evaluation, for use in regional plans and in the overall National Action Plan. A number of appropriate sets of national or State guidelines already exist. In some cases, nationally agreed guidelines will need to be developed in consultation with State agencies, and reviewed by technical experts before December 2001.

Further guidelines are required for managing the National Action Plan itself. First, they must outline the roles and responsibilities of the various partners in the National Action Plan. Also guidelines should identify locations that can be defined as integration sites at which key measurements can be made for monitoring purposes. Guidelines will guide the preparation of regional plans such as Integrated Catchment Management (ICM) plans, and determine a process for setting regional objectives and targets.

Targets, objectives and assets

The terms 'standards', 'targets' and 'objectives' are specially defined for the National Action Plan. Standards define national natural resource outcomes (stated below) and the best management practices required to achieve them. Targets are measurable interim levels that will be achieved on the way to a regional objective at some specified time in the future. Objectives are the levels of measurable properties which, when reached, indicate that a specific regional outcome (or set of outcomes) has been achieved. Other terms that have special definitions in the Plan and Framework are 'outcomes', 'region', 'valley', 'catchment' and 'management strategies'.

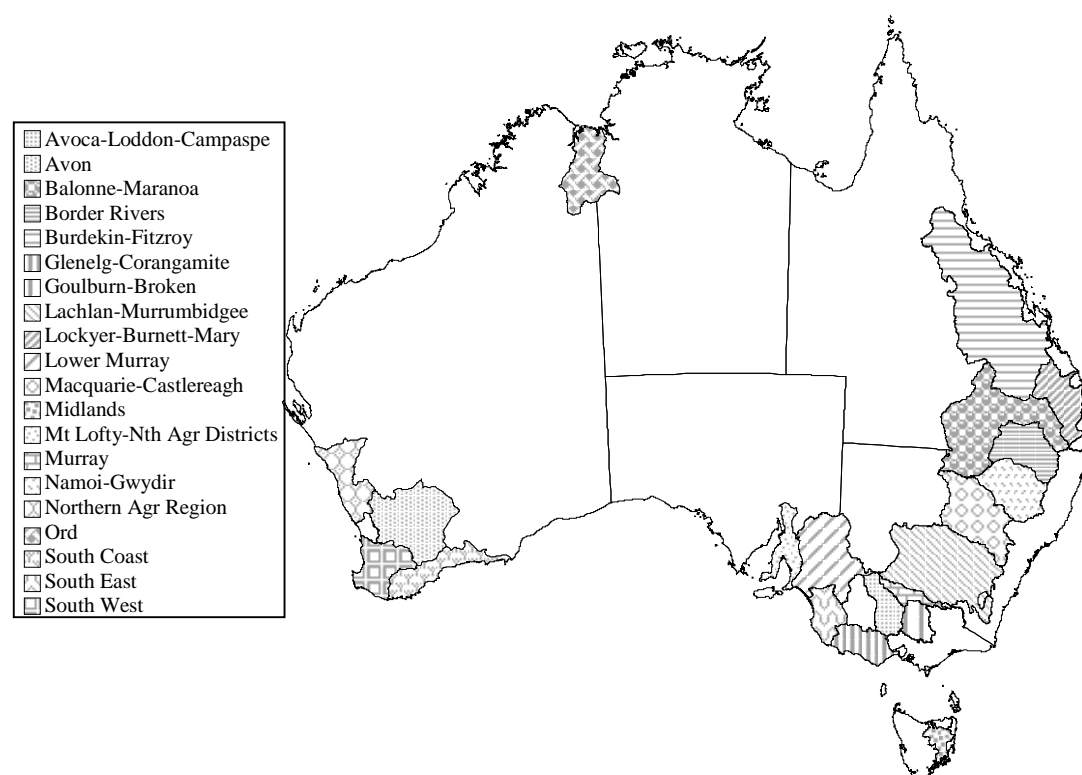
The Framework proposes a process for defining regional objectives and targets within accredited regional ICM plans. The target-setting and objective-setting process brings together a range of natural resource and socio-economic issues, so that there can be negotiation by the partners in the National Action Planning process and agreement on a set of acceptable and achievable targets.

The Framework focuses on the biophysical facets and responses of Australian salinity and water quality problems. However, the management actions and targets derived

will be entirely constrained by socio-economic feasibility and acceptability. It is important that regional planning allow the widest possible degree of community awareness of the planning process; opportunity for input and comment by all members of the community; and wide communication of outcomes of the planning process. Regional plans should seek to ensure that regional median gross farm incomes are at least maintained, and that long-term economic viability of regional industries and enterprises is improved through sustainable natural resource management practices.

At the broadest level, the assets that the National Action Plan is designed to protect are the shared biological, land and water resources of Australia. More specifically, as the Framework outlines, the assets include surface water resources for use in urban areas, industry, agriculture, and key ecosystems; groundwater resources; and land resources for conservation, production, indigenous cultural heritage, and for built or transport infrastructure.

In analysing assets and conflicts between them, the suite of potential management options available will be examined, across assets, to derive a compromise set of actions that are linked directly to the targets thus derived. Trading off against another asset may compromise the likelihood that a regional objective can be achieved and that a specific target will be reached. The extent to which trading off against another asset compromises the likelihood that a regional objective can be achieved and that a specific target will be reached must be assessed.



Map showing the 20 high priority regions identified in the National Action Plan

How long before results are seen?

Analysis suggests there are approximately 20 regions (see map above) across Australia which are high priority for action. Final details on regions to be included will be discussed with the States/Territories. It would be most effective to begin with those regions that are ready to commence detailed action planning or where investments now will avoid costly degradation.

Many natural resources may not show a clear response to changed management practices in the seven years committed for the National Action Plan. Long-term monitoring and evaluation, however, will track the expected responses through the next 50 years or so.

The immediate future

This National Standards Framework is an interim version to get the National Action Plan underway. During 2001, the Action Plan partners, working in government, industry and the community, will need to devise a procedure for collaboration and negotiation. They must arrange for the drafting of the necessary guidelines, as listed above, and identify techniques for assessing salinity and water quality targets, and make an indicative list of assets and their values.

The interim Framework will have to be tested in at least one region to develop it sufficiently that it can effectively fulfil its appointed role in the National Action Plan. Monitoring schemes that are appropriate for long-term assessments will have to be set up. Once all this is operative, the structure and definitions of the Framework can be finalised and a nationally collaborative effort to move towards improving Australia's water quality and salinity problems can proceed.

3 Structure of the Interim National Standards Framework

3.1 General approach

The interim National Standards Framework will incorporate, where possible, Australian Standard environmental risk management principles. It will address national natural resources condition outcomes including management standards where these relate closely to biophysical outcomes.

The general approach of the interim National Standards Framework is to bring together key elements of the currently available information on salinity, water quality and environmental flows. Extracts from the National Action Plan and Draft Inter Governmental Agreements provide background to the interim National Standards Framework (Appendix 1). The specifications of the requirements for the interim National Standards Framework are given in Appendix 2. The components of the Framework and the relationships between them are shown in Figure 1.

There are several central sources of information: the national Water Quality Guidelines (ANZECC, 1992; ANZECC/ARMCANZ, 2000a), reports by the Murray-Darling Basin Commission (MDBC), and State policy and action documentation, combined with the Australian dryland salinity and water resources assessments (NLWRA, 2001a,b) made during the National Land and Water Resources Audit (NLWRA). For environmental flows the Framework is based on the National Principles for the Provision of Water for Ecosystems (Appendix 6). The ANZECC Core Environmental Indicators for Reporting on the State of the Environment (Appendix 5; ANZECC, 2000) are to be used as the preferred indicators wherever possible.

Management of salinity and water quality involves difficult trade-offs because there are complex interactions between natural and human resources. The timescales at which natural resources respond to changed human behaviour may be longer than the lifetimes of those who implement the changes. In some cases, engineering solutions will be the only feasible approach for protecting assets. In other cases, new industries will be required if enterprises are to be viable in the long term. A successful National Action Plan for salinity will recognise that targeted investment will provide the best returns. Investment will support a mixture between 'business as usual', realignment of current practices, engineering solutions, new industries and admission that some damage is not amenable to repair.

As outlined in Figure 1, the interim National Standards Framework describes the intended national outcomes (see Section 3) and associated guidelines that are needed to give an overall contextual focus for the National Action Plan. At the State level the governmental responsibilities and inter-jurisdictional agreements are a mandate for certain objectives to be set to meet the necessary outcomes. Local government and regional management bodies, e.g. catchment management organisations of various

types, introduce local imperatives and community aspirations and needs. Cutting across this hierarchy are industries, with their need for profits within the constraint of maintaining, and where possible improving, ecological function. Spatially, the first division is between the regions that are declared high priority by the National Action Plan (Figure 6)¹. The next is the catchments within each of those regions and within them the various biophysical, institutional and human assets each of which can be ascribed a value (some may be considered irreplaceable, e.g. a particular region of significant biodiversity).

In the National Action Plan it is intended that these multiple outcomes will be achieved through action undertaken as a partnership between Commonwealth, State and local governments and regional institutions and communities. Funding will be equally shared between Commonwealth and State governments. The National Action Plan is silent on the role of industry from the point of view of funding and joining action.

Appendix 3 discusses the biophysical aspects of salinity and water quality and outlines some contrasts in the ways these issues have been handled to date. A conceptual model commonly used in ecology, namely a material budget, is proposed as the basis on which to manage salinity and water quality problems. This approach is, consequently, proposed as a biophysical basis for the National Action Plan.

3.2 Definitions

Standards define national natural resource outcomes (stated below) and the best management practices required to achieve them. National best management practice standards identify the governance, institutional, policy and legislative requirements for meeting the national outcomes.

Outcomes are statements of the natural resource conditions desired and are generally qualitative, e.g. rivers within a region sufficiently ecologically healthy to support a native fish population, soil that can continue to support intensive cereal production, agricultural industries to support following generations. The Framework focuses on outcomes at the national and regional levels.

Objectives are the levels of measurable properties which, when reached, indicate that a specific regional outcome (or set of outcomes) has been achieved: e.g. soil pH >5.5; river salinity at a defined point in the river <700 EC. The Framework focuses on objectives at the regional level.

¹ For the Murray-Darling Basin, effort will be required to assess the effects of excluding parts of the Basin from the National Action Plan. This is important where regions that contribute to the Morgan target are not included in the National Action Plan.

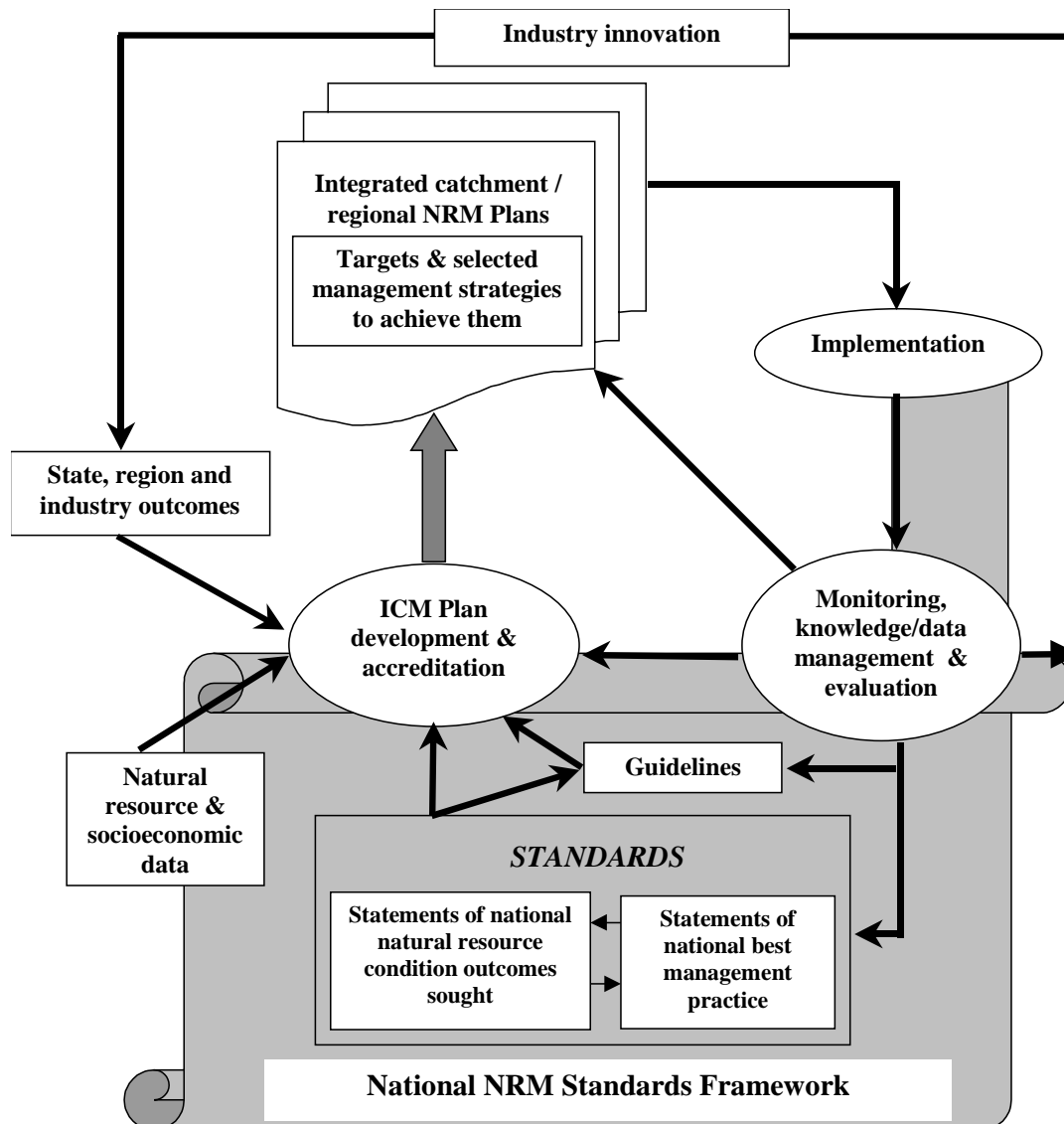


Figure 1. The components of the Framework and the relationships between them

Targets are measurable quantities which set a level towards achieving a regional objective at some specified time in the future, e.g. river salinity <800 EC by 2005; <850 EC by 2010; <800 EC by 2015; <700 EC by 2020 (in comparison to the example above the regional objective is reached by 2020 acknowledging a series of target levels between now and 2020). Targets are set within a region in the development of an Integrated Catchment Management (ICM) Plan. Targets are set using the national and regional outcomes as boundary conditions. A variety of targets can be used including levels in waterways, areas of land, species abundance, biological community outputs, groundwater depth. The National Action Plan emphasises targets associated with biophysical properties; no specific socio-economic

targets are set. Under the National Action Plan, Integrated Catchment Management Plans are assessed against whether targets are being achieved through a monitoring and evaluation scheme.

Management strategies are the land and water management actions that are implemented to achieve a specified target: e.g. fencing of riparian areas to prevent stock having general access to rivers; groundwater pumping; oxygenation of weirs; planting of recharge areas to perennials.

A *region* is an area identified under the National Action Plan as requiring priority attention for salinity or water quality action. Twenty regions have been identified (Figure 6). Regions are an aggregation of catchments (see definition below).

A *valley* is a more-or-less linear depression in the landscape through which surface and subsurface water drains. A *catchment* is the total area from which water drains to specific point in a river or other waterbody. Valleys are the parts of catchments that carry the majority of runoff and thus are the central concern of the strategy. In the National Action Plan the term valley has been used in the context of 'end-of-valley targets'. It is preferred that the term valley be restricted to this use and the term catchment be used to refer to a landscape unit within a region.

The term 'national water quality guidelines' (NWQG) refers specifically to the ANZECC/ARMCANZ (2000a) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.

In the NWQG, *trigger values* are the concentrations (or loads) of the key performance indicators measured for the ecosystem, below (or above) which there exists a low risk that adverse biological or ecological effects will occur. They indicate a risk of impact if exceeded and should trigger some action, either further ecosystem-specific investigations or implementation of management or remedial actions.

4 National Natural Resource Outcomes

4.1 Outcomes statements

Consistent with the goal of the National Strategy for Ecologically Sustainable Development (COA, 1992), the National Action Plan seeks to improve the total quality of life for Australians, both now and in the future, through management action on salinity and water quality. Three national outcomes are sought for natural resources.

1. The first outcome is rivers, ecosystems and catchments that are in sufficiently good condition to meet the needs of current and future generations. We will need to:
 - provide land and water for natural ecosystems, and for production, consumption and recreation. This will require reduction in trends of declining water quality; land management action to minimise flow-on effects to waterways; a halt to or slowing of the rate of land degradation; and, where practical, recovery, rehabilitation and management of degraded land;
 supported by:
 - maintenance or enhancement of the integrity and diversity of soils, water, flora and fauna (native and introduced) and provision of water quality and quantity sufficient to support natural processes.
2. The second outcome is industries that contribute to human and environmental well-being in both the short and long terms. Such industries will need to be innovative, competitive and profitable and will use natural resources in ways that generate wealth while safeguarding the welfare of future generations. It is accepted that this involves change in ecological systems. However, the maintenance of resource condition, and its improvement, where possible, remain primary goals.
3. The third outcome is regional communities that reflect the synergy of good environmental and industry conditions and that are provided with services commensurate with those provided to the majority of Australians. Such communities will be characterised by their participation in decision-making and management of the natural resources in a way that improves total quality of life both now and in the future.

In relation to the first national outcome above, Australia will need to move towards a patchwork of land uses and land management practices which:

- do not increase current levels of recharge to the groundwater systems, and which ultimately reduce recharge where necessary;
- maintain or reduce existing rates of sediment, nutrient and contaminant delivery to waterways;

- preserve the necessary natural resources, biological diversity and natural resource features of beauty, intrinsic and functional value.

In relation to the second national outcome above, some existing rural industries will have to find strategies to become more efficient. For example, some of them will need to equal or increase production using less land and/or water while maintaining or decreasing undesirable consequences, i.e. intensification with closer input/output controls. In other cases, a required outcome will be the generation of new industries.

4.2 National natural resource guidelines

To achieve the national natural resources outcomes, nationally agreed guidelines will be needed for establishing resource condition levels as a basis for regional objectives (and therefore targets). A number of such guidelines are already available:

- National Water Quality Management Strategy guidelines, such as the revised national Water Quality Guidelines (see Appendix 4) and the new Monitoring and Reporting Guidelines (ANZECC/ARMCANZ 2000b);
- MDBC strategies for ICM and salinity (see bibliography);
- State salinity strategies (see bibliography);
- SOE Core Indicators (Appendix 5 and bibliography), NLWRA indicators and other national initiatives;
- National Principles for Provision of Water for Ecosystems (Appendix 6);
- ANZECC National Framework for the Management and Monitoring of Australia's Native Vegetation;
- National Land and Water Resources Audit resource assessments (e.g. NLWRA 2001a,b);
- river health, e.g. AUSRIVAS (Coysh et al., 2000);
- identification of matters of national environmental significance under the Environment Protection and Biodiversity Conservation Act.

Guidelines will also be required for the management of information and data for regional plans and the overall National Action Plan. The partners will need to ensure that comprehensive data and information are readily available to underpin priority setting, implementation, monitoring, evaluation and reporting.

In some cases, nationally-agreed guidelines will need to be developed in consultation with State agencies, and reviewed by technical experts by December 2001. A number of guideline requirements are listed below.

4.2.1 *Water Quality Control*

A standard method for assessment of river condition is required against which changes due to management interventions from the National Action Plan can be measured. General indicators such as this help in the evaluation process to ascertain

whether beneficial change is occurring. It is not intended that targets be set for them. It is proposed that the NLWRA Australian River Condition method in combination with AUSRIVAS data be assessed as a starting point for development of national guidelines².

Currently, guidelines do not exist for the management of terrestrial systems in so far as they directly affect water quality. It is proposed here that sets of guidelines be agreed for:

1. the acceptable proportional change in soil nitrogen and total phosphorus beyond a background value associated with the local soil type and its likely transport into waterways. This would ensure that phosphorus delivered to streams through soil erosion is not further augmented through poor fertiliser application practice or industry practice, e.g. wastewater concentration. This would also contribute to the goal of improving economic return from fertiliser application. Further, it could ensure that soil fertility is maintained at minimum levels. In some areas, control over soil nitrogen levels would also assist with mitigation of soil acidity.
2. vegetation clearing where it is likely to lead to an increase in sediment and nutrient transport to waterbodies.

4.2.2 Controlling rise in salt loads

To control the rise of salt loads in water bodies and, through that, to protect the water resources and aquatic ecosystems, agreement is needed on maximum (or minimum) levels of salinity that are considered adequate to protect the aquatic ecosystems. Guidelines are required for assessing groundwater recharge and salt distribution in surface soils across any regional planning unit. To bring these concepts together, it will be necessary to develop guidelines for correlating waterway salt concentrations with the estimates of recharge and the likelihood that surface water and groundwater will intercept salt in their paths to waterways.

A great deal of information is available on the effects of agroforestry and the planting of perennials and trees in high, medium and low rainfall areas. This information requires collation into guidelines to assist in regional plan development. The scope of this exercise is outlined in Appendix 7.

4.2.3 Controlling land degradation

The national outcomes require that land degradation be controlled and reversed, and that important terrestrial ecosystems, productive farmland, cultural heritage, and built

² Victoria DNRE has developed a river condition index that is being used to assess condition. Following completion of the NLWRA work, a project should compare these indices to assess whether an acceptable conversion is possible between them. Similarly, the MDBC is planning a sustainable rivers audit that will develop the NLWRA indices to derive a set of operational monitoring indices. It is possible that this method could be later adopted through adaptive response of the National Action Plan Framework.

infrastructure be protected. Guidelines for assessing terrestrial systems are less well developed than for aquatic systems. Therefore, more work will be required to develop guidelines in the areas listed here.

1. Assessment of catchment health: General indicators such as this help in the evaluation process to ascertain whether beneficial change is occurring. It is not intended that targets be set for them Appendix 8 provides a summary of the current method for assessment under the NLWRA. The Appendix is presented as a starting point for discussion rather than as a proposed guideline.
2. Guidelines for soil salinity: draft guidelines are proposed in Appendix 9, as a beginning for guideline development by December 2001.
3. The national Water Quality Guidelines (ANZECC/ARMCANZ 2000a) provide appropriate levels that should offer protection against soil structural decline due to salinity and sodicity in irrigation water.
4. The NWQG document provides levels for salinity and sodicity for maintenance of plant productivity, and major ion constraints for livestock productivity.
5. Acceptable concentrations of nitrogen: ideally, guidelines could set out the maximum acceptable concentrations of nitrogen down the soil profiles for specific soil types, to minimise acidification, and effective methods and schedules for measuring them.
6. Leakage rates of nitrogen and phosphorus from farmland that is hydrologically above important native vegetation: the vegetation may be degraded by excess of these nutrients.
7. A national register of important terrestrial ecosystems is needed, e.g. wetlands, wildlife and seed banks, spectacular natural areas, world heritage areas, etc.
8. A national register of regions of cultural significance is needed, that ranks them according to the extent to which salinity or water quality issues compromise their cultural significance.
9. For 7 and 8 (above) it is equally important to record any ecosystems or regions of cultural significance that depend on saline or other natural water quality conditions.
10. To provide viable options for living with saline land, guidelines are required for revegetation options that are directed to land rehabilitation as opposed to recharge control. Such guidelines also need to help with assessment of land that is best left alone.

4.2.4 Engineering intervention

Guidelines are required which specify the major types of engineering interventions available and the situations under which they are most likely to be effective. The period over which engineering structures are likely to be effective should be included. Such guidelines should also consider the cost of the installation and maintenance.

5 National Management Standards

5.1 Scope

Government decision-making processes regarding natural resources management should be comprehensive and integrated (covering land, water, vegetation, soils, biodiversity, people).

Natural resources management needs to be considered as part of all major investment decisions and decision-making processes in all regions.

5.2 Policies and legislation

The details for policies and legislation concerning national management standards will be drawn from the Governance Working Group. Planning and decision-making, and accountability for decision and delivery of policy and program outcomes, should be clear and public.

Each jurisdiction should have legislation and policies that set out the policy, principles and process relating to:

- water quality management (based on the NWQG);
- land clearing (which meet the principles set out in the National Framework for the Management and Monitoring of Australia's Native Vegetation);
- water flows and allocation (consistent with COAG Water Reforms, National Principles for the Provision of Water for Ecosystems);
- soil conservation?
- etc.

5.3 Planning

Regional ICM planning processes should meet Accreditation Criteria and be consistent with recommended processes for development.

Planning processes for water quality issues should draw on draft National Standards for Coastal Water Quality Protection Plans.

5.4 Monitoring, evaluation, review and audit

The National Action Plan should be implemented in a way that allows performance to be assessed, through establishing criteria and mechanisms for review, feedback and continual improvement (internal/external and periodically). A detailed process for monitoring and feedback including responsibility for actions and timing requires further development. As a starting point, see the new Monitoring and Reporting

Guidelines, the *Australian Guidelines for Water Quality Monitoring and Reporting* (ANZECC/ARMCANZ 2000b).

5.5 Information base

Scientific knowledge should be the basis for planning and decision-making for preventing degradation and contributing to environmental repair or sustainability. However, lack of full scientific certainty should not be used as a reason for postponing action that could prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by:

- careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment;
- an assessment of the risk-weighted consequences of various options; and
- compliance and enforcement mechanisms.

Mechanisms should be established for assessing the adequacy of information for decision-making processes and its availability (e.g. inventory of assets, link between management, actions and outcomes, scientific/peer review). As new scientific information becomes available, there should be provision to periodically review practices, priorities and activities to achieve natural resource management outcomes.

Information management mechanisms should be established to ensure the availability of information for decision-makers and stakeholders.

5.6 Consultation

Adequate and appropriate consultation arrangements should exist between governments, community and other stakeholders.

5.7 Management practices

UNCED Agenda 21 obliges Australia, as a signatory, to encourage and assist government/business/industry to adopt codes of conduct which promote best environmental practice, and to report annually on their environmental record. A national standard to reflect this could be the following:

Industries and enterprises involved in NRM should develop and implement codes of best management practice and should be encouraged to adopt ISO 14001 series EMS standards.

5.8 National management guidelines

A range of guidelines is required for management of the National Action Plan.

1. Guidelines are needed that describe standard catchments. Each State should supply a spatial coverage of their breakup of the National Action Plan regions in that State, for consolidation to form a national standard set.

OR

1. Guidelines are needed that define the catchments as determined by the NLWRA. It is proposed that maps be made of these catchments, using the most recent nine second resolution digital elevation model of Australia. The maps will be the basis from which to define the valleys that will be the physical units for end-of-valley target-setting.
2. Guidelines should outline the roles and responsibilities of the various partners in the National Action Plan, e.g. resourcing, legislative frameworks, incentives, action, monitoring, data acquisition and information/data management systems.
3. Guidelines should identify locations suitable for being defined as integration locations for monitoring purposes. In the Murray-Darling documentation these relate to the end-of-valley targets. However, in other regions, alternative definitions will be required, particularly where the relief is low and rivers discharge into the landscape, e.g. into chains of ponds or wetlands, rather than into another catchment or estuary.
4. Guidelines need to be derived for local monitoring for water quality (see ANZECC/ARMCANZ 2000b). The local guidelines should identify the monitoring sites, the necessary infrastructure, the required accuracy and precision of monitoring data, and the information management requirements needed for ascertaining the impact of specific management interventions implemented under the National Action Plan.
5. Guidelines or a protocol are needed for regional plan preparation (see Section 6.1 for a proposed draft) and in association with them, guidelines for a process for regional objective-setting and target-setting.
6. Guidelines are needed so that an information infrastructure context can be identified (e.g. existing State databases) or established, consistent with current national and international standards (see ANZECC/ARMCANZ 2000b). New standards may be required where none currently exist. Such standards will need to be applied to:
 - (a) data management standards,
 - (b) monitoring standards, i.e. for precision, temporal scale and spatial distribution,
 - (c) reporting.

6 Regional Plan Development

6.1 Regional planning process

A process is set out for defining regional objectives and targets within accredited regional ICM plans. This is a preliminary approach that will require testing and adaptation before it is applied generally. The proposed planning process is derived from the draft National Standards for Coastal Water Quality Protection Plans.

In particular, State planning processes and broader considerations, such as MDBC initiatives, will need to be dealt with case-by-case because of the lack of generality across jurisdictions. The Accreditation Working Group will provide guidelines for bringing together the various existing planning processes to form a regional overview plan that can be accredited under the National Action Plan. The regional planning process ideally will be conducted as a partnership between the local, State and federal governments with the regional communities.

The regional plan development process as outlined in Figure 2 is an interim National Management Standard.

6.2 Assets

At the broadest level, the assets that the National Action Plan is designed to protect are the shared biological, land and water resources of Australia. More specifically within any given catchment the assets include:

- surface water resources for urban/industrial and irrigation use (i.e. reaches of streams and rivers and water storages essential for the viability of large urban/industrial centres and major irrigation areas, and for which no alternative water supplies of sufficient quantity and quality are available);
- surface water resources for maintaining key ecosystems and aquatic nature conservation areas, and for preserving rare or endangered species dependent on these (e.g. Ramsar-listed and priority wetlands);
- nationally and internationally significant terrestrial nature conservation areas and other areas that preserve key ecosystems, and rare or endangered species (e.g. national parks and nature reserves);
- productive farming lands — specifically irrigation areas and soils of high capability for sustainable dryland farm production in more reliable rainfall areas;
- productive grazing lands;
- indigenous cultural heritage items protected by State or Commonwealth legislation (e.g. middens, artefacts and sites of indigenous cultural significance);

1. Identify any NRM plans extant for the region
2. Identify the spatial extent to which the plan applies and the assets under consideration.
 - a. Delineation of the catchment (valleys) and waterways to which the plan applies and the activities that contribute to terrestrial asset and water quality conditions.
 - b. Identify the land and water assets within the catchment (State plans and processes to be combined with National outcomes standards).
 - c. Assess the value of each asset identified in (2b).
3. Assess the threats to and opportunities for land and water assets and establish interim regional objectives and targets.
 - a. Identify the pollutants/materials that constitute a threat to each asset (within- and out-of-catchment).
 - b. Determine the sensitivity of each asset to the threatening materials (use of existing or new guidelines as necessary);
 - c. Identify, for assets with areal extent, the maximum acceptable extent (incorporating seasonality) and how this differs from the current extent.
 - d. Identify, for waterways, the maximum acceptable contaminant concentrations and loads required to achieve and maintain water quality (including seasonal flow conditions and ecological responses and tolerances) and how this differs from the current condition;
 - e. Identify the constituent point and diffuse source contributions to assets requiring protection;
 - f. Allow for necessary future growth.
 - g. Establish the regional objective for each asset and interim targets initially over a 10 year timeframe.
4. Establish regional objectives and targets using the interim targets by analysing the priorities for trade-offs.
 - a. Estimate the time required to attain and maintain regional objectives and the basis for that estimate;
 - b. Describe the control actions and/or management measures which will be implemented to achieve the source contributions, for all sources by category or subcategory of activity;
 - c. Set out a timeline for implementing the control and/or management actions including a schedule for revising the regulatory and management arrangements;
5. Specify an information management plan.
 - a. State the accuracy and certainty of pollutant and objectives estimates and the requirements for monitoring and modelling.
 - b. State the data and information resources required: their custodians, quality, currency, comprehensiveness and accessibility.
 - c. Define the long term management arrangements for new data and information generated through development and implementation of the plan.
6. Set out an evaluation, reporting and monitoring scheme.
 - a. Assign responsibilities for various aspects of monitoring (including consideration of community-based monitoring, e.g., Waterwatch);
 - b. Agree on a process to check that the plan is implemented as agreed;
 - c. Determine, where possible, if natural resource changes can be attributed to management actions, *i.e.*, whether biophysical targets are being met;
 - d. Adaptively manage the planning process, *i.e.*, check whether the standards, objectives and targets require resetting in the light of new technical methods or data, or feedback that the region is not responding to management action as projected at the outset;
 - e. State the process and timing for revising the plan.
7. State the strategies for the maintenance of effort over time acknowledging the National Action Plan is initially for only 7 years but the response times for many actions will be much longer.
8. Identify participants responsible for implementing and resourcing the various actions.

Figure 2. Interim protocol for formulating regional ICM plans

- important built infrastructure (including urban heritage buildings, transport infrastructure) and public and corporate utility infrastructure which would be significantly adversely affected by rising water tables and salinity; and
- items of national environmental significance under the Environment Protection and Biodiversity Conservation Act (Ramsar wetlands of international significance, nationally threatened species and communities, migratory species, World Heritage properties), the protection of which is a key reason for the Commonwealth to provide public funding for land and water management activities.

6.3 Types of targets

A fundamental part of developing regional plans_(Figure 1) is the setting of regional objectives and targets.

Targets themselves are not the outcomes sought. They are a way of measuring progress towards achieving the regional objectives set out under the National Action Plan and brought together from other existing ICM planning processes and plans.

Targets can have both spatial and temporal aspects as indicated by the examples given in the definition (Section 3.2). The Framework emphasises three target types: namely, integrative, e.g. end-of-valley, terminating lake system, local reservoir; catchment contribution, e.g. proportion of national habitat for a given species; within-catchment, e.g. rural reservoir salinity level.

- (i) Integrative targets: it is desirable to monitor the combined integrative effects of landscape processes as shown by the levels of appropriate targets in a suitable integrator. An example of an ‘integrative target’ is the end-of-valley target adopted by the Murray-Darling Basin Council for assessing Murray-Darling Basin river salinity trends (MDBMC, 2000a). In many cases, a river is a suitable integrator of catchment processes because of the accumulating nature of water flow to and through it. However, in some cases rivers are not the appropriate or practical integrative features; examples include chains of ponds, wetlands and discharge areas (e.g. Bui et al., 1996; Bui and Moran, 2000) lying in low landscape positions and/or on impermeable soil.
- (ii) Catchment contribution targets: catchments have a spatial context within which they sit. This begins with the surrounding region, extends to the continent and eventually the world. There are a number of assets (Section 6.2) that require targets for which this context must be considered. In such cases targets will be the *contribution* from a given catchment to the objective (and targets) over a broader domain. These are referred to as ‘catchment contribution targets’. A clear and agreed existing example is the interim river salinity target at Morgan in the Murray-Darling Basin. Other examples of targets that contribute to national or international objectives include preservation of habitat niches and internationally significant wetlands, contributions to carbon sequestration quantities, and recharge contributions to regional groundwater aquifers.

(iii) Within-catchment targets: assets that are important within a catchment and which require protection or restoration can be identified (Section 6.2). Targets will be required for these assets. Examples include rural drinking water reservoirs, habitat niches, town and road infrastructure, remnant (and more extensive) native vegetation, wetlands, ecological communities (and components thereof). For some degraded areas, alternative uses will need to be found and implemented, e.g. for saline seeps and scalds, and targets will be needed for assessing their success. These are referred to as ‘within-catchment targets’.

Integrative targets, catchment contribution targets and within-catchment targets will be required in a number of different forms, namely biophysical, ecosystem function, groundwater, and intrinsic values.

6.3.1 *Biophysical targets*

Biophysical targets are a statement of the expected (or desired) change in a component of a material budget over a given period of time. An introduction to material budgets is given in Appendix 3. Simply stated, they are balance sheets of materials entering and leaving a system. It is possible to use carbon material budgets to link water, salt, sediment, contaminant and nutrient material budgets. This provides a simple mechanism through which loads and concentrations can be expressed.

Our ability to precisely measure and model material budgets is continually improving. Lack of complete knowledge about a material budget does not negate its value as a conceptual and operational framework for trading off the various salinity and water quality threats to assets. A significant benefit from the adaptive management approach proposed in this Framework is that there is likely to be gradual improvement in the estimation of material budgets, as techniques for modelling improve and, most importantly, as data from monitoring the specific catchments become available.

In the majority of cases, seven years of data will be insufficient to show if there has been a definite biophysical response to a given action. Therefore, it will be important to link the targets, based on material budgets, to a predictive/explanatory modelling exercise and to continuous modelling of real levels over time.

6.3.2 *Ecosystem Function (Functional Biodiversity) targets*

Much effort has been expended in recent years attempting to quantify the functional role of biodiversity. Research effort has centered on whether greater numbers of species or greater complexity in communities leads to greater productivity and ‘stability’. The research results are equivocal at best and are often contradictory, but what has emerged is the concept that sustainable natural or agricultural systems need some degree of functional redundancy in their species complement. This ensures that under a variety of disturbance regimes or changes of physical inputs, productivity and other functions can be retained, because species with equivalent functions take over. This may apply seasonally or in response to human-induced disturbance. Clearly, the more species and habitat that are lost from an area, the greater the risk of loss of ecosystem function and hence sustainability. The way that organisms interact with

their environment forms part of the material budgets of natural and agricultural systems, and hence functional biodiversity targets can be assessed in terms of their contributions to material budgets.

The broader benefits derived from systems that retain their functional diversity can be categorised as ‘ecosystem services’ and this term covers such areas as regulation of river flows and groundwater levels, water filtration, prevention of soil erosion, pollination and pest control. However, this functional role of biodiversity will be difficult to quantify into meaningful targets because we will often require near-complete local and regional assemblages of organisms to achieve sustainable systems with high levels of functional redundancy. Yet this type of target is integral to the landscape and will need to be addressed across a variety of spatial and temporal scales.

6.3.3 *Groundwater targets*

Groundwater targets will be required for assessment of the quantity and quality of groundwater and the extent to which the needs of groundwater-dependent ecosystems are being met. The nature of the groundwater system (local, intermediate or regional) (see Appendix 3) will determine whether a target for water table depth is ‘within-catchment’ or ‘catchment contribution’. A distinct difficulty with groundwater targets is the lack of large-scale (detailed) hydrogeological mapping. However, as with the use of material budgets, the National Action Plan states that lack of full scientific certainty will not be taken as a barrier to implementation of ‘best bet’ actions. Targets associated with water table depth are also determined by approximating the water budget as well as possible. Even empirical analyses from bore data should use a mass balance approach to assess trends.

6.3.4 *Intrinsic value targets*

‘Intrinsic value targets’ are a significant type of target that must also be addressed; examples include rare geological or geomorphic features, sites of cultural significance and rare and endangered species and communities. Targets relating to intrinsic values must also address the concept of the representativeness of plant and animal communities in regions, using approaches such as complementarity analysis, because the preservation of biodiversity (both functional and intrinsic) is given high priority in the statement of national outcomes (Section 4.1). It is expected that there will be some overlap with the State and regional outcomes desired. Varying levels of targets of pre-1750 vegetation communities, plant species and animal species were set during the recent round of Regional Forest Agreements (RFA) using the JANIS criteria. These were specifically designed for the formation of a minimum Comprehensive Adequate and Representative (CAR) reserve network, rather than for achieving fully integrated biodiversity conservation across the entire landscape. Importantly, the target setting used for the RFA process relied on complementary management of those areas that were not formally reserved. However, the Comprehensive Regional Assessment (CRA) process which fed data into the RFA process may provide a sound model for the assessment of and target setting for other local and regional areas.

Plans should identify and be at least consistent with existing or draft laws, policies and management plans dealing with cultural heritage, wildlife protection, nature conservation and biodiversity. Where possible, plans should seek to be synergistic with and enhance the effectiveness of such other resource and environmental programs.

6.4 Socio-economic considerations

Institutional and socio-economic targets have been explicitly omitted from this Framework because they are considered neither useful to the National Action Plan nor necessarily achievable. However, some broad socio-economic considerations provide a useful backdrop and set of constraints for the target setting procedure.

- Regional planning should allow the widest possible degree of community awareness of the planning process; opportunity for input and comment by all members of the community; and wide communication of outcomes of the planning process. Through this, regional planning will expand and enhance the information base accessible to the regional community and available for improving resource management.
- Regional plans should seek to ensure that regional median gross farm incomes are at least maintained, and that long-term economic viability of regional industries and enterprises is improved through sustainable natural resource management practices.
- Non-economic and quality of life values should, where possible, be enhanced through regional plans and the planning process (e.g. community networks and viability, indigenous culture, information resources, etc.).
- Plans will identify the costs and benefits (financial, other) of management strategies and will seek to ensure equitable sharing of these amongst stakeholders. As a general principle, the beneficiary or beneficiaries of strategies or investments would be expected to share a significant proportion of the costs. However, this may be difficult to calculate in cases where benefits will only accrue in the long term, where there is considerable uncertainty, or where there is a mixture of public and private benefits.
- Regional planning processes and plans will identify and seek coordination with other regional planning processes, so as to maximise effectiveness across different sectors e.g. economic, social, infrastructure, employment.

6.5 A target-setting process

The target- and objective-setting process brings together a range of natural resource and socio-economic issues, so that there can be negotiation and agreement on a set of acceptable and achievable targets. Targets are set by the partners in the planning process, as set out in Section 3.1. The National Action Plan proposes that the

negotiators be assisted by a group (or groups) of technical experts (salinity response teams).

This Framework proposes a process for defining regional objectives and targets within accredited regional ICM plans (Figure 3). The target setting process is supported by knowledge and biophysical and socio-economic data management protocols. An assessment of the regional context is needed which includes identification of the regional outcomes sought and the regional resource condition. Local industry goals or requirements and opportunities for development are taken into account at this stage. An assessment of risks to assets (and opportunities for their development) and their values is used to derive a set of interim regional objectives and targets. Interim targets are fine-tuned using a more thorough analysis in which trade-offs between issues are assigned priorities according to their socio-economic acceptability and feasibility, and this leads to selection of a set of actions for land and water management. Both these processes refer back to the national natural resource outcomes through the negotiation of objectives and targets.

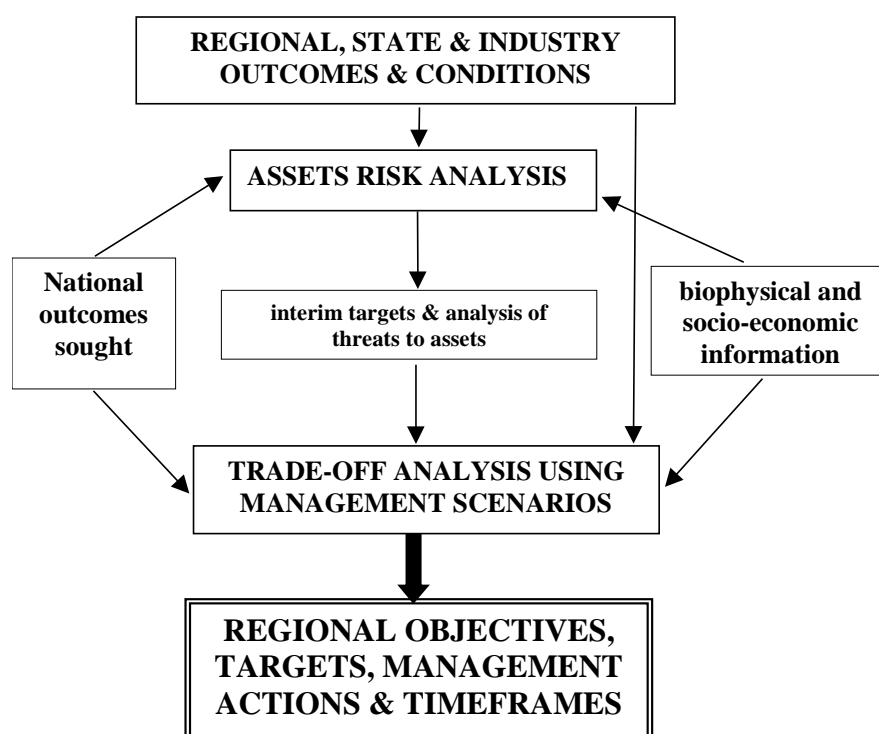


Figure 3. Proposed process for setting objectives and targets within regional plans and selecting a set of management options to achieve them

6.5.1 Context

A range of inputs can be brought to bear upon target setting. At the highest (aspirational) level the outcomes sought from national, State and regional perspectives provide context. The regional biophysical and geographic settings determine what is possible from a background condition. The background condition may be the natural

state or some other defined reference condition. The reference condition is used, in conjunction with guidelines, to determine regional objectives. Estimates are made for continuing ‘as is’ (i.e. ‘business as usual’). This provides an assessment of how far the environment is away from a desired condition and at what rate it is moving. It thereby indicates those assets that are potentially under threat and where opportunities might lie. The biophysical conditions thus determined include productivity estimates and therefore allow estimates of local economic conditions (with the necessary assumptions regarding markets).

6.5.2 Asset risk analysis

After the regional context has been assessed, the risks to assets need to be analysed.

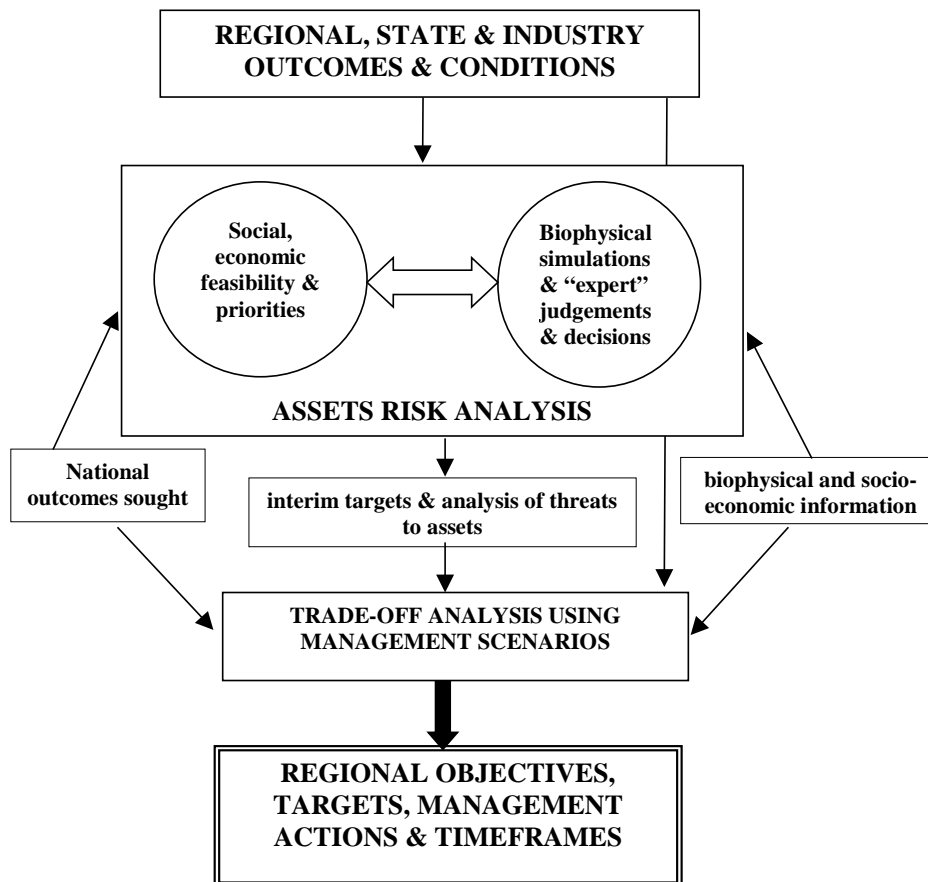


Figure 4. Detail of asset risk analysis in the context of target setting

The negotiating partners will assess the risk posed to (and opportunities presented by) the assets within the catchment as a result of an ‘as is’ situation (Figure 4). This requires an inventory of the assets to ensure that those assets indirectly affected by changes in the environment are considered. Any catchment contribution constraints must also be considered. A qualitative risk assessment, similar to that adopted by Emergency Management Australia, is proposed (EMA, 2000). In this assessment, the likelihood of each asset being threatened is examined against the consequence of the

threat, to determine the level of risk posed to the asset (Appendix 10). The number of categories and their detailed definitions should be part of the work required to establish the guidelines by December 2001. Interim targets are determined by making a first pass biophysical and socio-economic assessment of what would happen if the environment were shifted into acceptable levels for the assets under consideration. Broad management options are considered only, and cost estimates are approximate.

The national standards will be used to guide the statement of level of risk in a fashion parallel to the NWQG decision tree process. The target required will then depend on the value of the asset and the level of risk. Appendix 10 gives an example of how this might be carried out. While there is not a complete dichotomy, the level of risk is more heavily weighted to the biophysical information, and the ascribed value and industry opportunities are derived more from the socio-economic analysis. **In this way, all action is taken with reference to the biophysical system and is entirely constrained by what is socio-economically acceptable and feasible.**

6.5.3 Trade-off analysis

The asset risk analysis will be the basis of a set of interim targets. The next stage will be to analyse the extent to which:

- specific management options are available to achieve the interim targets; and
- targets associated with various assets are potentially in conflict, either because mutually exclusive biophysical results are to be attempted or because two options have a social or economic conflict. In either case, a trade-off prioritisation analysis and negotiation are required.

Next, there must be a more detailed assessment of the threats posed to assets when other assets, potentially of higher priority, must be protected (Figure 5). A qualitative risk analysis (Appendix 10) similar to that performed for asset risk analysis is proposed. The constraints placed by the outcomes sought at various levels (biophysical and socio-economic) must also bound the trade-off negotiations.

It is envisaged that the negotiations will be between people rather than through a formal optimisation or decision support system. It is not clear how much assistance can come from decision support tools for such situations. Further discussion is required. Many tools are available, of varying complexity and quality.

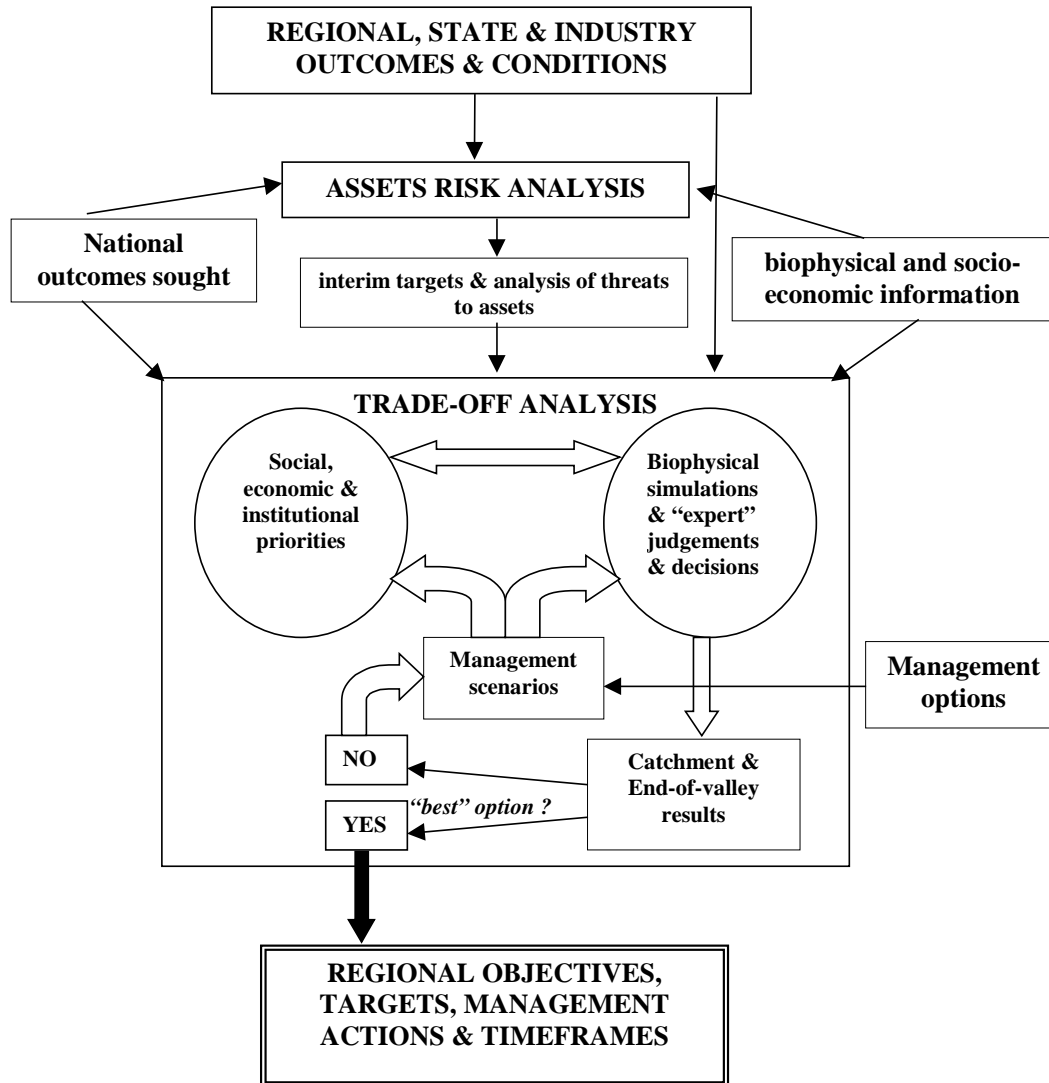


Figure 5. Detail of trade-off analysis in the context of target setting

In going through this analysis, the suite of potential management options available will be examined, across assets, to derive a compromise set of actions which are linked directly to the targets thus derived. The previous analysis of risk and ratio of cost to value will be examined in the light of more detailed costing associated with the management strategies selected. Trading off against another assets may compromise the likelihood that a regional objective can be achieved and that a specific target will be reached. The extent must be assessed. **Again, the management actions and targets thus derived will be based on likely biophysical response but entirely constrained by socio-economic feasibility and acceptability. Targets should not be set that are not achievable and this analysis should constrain such outcomes.**

7 Monitoring and Evaluation

Adaptive management and risk management both facilitate dealing with uncertainty. Therefore, appropriate monitoring and evaluation are critical. Monitoring and evaluation must be designed into the strategy or plan from the start. The three main considerations for monitoring and evaluation are:

- long-term monitoring of biophysical conditions, the time frame of which will exceed the initial seven years of the National Action Plan and of individual regional/catchment plans accredited under it;
- monitoring and evaluation of specific regional/catchment plans and the management strategies that they contain; and
- monitoring and evaluation of the direction and achievement of the National Action Plan as a major policy program.

Each of these three aspects of monitoring must be founded on a well-developed conceptual model, and the monitoring must be designed to integrate all three. None of these three will be possible in the absence of two preconditions: an explicit program logic that is soundly linked to program implementation, and explicit targets or at least desired directions for each element (Curtis et al., 1998).

There are five core elements of a monitoring and evaluation strategy in the context of the National Action Plan:

- definition of what is to be monitored (e.g. water quality, number of accredited plans, uptake of management strategies, etc.);
- design of a monitoring program (or, rather, an integrated set of specific monitoring strategies associated with any given plan);
- definition of responsibilities for monitoring, custodianship of information, and the source of informational, financial and human resources;
- definition of the responsibility for and the timing, process and content of periodic evaluation; and
- assignation of responsibility to implement the outcomes of evaluations.

To guide the design and operation of monitoring strategies (at various levels) within the National Action Plan, this project should develop three sets of reasonably simple guiding principles:

- guiding principles for biophysical monitoring. As well as standard scientific criteria and quality controls, this will need to pay particular attention to the current/previous state of long-term monitoring (e.g. water quality, groundwater levels), the adequacy of this, and new monitoring needs that arise from the management strategies chosen. The biophysical monitoring must be part of an integrated evaluation that will include simulation and/or expert judgement modelling of the biophysical data. It is only through a modelling process that the effect of management intervention can be assessed against external factors, e.g.

climate variation and timing (a drought may set in immediately after management action, for example).

- guiding principles for monitoring of management strategies, stressing the need for information on the uptake of landholder/manager experience with implementation and effectiveness the modes of gathering this information;
- guiding principles for program monitoring and evaluation (Curtis et al., 1998). Relevant experience is also available in existing program implementation and evaluation protocols used by Commonwealth departments).

These will need to be integrated so that, for example, linkages between biophysical monitoring and plan evaluation are not ignored.

The basis for evaluation of integrated catchment/regional management plans will be regional monitoring. It is acknowledged that within the initial seven-year timeframe few biophysical shifts (even if they can be measured) will indicate permanent changes. This will vary between biophysical attributes and regions. It is, therefore, necessary to include monitoring (and therefore evaluation) of the management actions taken to lead to changes. It is necessary that monitoring be viewed in a longer-term context than the initial seven years.

8 Process for finalisation of standards

The process for finalisation of the Framework will consist of:

- provision of guidelines for setting regional objectives where guidelines are not currently available. This includes the need for the guidelines listed to be independently assessed technically and practically (by the scientific community, jurisdictions and the public) to determine the best tools to assist in the implementation of targets under the National Action Plan. Guidelines for engineering options will require additional attention.
- detailing the use of current and new guidelines in the context of the regional ICM planning under the National Action Plan;
- establishing a set of techniques acceptable for assessment of salinity and water quality targets. This will consist mainly of agreed methods for assessing the extent to which a land or water management intervention is likely to result in a given change in natural resource condition. Significant technical interaction and testing will be required to achieve techniques that are robust and acceptable to the state agencies.
- compiling an indicative list of assets;
- provision of guidelines for assessment of asset values;
- definition of qualitative risk assessment methods for asset threats and trade-off of priorities based on outcomes sought (all levels), biophysical possibility, social acceptability and economic plus social costs, i.e. threat–value–feasibility–cost–acceptability analysis;
- clarification of the expected procedure for engagement of the necessary stakeholders (all levels) in the negotiating process when setting objectives and targets in regional plans;
- testing of the framework for regional plan development in at least two regions with one preferably being a region with non-riverine integration, e.g. lake terminated river system (these are prevalent in WA but other examples exist, e.g. Lachlan R., NSW);
- following testing, drafting of a ‘how to’ guide for regional planning under the National Action Plan;
- development of a list of information products required, including source data, custodians, intellectual property and access conditions, scale/resolution and format;
- drafting of a monitoring and evaluation procedure that can be adapted for each region. It can be based on the new Monitoring and Reporting Guidelines (ANZECC/ARMCANZ 2000b).

- development of a framework for assessment of management options for control of water quality. This should relate management options to industries and the likely impact of the available options.
- finalisation of the Framework structure and definitions.

9 References and Further reading

9.1 Commonwealth Government

- Anon. (1999) *Managing Natural Resources in Rural Australia for a Sustainable Future*. A discussion paper for developing a national policy.
- Anon. (2000) *Our Vital Resources*. A National Action Plan for Salinity and Water Quality in Australia.
- Anon. (2001) *The Contribution of Mid to Low Rainfall Forestry and Agroforestry to Greenhouse and Natural Resource Management Outcomes: Overview and Analysis of Opportunities*. Prepared for Australian Greenhouse Office and Murray-Darling Basin Commission (in press).
- ANZECC (1992) *Australian Water Quality Guidelines for Fresh and Marine Waters*. Australian and New Zealand Environment and Conservation Council, Canberra.
- ANZECC (2000) *Core Environmental Indicators for Reporting on the State of the Environment*. State of the Environment Reporting Task Force. Australian and New Zealand Environment and Conservation Council.
- ANZECC/ARMCANZ (1996) *National Principles for the Provision of Water for Ecosystems*. Sustainable Land and Water Resources Management Committee, Subcommittee on Water Resources, Occasional Paper SWR No. 3, July 1996. Australian and New Zealand Environment and Conservation Council / Agriculture and Resource Management Council of Australia and New Zealand, Canberra.
- ANZECC/ARMCANZ (2000a) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (Volume 1: The Guidelines; Volume 2: Aquatic Systems — rationale and background information). National Water Quality Management Strategy Paper No. 4. Australian and New Zealand Environment and Conservation Council / Agriculture and Resource Management Council of Australia and New Zealand, Canberra.
- ANZECC/ARMCANZ (2000b) *Australian Guidelines for Water Quality Monitoring and Reporting*. National Water Quality Management Strategy Paper No. 7. Australian and New Zealand Environment and Conservation Council / Agriculture and Resource Management Council of Australia and New Zealand, Canberra.
- COA (1992) *National Strategy for Ecologically Sustainable Development*. Commonwealth of Australia. Australian Government Publishing Service, Canberra.
- EMA (2000) *Emergency Risk Management: Applications Guide*. Emergency Management Australia, Canberra.

- MDBMC (2000a) Basin Salinity Management Strategy, 2001–2015. Murray-Darling Basin Ministerial Council, Canberra.
- MDBMC (2000b) Draft Integrated Catchment Management in the Murray-Darling Basin, 2001–2010. Murray-Darling Basin Ministerial Council, Canberra.
- NHMRC/ARMCANZ (1996) *Australian Drinking Water Guidelines*. National Water Quality Management Strategy Paper No. 6. National Health & Medical Research Council/Agriculture and Resource Management Council of Australia and New Zealand, Canberra.
- NLWRA (2001a) *Australian Dryland Salinity Assessment 2000*. National Land and Water Resources Audit, Canberra.
- NLWRA (2001b) *Australian Water Resources Assessment 2000*. National Land and Water Resources Audit, Canberra.
- Standards Australia (2000) *Environmental Risk Management: Principles and Processes*. Handbook 203:2000. SA, Sydney.

9.2 State Government

- Department of Water Resources (2000) Draft South Australian River Murray Salinity Strategy. Government of South Australia, Adelaide.
- Maschmedt, D. (2000) Assessing Agricultural Land — *Agricultural Land Classification Standards Used in South Australia's Land Resource Mapping Programs*. Primary Industries and Resources South Australia Land Information, Adelaide.
- NRE (2000) *Restoring Our Catchments. Victoria's Salinity Management Framework*. State Government of Victoria.
- NSW Government (1999) Water Quality and River Flow Interim Environmental Objectives: Gwydir River Catchment. NSW Environmental Protection Authority.
- NSW Government (2000a) NSW Salinity Strategy — Taking on the challenge, NSW Department of Land and Water Conservation.
- NSW Government (2000b) NSW Salinity Strategy — Salinity Targets Supplementary Paper. NSW Department of Land and Water Conservation.
- PIRSA (2000a) Draft: A State Dryland Salinity Strategy, South Australia. Department of Primary Industries and Resources, South Australia (for the Soil Conservation Council of South Australia).
- PIRSA (2000b) Directions for Managing Salinity in South Australia. Department of Primary Industries and Resources, South Australia.

State of Queensland (1997) *Salinity Management Handbook*. Scientific Publishing, Resource Sciences Centre #222, Department of Natural Resources, Queensland.

State Government of Victoria (1995) *Nutrient Management Strategy for Victorian Inland Waters*. Department of Conservation and Natural Resources. ISBN 0 7306 6054.

Natural Resource Management in Western Australia State Salinity Council (2000a) *The Salinity Strategy. Natural Resource Management in Western Australia*. Western Australian State Salinity Council.

Natural Resource Management in Western Australia State Salinity Council (2000b) *Salinity Actions. Natural Resource Management in Western Australia*. Western Australian State Salinity Council.

9.3 General literature

Abernethy, B. and Rutherford, I.D. (1999) *Guidelines for Streambank Stabilisation with Riparian Vegetation*. Technical Report. Cooperative Research Centre for Catchment Hydrology, Melbourne.

Bailey, P.C.E. and James, K. (2000) *Riverine and Wetland Salinity Impacts — Assessment of R&D Needs*. Occasional Paper 25/99, Land and Water Resources Research and Development Corporation, Canberra.

Beer, T. and Ziolkowski, F. (1995) *Environmental Risk Assessment: An Australian Perspective*. Supervising Scientist Report 102. Commonwealth of Australia. (<http://www.environment.gov.au/ssg/pubs/risk/risk.toc.html>).

Bruvold, W.H. and Daniels, J.I. (1990) Standards for mineral content in drinking water. *Journal of the American Water Works Association*, 82: 59–65.

Bui, E.N. and Moran, C.J. (2000) Regional-scale investigation of the spatial distribution and origin of soluble salts in central north Queensland. *Hydrological Processes*, 14: 237–250.

Bui, E., Smettem, K.R.J., Moran, C.J. and Williams, J. (1996) Use of soil survey information to assess regional salinization risk using GIS. *Journal of Environmental Quality*, 25: 433–439.

Bui, E.N., Curtis, A., Robertson, A. and Race, D. (1998) Lessons from recent evaluations of natural resource management programs in Australia. *Australian Journal of Environmental Management*, 5: 109–119.

Coysh, J.L., Nichols, S.J., Simpson, J.C., Norris, R.H., Barmuta, L.A., Chessman, B.C. and Blackman, P. (2000) <http://ausrivas.canberra.edu.au>, Web page for the AUSTRALIAN RIVER ASSESSMENT SYSTEM (AUSRIVAS).

- Dovers, S. (1999) Adaptive policy, institutions and management: challenges for lawyers and others. *Griffith Law Review*, 8: 374–393.
- Dovers, S. and Mobbs, C. (1997) An alluring prospect? Ecology, and the requirements of adaptive management. In: Klomp, N. and Lunt, I. (eds), *Frontiers in Ecology: Building the Links*. Elsevier, London.
- Dovers, S. and Wild Rivers, S. (in prep). *Processes and Institutions for Resource and Environmental Management: Australian Experiences*. Final report to Land and Water Australia, Centre for Resource and Environmental Studies, ANU.
- Harper, R.J., Ryan, P.J., Booth, T.H., McKenzie, N.J. and Gilkes, R.J. (2001) *The Australian Farm Forestry Site Selection Manual*. Rural Industries Research and Development Corporation. (in press)
- Jones, B.K., Ritters, K.H., Wickham, J.D., Tankersley Jr, R.D., O'Neill, R.V., Chaloud, D.J., Smith, E.R. and Neale, A.C. (1997) *An Ecological Assessment of the United States Mid-Atlantic Region*. United States Environmental Protection Agency. Office of Research and Development Washington, DC. EPA/600/R-97/130, pp. 1–105.
- Karssies, L.E. and Prosser, I.P. (1999) *Guidelines for Riparian Filter Strips for Queensland Irrigators*. CSIRO Land and Water Technical Report 32/99, Canberra.
- Lovett, S. and Price, P. (eds) (2000a) *Riparian Land Management Technical Guidelines Volume One: Principles of Sound Management*, Land and Water Resources Research and Development Corporation, Canberra.
- Lovett, S. and Price, P. (eds) (2000b) *Riparian Land Management Technical Guidelines Volume Two: On-Ground Management Tools and Techniques*. Land and Water Resources Research and Development Corporation, Canberra.
- Myers, B.J., Bond, W.J., Benyon, R.G., Falkiner, R.A., Polglase, P.J., Smith, C.J., Snow, V.O. and Theiveyanathan, S. (1999) *Sustainable Effluent-Irrigated Plantations: An Australian Guideline*. CSIRO Forestry and Forest Products, Canberra, Australia. web page: http://www.ffp.csiro.au/pff/effluent_guideline/
- Nambiar, S., Cromer, R. and Brown, A. (2000) *Restoring Tree Cover in the Murray-Darling Basin*. CSIRO Forestry and Forest Products, Canberra.
- Prinsley, R. and Davis, S. (2000) *Emerging Products and Services from Trees in Lower Rainfall Areas*. The JVAP Research Update Series No 2. RIRDC Publication No. 00/171.
- Stirzaker, R., Vertessy, R. and Sarre, A. (eds) (2001) *Trees, Water and Salt: An Australian Guide To Using Trees for Healthy Catchments and Productive Farms*. (in press)

- Tickle, P., Keenan, R., Walker, J. and Barson, M. (1999) Can commercial tree planting help dryland salinity mitigation and meet greenhouse gas abatement objectives? GH salinity paper final August 4: AFFA Co-ordinating Working Group on Vegetation, August 1999.
- Veitch, S.M. (1997). Land Use Decisions and Site Selection: A GIS-based Approach. In: Denzer, R., Swayne, D.A., and Schimak, G. (eds), *Environmental Software Systems*, Vol. 2, Chapman and Hall, London.
- WHO (1984) Health Criteria and Other Supporting Information, Vol. 2 of Guidelines for Drinking Water Quality. World Health Organization, Geneva.
- Zorzetto, A. and Chudleigh, P. (1999). Commercial prospects for low rainfall agro-forestry. A report for the RIRDC/LWRRDC/FWPRDC Joint Venture Agro-forestry Program. RIRDC Publication No 99/152. RIRDC Project No AGT-4A.

10 List of Abbreviations

AM — Adaptive Management

ANU — Australian National University

AS — Australian Standard

BRS — Bureau of Rural Sciences

COAG — Council of Australian Governments

CRES — Centre for Environmental Studies

CSIRO — Commonwealth Scientific and Industrial Research Organisation

DOC — dissolved organic carbon

EC — electrical conductivity units

ICM — Integrated Catchment Management

LWA — Land and Water Australia

LWRRDC — Land and Water Resources Research and Development Corporation
(now Land & Water Australia)

MDBC — Murray-Darling Basin Commission

National Action Plan — National Salinity and Water Quality Action Plan

NHT — Natural Heritage Trust

NLWRA — National Land and Water Resources Audit

NRM — Natural Resource Management

NWQG — National water quality guidelines (referring specifically to the ANZECC/ARMCANZ (2000a) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*)

NZS — New Zealand Standard

RBA — rapid biological assessment

SPM — suspended particulate matter

TDS — total dissolved solids

Appendix 1. National Salinity and Water Quality Action Plan — Background

The following short summary is verbatim from the Prime Minister's statement.

The National Action Plan identifies high priority, immediate actions to address dryland salinity and deteriorating water quality in key catchments and regions across Australia.

The goal of the National Action Plan is to motivate and enable regional communities to use coordinated and targeted action to:

- prevent, stabilise and reverse trends in dryland salinity affecting the sustainability of production, the conservation of biological diversity and the viability of our infrastructure
- improve water quality and secure reliable allocations for human uses, industry and the environment.

National Action Plan

The Action Plan builds on the work established under the NHT, the Murray-Darling Basin Commission, State/Territory strategies and the COAG Water Reform Framework by implementing:

- targets and standards for natural resource management;
- integrated catchment/regional management plans developed by the community;
- capacity building for communities and landholders;
- an improved governance framework to secure the Commonwealth-State/Territory investments and community action in the long term;
- clearly articulated roles for the Commonwealth and States/Territories; and
- a public communication program.

This document addresses the underpinning requirements for the first of the above implementation points of the National Action Plan, namely, **targets and standards for natural resource management**. The National Action Plan will implement targets and standards for natural resource management particularly for water quality and salinity, with the States and Territories, either bilaterally or multilaterally, as appropriate. The targets and standards should address salinity, water quality and associated water flows, and stream and terrestrial biodiversity based on good science and economics.

Landcare and the Natural Heritage Trust have made good progress towards tackling water quality, salinity and natural resource management issues. However, the lack of agreed specific on-the-ground outcomes and targets for water quality, salinity and other natural resource management attributes has been a major barrier to guaranteeing a return on the Commonwealth's investment.

Agreed targets and standards will need to be set by the Commonwealth and the States and Territories, either bilaterally or multilaterally, as appropriate, in consultation with the relevant community to ensure effective use of funding.

This interim National Standards Framework is also closely linked to the content of regional integrated catchment management (ICM) plans. The emphasis in regional plans will vary from catchment to catchment (or from region to region), but to address water quality, salinity and associated biodiversity issues, plans are likely to include specific actions to:

- map salinity hazard using ‘ultrasound’ technology and assess catchment/region condition and issues;
- maintain and improve the condition of existing native vegetation;
- establish multiple purpose perennial vegetation (focused on agriculture, forests, biodiversity and carbon credits) in targeted areas, identified by mapping salinity, vegetation and hydrological characteristics, and modelling groundwater movements;
- protect and rehabilitate damaged high priority waterways, floodplains and wetlands;
- improve ‘environmental flows’ in waterways, where this is beneficial;
- improve stream water quality and habitat characteristics using engineering works in critical areas (e.g. salt interception devices and groundwater pumping, removal of weirs and redundant structures, fish ladders, artificial wetlands);
- install drainage in catchments/regions where agreed by affected land managers and where it is likely that downstream impacts will be positive and that the overall benefits of the scheme will provide substantial long-term results over other approaches;
- address the difficult adjustment and property amalgamation issues; and
- address the degradation of rural urban infrastructure (buildings, roads, etc.).

Integrated Catchment Management plans may indicate that substantial land and water use change is required to address dryland salinity and deteriorating water quality, potentially affecting the viability of regional communities. The States and Territories have prime responsibility in this area. However, given the national significance of these issues and the potential for substantial costs, the Commonwealth is prepared to consider a contribution towards appropriate compensation to promote adjustment.

To ensure that integrated catchment/region management plans contribute to the achievement of nationally agreed outcomes, catchment-specific or region-specific targets for salt, nutrients, water flow regimes, water quality, stream and terrestrial biodiversity will be required.

It is proposed that highly salinised catchments/regions be addressed. Analysis suggests there are approximately 20 such catchments/regions (Figure 6). Final details on catchments/regions to be included will be discussed with the States/Territories.

Catchments/regions that are ready to commence detailed action planning or where investments now will avoid costly degradation would be the most effective starting point. The pace of specific activity may vary between catchments/regions.

The indicative list of catchments/regions for action is: Burdekin-Fitzroy (Qld); Lockyer-Burnett-Mary (Qld); Balonne-Maranoa (Qld–NSW)); Border Rivers (Qld–NSW); Namoi-Gwydir (NSW); Macquarie-Castlereagh (NSW); Lachlan-Murrumbidgee (NSW); Murray (NSW); Goulburn-Broken (Vic); Avoca-Loddon-Campaspe (Vic); Glenelg-Corangamite (Vic); Midlands (Tas); Lower Murray (SA–Vic); Mt Lofty-Northern Agricultural Districts (SA); South East (SA); Avon (WA); South Coast (WA); Northern Agricultural Region (WA); South West (WA); and Ord (WA–NT).

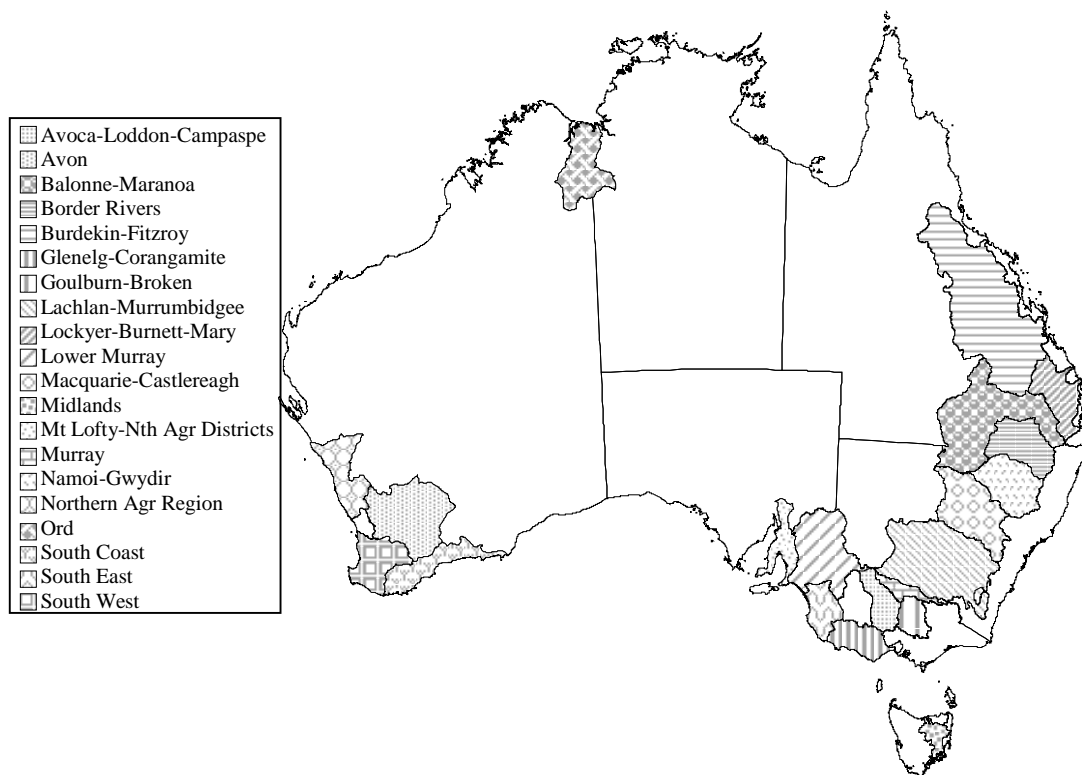


Figure 6. The 20 regions of Australia chosen as of highest priority for the National Action Plan

Draft Intergovernmental Agreement

Standards and targets are described in the draft intergovernmental agreements in the following clauses:

20. The Parties agree to develop standards on salinity, water quality and associated water flows by December 2001, with interim standards by March 2001 building on existing standards where possible. These standards will be designed to achieve the purpose of this Agreement set out in clause 5 and will comprise:
 - i) national natural resource condition outcomes that can vary between bio-geographical regions/catchments; and
 - ii) national management standards defining best practice natural resource management which, when adopted, will assist in achievement of the national natural resource condition outcomes.
21. Parties agree to develop by December 2002 further standards for natural resource management as described in para 3.1 of the Action Plan, which build on the standards for salinity, water quality and associated water flows developed under this Agreement.
22. The Parties agree that catchment/region specific targets for salt, nutrients, associated water flow regimes and water quality, and subsequently for natural resource management aspects described in para 3.1 of the Action Plan, will need to be developed by the catchment/regional body with reference to the standards. These catchment/regional targets will be:
 - i) based on good science and economics;
 - ii) measurable and time-bound; and
 - iii) able to be practically applied at the catchment/regional level and be achievable in a cost-effective way.

The standards referred to in clauses 20 and 21 and will be agreed by the Ministerial Council that is established or by earlier agreement.

Appendix 2. Requirements for a National Standards Framework

The interim National Standards Framework will be based on Australian Standard environmental risk management principles. It will address national natural resources condition outcomes including management standards where these relate closely to biophysical outcomes.

The Framework will:

- recognise biophysical and socioeconomic, i.e. industry, institutional (regional, State, Commonwealth) and local (implementation) components. At the regional targets level, the Framework will foster the consideration of management options (for institutional implementation as well as biophysical land management) in terms of their chance of success in a given location/environment for a range of specific issues.
- assist in developing standards for natural resource condition outcomes that are desirable for maintaining ecosystem health, function and productivity, and take into account natural variability, but without taking into account the capacity of governments and the community to achieve them. Judgements on capacity, timing and trade-offs between outcomes will be made by the partners during regional target setting as part of the planning process.
- permit addition of other factors at a later date, e.g. biodiversity and groundwater standards, and accommodate their target setting methods;
- draw on relevant work already undertaken;
- explicitly list known constraints to its application;
- propose a process for finalisation of the interim standards by December 2001;
- define a (non-exhaustive) list of possible types of targets associated with standards;
- propose a process for evaluation of the success of the implementation of standards, including general guidelines on monitoring, reporting and compliance arrangements;
- ensure the ready availability of comprehensive data and information to underpin priority setting, program implementation, monitoring, evaluation and reporting.

Salinity and water quality will remain conceptually separate in the Framework acknowledging that at some point in the analysis trade-offs must be taken into account. Environmental flows standards and principles for caps on water extraction will be based on the ANZECC/ARMCANZ National Principles for the Provision of Water for Ecosystems (Appendix 6).

Implementation of the Framework and ensuing standards will be through action against targets negotiated at the regional level. Actions to meet targets will be taken

by regional communities but also through broader State and Territory institutional and policy reform.

Appendix 3. Salinity and Water Quality — Contrasts and Links

The essential principles of the Framework are to use a risk management approach to bring together salinity and water quality objectives. There are significant differences between the approaches adopted for salinity and water quality. This is in part because the nature of the issues differs. However, the differences also reflect different backgrounds in the disciplines. This appendix summarises these differences, to provide context for the Framework. It describes a conceptual and physical model — ‘material budgets’ — that allows us to treat salinity and water quality using a consistent approach. Even with this, it is not considered necessary for the Framework to attempt to force the same approach to all salinity and water quality issues. It is necessary that the regional plans recognise the differences and take them into account when analysing trade-offs and designing management actions and monitoring.

A3.01 Salinity

The salinisation of soils and water bodies has accelerated above natural levels in response to land management change since European settlement. It varies from catchment to catchment in its severity and in the time it has taken to develop, and is likely to vary in the speed of its response to future management intervention. Consequently, there has been strong focus on the potential effectiveness of a range of management strategies. The aim is to maximise the response for a given investment and to use short-term tactics to supplement those best-bet management interventions that are not likely to take effect for many years. It is anticipated that short-term tactics may be able to save critical assets or protect human and ecological values. Salinity management objectives for a given valley or catchment must be set in the context of the groundwater in that area. The nature of groundwater systems is the primary factor that determines the likely response to salinity mitigation; broadly they can be categorised as:

1. *Local.* Groundwater systems occupying ~25 Mha across Australia of which 3% are projected to be affected by salinity within 100 years. These systems respond relatively rapidly to increased recharge (potentially resulting in salinity) and where response to salinity mitigation intervention should occur within 10-15 years.
2. *Intermediate.* Groundwater systems occupying ~40 Mha across Australia of which 5% are projected to be affected by salinity within 100 years. These systems take decades to come into a new hydrological balance following land management changes that increase recharge. Therefore, the expression of salinity may continue to increase for some time even after mitigation management has been implemented. Where the geological substrate is highly permeable and water balance is already approaching a new balance, response to management intervention may be in a similar timeframe to local systems. Where the

permeability is slow and the rate at which water is removed from the aquifer (discharge capacity) is slow response to management interventions is likely to take decades.

3. *Regional.* Groundwater systems occupying ~45 Mha across Australia of which ~6% are projected to be affected by salinity within 100 years. These systems may take centuries to reequilibrate following increased recharge regime and response to land management intervention for salinity control is likely to be beyond the timeframe of natural resource planning, i.e. > 50 years.

A3.02 Water Quality

The revised National Water Quality Guidelines take a new approach to setting guidelines. The guidelines state the issues important to water quality in various situations and identify indicators of condition. The NWQG are also concerned with the quality of water for environmental values, and, in the case of ecosystem protection, for a range of defined types of water body or ecosystem. The degree of disturbance an area may suffer, and its geographic location, are categorised. The factors that stress or modify the system for a given issue are listed and indicators of pressure on these are identified.

A great deal of effort has been put into the NWQG for identification and monitoring. Management interventions and time scales of response have not been dealt with as thoroughly. For water quality, national guideline levels have been agreed upon (ANZECC, 1992; ANZECC/ARMCANZ, 2000a) which indicate whether a particular type of area is at risk of expressing an undesirable condition. The agreed levels depend on the degree to which the area is disturbed, and the desired condition for that water body. Three categories are defined.

1. For 'high conservation value ecosystems', the NWQG advise that no change from ambient conditions should be tolerated, unless it can be demonstrated that such change will not compromise the objectives for maintenance of biological diversity in the system. Where comprehensive biological effects data are unavailable, a monitoring program would be required to demonstrate absence of change in values of physical and chemical stressors, using statistically conservative decision criteria as the basis for evaluation. Values of the criteria as recommended for biological indicators might be used as a starting point in negotiations.
2. In 'slightly/moderately disturbed ecosystems', where the objective is to maintain biological diversity, the NWQG acknowledge that stakeholders may decide to allow some small change to biodiversity as well as to improve or restore the ecosystem to a substantially unmodified condition, depending upon the situation.
3. In 'highly disturbed ecosystems', the management target will be to maintain, and preferably, improve the ecosystem, although in many cases the possibility of restoring the system to a substantially natural ecosystem may not be realistic. Urban aquatic systems (rivers, streams, wetlands, and estuaries) are a case in point.

For most of these, the hydrology in particular has been so markedly changed that, at best, only a somewhat modified ecosystem can be achieved.

A3.03 Material budgets

A 'material budget' is similar to a fiscal budget in that a finite resource moves between a set of stores that may differ in size, as may the rates of transfer between the stores. The material budget of central interest to the National Action Plan is the water budget. Budgets can also be drawn up for salt, sediment and nutrients.

The water budget (also called the water balance) is a balance between the water source for a catchment, i.e. rainfall (and snow), and the various destinations for the water. The destinations are: evaporation and evapotranspiration (water returned to the atmosphere through plants); storage in the soil and deeper regolith in the catchment (as groundwater); transmission into and out of the groundwater; and transport into and along rivers. In some cases, water may also enter a catchment through groundwater aquifers, or, if the catchment has another above it, by river transfers into the catchment below.

Similarly, a salt budget has sources and destinations. Rainfall contains some salt and over geological time this becomes the major source of salt in most areas around Australia. Salt can also be derived from saline aquifers (sedimentary rocks previously in a marine environment) and through rock weathering. Salt is transported with water through the landscape and can therefore appear widespread in some regions and in specific and constrained concentrations (through geological and/or geomorphic processes) in other regions.

The reason that salinity is now a natural resource concern is that the water budget (balance) has been shifted, mainly through a change in the vegetation. In some parts of Australia, the times of the year when the vegetation most demands water is not the time of year when water becomes available through rainfall. As a generality, the changes imposed on the Australian landscape have led to a net increase in the drainage of water to a depth in the soil where it can not be taken up by plants and transpired. This water too often makes its way into the groundwater aquifers and is then termed 'recharge'. We have shifted the water balance in Australia towards an increase in recharge. However, the rate at which water can move out of an aquifer (aquifer discharge) is slow and cannot practicably be altered. Therefore, the water enters the groundwater more rapidly than it can be removed, the groundwater aquifers fill and the water table rises. If salt is present in the regolith, the salt is transported to the soil surface with the water and concentrates there through evaporation.

Changes in the Australian landscape have also shifted other components of the water balance in some regions and have affected other material budgets. For example, the amount of water that never enters the soil but simply moves across the surface (called 'run-off') has increased in many areas because of the changes in the surface soil conditions, e.g. soil compaction, formation of crusts and seals, reduced surface soil permeability. Also, soil disturbance, such as by cultivation and animal activity, makes

surface soil more readily transportable than under natural conditions. Since settlement, we have increased the amount of surface run-off available to transport the soil and made the soil easier to transport. The transported soil (called sediment when it enters waterbodies) consists partly of mineral matter and partly of organic matter, and this affects the 'nutrient budget'. Nutrients are attached to the organic matter and also to the mineral soil particles. For example, phosphorus ions accumulate on both organic and mineral particles which may be a result of fertiliser applications; nitrogen builds up in the organic matter and in some cases acidifies the soil, although it leaches through soil that contains little organic matter. Phosphorus in river sediment and nitrogen in solution can stimulate blue-green algal growth. Pesticides, in run-off or in groundwater that drains relatively quickly into rivers contribute to poor river quality, can accumulate in animal tissues, and may make the water toxic for human consumption. Nutrient budgets help track these potential water quality problems.

Thus, the concept of material budgets can unify management approaches to salinity and water quality.

A3.04 National standards for the provision of environmental flows

This Framework adopts verbatim the ARMCANZ/ANZECC National Principles for the Provision of Water for Ecosystems. The National Principles were first developed in 1994 (ANZECC/ARMCANZ, 1996). Since then, jurisdictions have been progressively implementing their obligations under the COAG Water Reform Framework — including undertaking water allocation decisions and providing water for ecosystems in that process.

As jurisdictions have moved into this implementation phase, a number of further issues relating to the provision of water for ecosystems have become apparent. Therefore, the National Principles are currently being revised to provide further direction to these emerging issues (see Appendix 6 for a summary of the current draft proposal). This process is being carried out under the auspices of the ANZECC/ARMCANZ High Level Steering Group on Water. The standards in this Framework are based on these revised principles. However, the development of the standards/principles is ongoing. It is anticipated that they will be reviewed at the ANZECC/ARMCANZ level over time as further information is made available on ecosystem requirements and the management of water allocations for use by the environment.

Appendix 4. National Environmental Water Quality Guidelines

The revised NWQG (ANZECC/ARMCANZ, 2000a) provide agreed national standard trigger values for water quality in waterways and, estuaries and wetlands. Values are provided for human and livestock consumption and to deal with a range of ecosystem health issues including:

- nuisance growths of aquatic plants (eutrophication);
- lack of dissolved oxygen (asphyxiation of respiring organisms);
- excess suspended particulate matter (smothering of benthic organisms; inhibition of primary production);
- change in salinity (change in biological diversity);
- unnatural change in temperature (change in biological diversity);
- unnatural change in pH (change in biological diversity);
- poor optical properties of water bodies (reduction in photosynthesis; change in predator–prey relationships);
- unnatural flow (inhibition of fish migration; associated temperature modification of spawning; changes in estuarine productivity);
- toxicity resulting from contaminants associated with the water (and sediment).

Similarly, the NWQG provide guidelines for assessment of biological health of aquatic ecosystems.

Appendix 5. ANZECC State of Environment Core Indicators

The ANZECC Core Indicators for Reporting on the State of the Environment were endorsed by ANZECC in 1999 and published in 2000 (ANZECC, 2000). The indicators have been designed to link with other important projects such as the National Land and Water Resources Audit. As such, they should play a valuable role in the monitoring and reporting of the National Action Plan. Indicators from two of the seven reporting themes, Land and Inland Waters, are relevant to salinity and water quality. Some examples are listed below (Table 1). Methods already exist for measuring some of the above indicators, and methods for measuring others will become available from other sources, such as projects being undertaken as part of the National Land and Water Resources Audit.

Table 1. A selection of State of the Environment core indicators for land and inland waters that should be suitable for use in the national Action Plan

Theme	ANZECC Code	Core Indicator
Land	L 1	Changes in land use
	L 2	Potential for erosion
	L 4	Area of rising watertables
	L 5	Area affected by salinity
Inland Waters	IW 1	Groundwater extraction versus availability
	IW 2	Exceedences of groundwater quality guidelines
	IW 3	Extent of deep-rooted vegetation cover by catchment
	IW 4	Surface water extraction versus availability
	IW 7	Surface water salinity
	IW 8	Exceedences of surface water quality guidelines
	IW 13	River health (AUSRIVAS)

Appendix 6. National Principles for the Provision of Water for Ecosystems

The following principles are taken from the draft National Principles for the Provision of Water for Ecosystems, as of September 2000. When that draft document is accepted the principles herein should be adjusted to match those that are eventually accepted.

1. Purpose

In 1994, the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) and Australian and New Zealand Environment and Conservation Council (ANZECC) jointly developed a set of National Principles for the Provision of Water for Ecosystems. The purpose of these National Principles (1994) was to provide policy direction on how the specific issue of providing water for ecosystems should be dealt with in the context of general water allocation and management decisions. These water allocation processes share water amongst the various competing users including the environment. They include a detailed planning process involving all resource users.

Since 1994, States and Territories have been undertaking water allocation processes as part of their responsibilities as water resource managers and in implementing the national COAG Water Reform Framework. During this implementation phase, a number of issues arose where further national policy direction was required. As a result, these National Principles have been revised to provide relevant, ongoing national direction in the area of the provision of water for ecosystems.

2. Goal

The goal for providing water for ecosystems is to sustain and where necessary restore ecological processes, habitats and biodiversity of water-dependent ecosystems.

3. Principles

Basic Premise of Principles

Principle 1. River regulation and/or consumptive use of both surface and groundwater should be recognised as potentially impacting on ecological values.

Assessing Ecological Water Requirements

Principle 2. The determination of ecological water requirements should be on the basis of the best scientific information available on the water regimes necessary to sustain the ecological values of water-dependent ecosystems.

Principle 3. In assessing ecological water requirements, the following must be taken into account:

- the needs of downstream or other connected water-dependent ecosystems;
- and

- the ecological significance of the major features of the natural water regime.

Provision of Water for Ecosystems

Principle 4. Environmental water provisions should be legally recognised.

Principle 5. In systems where there are existing users, provision of water for ecosystems should go as far as possible to meet the water regime necessary to sustain the ecological values of water-dependent ecosystems whilst recognising the existing rights of other water users.

Principle 6. Where environmental water provisions are insufficient or there is scientific knowledge of significant environmental damage as a result of inadequate water regimes, then extraction should be capped and action (which may include reallocation) should be taken to improve environmental condition.

Principle 7. The rules governing water markets should ensure that there is no adverse impact on local ecological values unless there is a net ecological benefit.

Principle 8. Further allocation of water for any use should only be on the basis that natural ecological processes and biodiversity are sustained (i.e. ecological values are sustained).

Optimising Water Management for Ecological Outcomes

Principle 9. All water uses should be managed in a manner which recognises ecological values.

Principle 10. Where possible, water sharing rules and operation schedules need to be developed that recognise the within year and inter year requirements of water-dependent ecosystems and optimise ecological and water supply outcomes.

Principle 11. In relation to water resource management works:

- structural modification of existing works should be encouraged, where they are possible and can deliver a net improvement in ecological values; and
- any new works, where essential, or renewal of assets should be undertaken to current best practice environmental standards.

Principle 12. Actions to achieve system water savings should ensure that there are no adverse impacts on local ecological values unless there is a net ecological benefit.

Principle 13. Appropriate demand management, water pricing and water use monitoring strategies should be used to assist in sustaining ecological values of water-dependent ecosystems.

Risks to Environmental Water provisions

Principle 14. All water in the catchment must be considered when making water allocation and management decisions to determine and protect both environmental water provisions and the entitlements of other users.

Principle 15. Strategies for broad scale land use change within a catchment should consider implications for environmental water provisions as well as for other users.

Principle 16. Environmental water provisions should be responsive to monitoring and improvements in understanding of ecological water requirements.

Complementary Actions to Providing Water for Ecosystems

Principle 17. The benefits of environmental water provisions should be optimised by a range of complementary catchment, riparian and instream measures to maintain or restore the health of water-dependent ecosystems.

Accountability

Principle 18. Accountabilities in all aspects of management of environmental water provisions should be transparent and clearly defined.

Further Research

Principle 19. Strategic and applied research to improve understanding of ecological water requirements is essential.

Community Involvement

Principle 20. All relevant environmental, social and economic stakeholders should be involved in water allocation planning and decision-making on environmental water provisions.

Appendix 7. A Process for Guidelines for Revegetation Using Perennials

It is generally accepted that current farming systems have only a limited capacity to reduce groundwater recharge rates to match those that existed under natural vegetation. Revegetation will involve incorporation of productive and profitable perennials (woody and herbaceous) into farming systems that currently consist predominantly of annual crops and pastures. Incorporation of trees and shrubs can be through a mosaic of commercial farm forestry, agroforestry and environmental or biodiversity plantings, and it can be across the spectrum of land types that have excessive recharge to groundwater systems and those that are discharging water and salt.

The capacity of revegetation to modify recharge at appropriate spatial and temporal scales is greatest for local and intermediate groundwater systems. The area of revegetation required to reduce recharge for a given catchment and groundwater system varies from 10% to 90%, but in most instances it is at least 40% (Anon., 2001). Targeted tree planting will therefore be required where possible (Stirzaker et al., 2001). There are good opportunities to use tree crops to modify the water balance of agricultural systems. The water use of plantations is closely linked with their productivity. Detailed growth predictions are only available for a small suite of commercial tree species but more general information is available for a wider range of species. Current predictions are that the area of salinised land will continue to expand rapidly in the face of a limited capacity to incorporate perennials at a sufficient scale and rate to have any impact on recharge. Finding productive and profitable revegetation options for living with saline land is therefore assuming increasing importance.

Most of the required revegetation will be in the 350–700 mm rainfall zones which correspond to >90% of the occurrence of dryland salinity (Tickle et al., 1999). Several projects are now addressing the capacity of trees to produce marketable products in these regions (Zorzetto and Chudleigh, 1999; Prinsley and Davis, 2000). With respect to forestry and agroforestry industries, a recent report (Anon., 2001) presents an overview and analysis of the contributions these can make to greenhouse and NRM. It concludes, among other things, that: (i) large markets for a diverse range of products offer the most attractive opportunities for significant investment; (ii) marketing more than one product from the same feedstock is most attractive (e.g. integrated mallee oil processing industry in WA). Thirdly, it finds that options for industry development include: (a) extending established industries (e.g. eucalypt plantations for pulp); (b) creating new industries (e.g. short-rotation perennial tree or shrub crops grown for a wide range of industrial products); (c) improving existing mid- to low-rainfall timber industries. Potential products include solid wood products, pulp and paper, wood composites, electricity, liquid fuel and niche market items.

Synthesis of disparate information and existing guidelines will be essential for developing national and regional guidelines for revegetation to manage land and water salinity.

The following processes are envisaged as necessary if guidelines are to be produced by December 2001:

- i) generation of species-specific maps indicating potential productivity (and thus likely water use) based on soils and climate for salinity-prone regions and improved site and species selection to account for climatic, hydrological, geomorphological and soil factors affecting growth (Stirzaker et al., 2001; Harper et al., 2001);
- ii) aggregation of tree water use information to provide catchment/region-specific understanding of likely water balance changes with varying farm forestry scenarios;
- iii) development of a framework for determining the impact of revegetation on land and water salinisation within and between catchments, especially with respect to river water quality targets; and
- iv) development of best-bet options for species, silviculture and landscape arrangement, to maximize productivity and profitability on non-saline and saline areas of salinised catchments in high priority regions.

Appendix 8. Assessing the Condition of Australia's Catchments at the National Scale

The following is a summary of the catchment health indicators being developed under the National Land and Water Resources Audit.

The condition of Australia's catchments is being assessed for the National Land and Water Resources Audit within the theme 'River, estuary and catchment condition'. The broad aim of the Catchment Condition Project is to determine the current biophysical condition of water catchments (sizes ranging from 50 km² to >1000 km²) in the intensive land use zone. Catchments were chosen as an appropriate reporting unit because most environmental degradation issues in Australia are associated with the water cycle.

Catchment assessments help to frame integrated natural resource management programs and provide a focus to link government initiatives with the on-ground actions needed to manage on-site and off-site problems such as salinity, flooding, surface soil erosion and soil structure decline. The relative condition of catchments across the intensive agricultural zone is therefore of interest to local Landcare groups as well as to policy-makers in State and Commonwealth departments.

An indicator approach is being used that assesses catchment condition from national-scale attribute data. This approach is preferred to detailed process modelling because the complex interactions between biophysical processes in catchments cannot be credibly modelled using existing data. National-scale data are generalised from detailed data and highlight the predominant processes that drive catchment condition. The major benefit of national-scale data is that, when used with decision support systems, a variety of condition assessments can be reviewed in a wide spatial and conceptual context that small area assessments cannot provide. The GIS-based decision support system 'ASSESS' (Veitch, 1997) is being used to produce maps of single attributes, or of composite indices based on an aggregation of indicators. For example, the conditions of water, land and biological components are ranked for sub-catchments in regions or for the nation.

Catchment condition is judged or estimated from biophysical and geomorphic characteristics, in the contexts of societal values, land use and economic factors. The assessment process is based on the methods used by the United States Environmental Protection Agency to develop indicators for environmental monitoring and assessment (Jones et al., 1997). The strength of this approach is that it is driven by societal values — what people want or expect with respect to the quality of land, water, and biological resources. This leads to specific assessment questions that address the environmental concerns at the scales of interest. The process starts with a sequence of steps that lead to the selection of a set of indicators that form the basis of the catchment condition assessment, either as a specific measure or as an aggregated measure (an index).

The data used are qualitative and quantitative, and are interpreted in many ways according to sets of values, so a single objective assessment of catchment condition is impossible. However, a relative ranking to represent each set of values will highlight the differences in condition within and between regions sufficiently well for management and policy purposes at the national scale. These can be considered as individual attributes, or aggregated, for example, to a land index, water or biological index, or as an overall aggregated catchment condition index.

The assessment process uses societal values that are usually broad and relevant to the general public, landholders, and land and water managers across Australia. In the catchments, these include values such as clean water, habitat for valued and endangered species, and sustainable soil resources for agriculture. In many cases societal values can differentiate, for example, between the value of cleared land for agriculture and its value for conservation.

Consumed products (e.g. agricultural, forestry, fish production, economic values) and non-consumed products (e.g. social factors, quality of life, conservation, recreation, tourism) are used to compare the goods and services delivered by a catchment against its assessed condition. Colour-range maps are used to show condition assessments between areas where good catchment condition coincides with high levels of consumed goods, to areas with poor condition providing low levels of goods and services. Indices of biophysical catchment condition can also be compared with other sources of condition information, such as nutrient exceedence data, when available, or independent estimates of stream and estuary condition coming from other Audit theme projects. Comparisons help to discriminate between the components of the condition assessment and to highlight anomalies, such as a catchment in poor condition but with good stream and estuary condition. Similarly, targets for surface water quality and salinity condition can be reviewed against the catchment condition assessment to highlight areas and causes of concern, and so highlight priorities for management.

Appendix 9. Summary of Guidelines for Soil Salinity

The section is concerned with the assessment of soils for salinity and the relationship with shallow water tables and groundwater salinity.

A9.1 Soil salinity of parameters

Five parameters, identified below, give an interpretive understanding and evaluation of soil salinity.

Parameter	Reason for Use	Section No
Saline land classification	Risk assessment	A9.2
Soil salinity of the surface soil	Salinity impact	A9.3
Soil salinity profile	Processes and changes with time	A9.4
Watertable depth in open shallow wells	Processes of salinisation and trends	A9.5

A9.2 Saline land classification

A saline soil is a soil containing high enough concentrations of soluble salts within the surface soil profile to result in reduced plant productivity or plant death.

Climate, soil properties, depth to salinity in the soil, and plant species all influence the effect of salinisation on plant productivity. The degree of soil salinisation is the result of an interaction between rising watertables and natural concentrations of salt in the soil. As shallow watertables rise towards the soil surface, evaporation occurs and surface soil salinity results.

While it is difficult to estimate severity by any universally applicable objective criteria, common classes offer a framework to describe what is happening or what may be expected to happen in an area. By using standard terms such as these, salt-affected areas can be mapped and described in different regions using comparable criteria.

Table 2 summarises some broad categories which can be used to evaluate land on the basis of the current degree of salting as well as the degree of salinity risk under changed land use or land management conditions (based on watertable salting).

Table 2. Classes of salt-affected land (adapted from MDBC 1993). ‘Watertable salting’ refers exclusively to the process of shallow watertable-related salinity; ‘Land’ refers to land systems (recurrent patterns of geology, soils and vegetation) and associated surface and groundwater systems.

Class	Description
Not at risk	Land not predisposed to watertable salting regardless of land use or management
Stable	Land predisposed to watertable salting but unlikely to become saline under existing land use or management
At risk	Land predisposed to watertable salting which is likely to become saline under existing land use or management
Slightly affected	Land showing a reduction in the vigour of salt-intolerant plants; some salt-tolerant plants; seasonally or permanently shallow watertable; and perhaps small bare areas
Moderately affected	Land showing a significant loss of salt-intolerant plants; salt-tolerant plants are common; seasonally or permanently shallow watertable; bare areas up to about 5 m ² in size; some erosion present
Severely affected	Land showing an absence of salt-intolerant plants; permanent shallow watertable; large bare areas which are often badly eroded

A9.3 Soil salinity

Soil salinity can be assessed using a range of criteria. However, since salinity is normally associated with changes in vegetation, it is best linked directly to plant growth. The extensive survey of Maas and Hoffman (1977) provided clustered groupings for plant salt tolerance.

These groupings can be directly related to soil salinity as assessed by the electrical conductivity (EC) of a saturated soil extract EC_{se} . While there is debate on whether average root zone weighted EC_{se} or water uptake weighted EC is used, sampling four depths in the soil profile offers not only varying methods of integration but also a benchmark to determine what processes are dominating at a particular time in the region being evaluated.

Because of the difficulty of measuring EC_{se} , it is normal to measure the EC of a 1:5 soil:water suspension ($EC_{1:5}$) instead. This measure is not applicable across varying soil textures and salt compositions and needs to be converted to EC_{se_2} .

A number of soil salinity criteria are in use worldwide. Many of these criteria are specific to the areas in which they were developed, so their application to other

environments is limited. Most of these criteria were developed to provide rough practical guidelines for interpreting soil salinity data. Most soil processes and values occur on a continuum, so criteria that suggest sharp class boundaries should be applied with some flexibility.

Table 3 gives soil salinity criteria that are related directly to plant response and also indicate appropriate $EC_{1.5}$ figures based on a dominantly chloride salt composition.

Table 3. Soil salinity criteria EC_{se} and $EC_{1.5}$ for four ranges of soil clay content

Plant salt tolerance grouping ¹	Corresponding EC_{se} range ² (dS/m)	$EC_{1.5}$ reading, based on clay content of soil (dS/m)				Soil salinity rating
		10–20% clay	20–40% clay	40–60% clay	60–80% clay	
sensitive crops	<0.95	<0.07	<0.09	<0.12	<0.15	very low
moderately sensitive crops	0.95– 1.9	0.07–0.15	0.09–0.19	0.12–0.24	0.15–0.3	low
moderately tolerant crops	1.9– 4.5	0.15–0.34	0.19–0.45	0.24–0.56	0.3–0.7	medium
tolerant crops	4.5–7.7	0.34–0.63	0.45–0.76	0.56–0.96	0.7–1.18	high
very tolerant crops	7.7–12.2	0.63–0.93	0.76–1.21	0.96–1.53	1.18–1.87	very high
generally too saline for crops	>12.2	>0.93	>1.21	>1.53	>1.87	extreme

Notes: 1. These groupings are statistically derived divisions based on families of linear curves representing the salt tolerance ratings of the majority of crops reported by Maas and Hoffman (1977). The terminology of Maas and Hoffman (1977) has been modified and an additional group of sensitive crops incorporated.

2. EC_{se} given here is the boundary EC_{se} at which 10% yield reduction occurs for these plant salt tolerance groups.

A9.4 Interpretation of salt profile shape

Soil salinity measurements taken at depths 0–0.1 m, 0.5–0.6 m, 0.8–0.9 m and 1.4–1.5 m will allow an identification of the document processes operating at the time of measurement.

Typical salt profile shapes associated with recharge areas, discharge areas, normal areas, and intermittent recharge–discharge areas can be identified.

The **recharge** profile is indicative of a soil with high hydraulic conductivity (water moves easily through it) and seasonal or annual flushing of the small amounts of salt that accumulate as a result of evapotranspiration.

In the **normal** profile, the soil hydraulic conductivity is low and plants use more of the water in the soil profile, leaving salts behind. The depth in the root zone below which salt concentration is essentially constant represents the depth at which the roots are not taking up water. Over long time periods, each small pulse of salt in the recharge water builds up the general shape of the profile. The depth to the point of constant concentration varies with soil properties and the quantity of rainfall as well as the rooting depth of the vegetation. Thus, some soils that also show reasonable recharge may have a normal soil salt profile shape, but at a relatively low concentration.

The **discharge** profile is indicative of evaporation of water brought to the soil surface by capillary rise from a shallow watertable. In the other profiles described above, the dominant source of water is from the soil surface as rainfall. In this profile, the salt concentration at depth in the soil profile reflects the saline concentration of the shallow watertable. The degree of salt concentration at the soil surface will depend on rainfall, leaching, and surface salt flushing.

In a soil represented by the **intermittent** profile, the watertable may have fluctuated over a number of years from being shallow enough to result in salt concentration due to capillary rise to deeper depths where capillary rise is so low that it is essentially zero. In this case, the salt concentration is moved downwards by rainfall and upwards with the intermittent watertable rises, resulting in a fairly pronounced peak. This profile can also indicate bypass flow, where the soil is structured with macropores, allowing water to bypass the soil matrix into a better structured soil or aquifer below the root zone.

A9.5 Impact of shallow water tables

Soil surface salinity can result directly from upward flux of saline water or evaporation at the soil surface of water moving up through the soil matrix. The latter is most common and may result from saline or non-saline groundwater.

Evaporation from surface soil is an energy-efficient means of removing free water, since the actual evaporation rate often exceeds the actual evapotranspiration rate of introduced vegetation (particularly if the vegetation is affected by waterlogging or salt) and may approximate potential evaporation rates from an evaporation pan.

Talsma (1963) determined the critical depth of watertables at which groundwater supply equalled the daily evaporation rate for several soils. The results for a medium clay and a loam are shown in Table 4. Watertables have to be shallower in heavier soils and under conditions of higher daily evaporation rates (for example, in summer) before maximum capillary rise and salting will occur. Surface mulching can reduce the evaporation rate considerably.

Experience in Queensland, where daily evaporation rates generally exceed 5 mm/d, is that watertables need to be within one metre of the soil surface for a considerable part of the year for serious surface soil salting to develop.

Table 4. Watertable depths at which upwind water movement from the watertable equals daily class A pan evaporation for two soils (after Talsma 1963)

Soil type	Depth to watertable (m) for daily evaporation rate (mm/d)					
	1	2	4	5	8	10
Medium clay	1.3	0.9	0.6	0.5	0.4	0.4
Loam	2.0	1.6	1.3	1.2	1.1	1.0

Appendix 10. Risk assessment procedure for setting targets

Figure 7 shows a risk assessment process for the analysis of assets and values for setting interim targets.

First, the impact of a change in the biophysical environment is assessed (generally this will be a shift in a term in the material budget, e.g. rate of recharge). If the asset under consideration is sensitive to the biophysical change then the impact is large and becomes larger as the magnitude of alteration in the biophysical system increases. Tolerance is likely to be a step function or non-linear with change in the biophysical system, e.g. once an aquifer is full and discharge to the soil surface has extended to its maximum areal extent, the system will be less sensitive to further increases in recharge. If the impact is assessed to be low, then the need for action is deemed low. If the impact is assessed to be high, then the hazard posed to the asset is assessed by considering the cost of action compared to the value of the asset. In the asset risk assessment phase, these matters are considered at a broad level, i.e. detailed costing and management scenarios are not performed.

If the hazard is considered high, the overall risk is assessed. Risk is estimated by assessing whether the level of biophysical change resulting in high impact is likely to be reached. If it is, the potential for conflict between targets or other assets is rapidly assessed. If the asset has a high priority then the targets associated with it confer high priority onto the action proposed.

A more complete trade-off analysis follows the same procedure except that the costs and management actions are more closely analysed. This requires a broad consideration of interactions and a great deal of effort in assessing options, i.e. their likelihood of implementation, cost, and certainty of the estimation of their likely success.

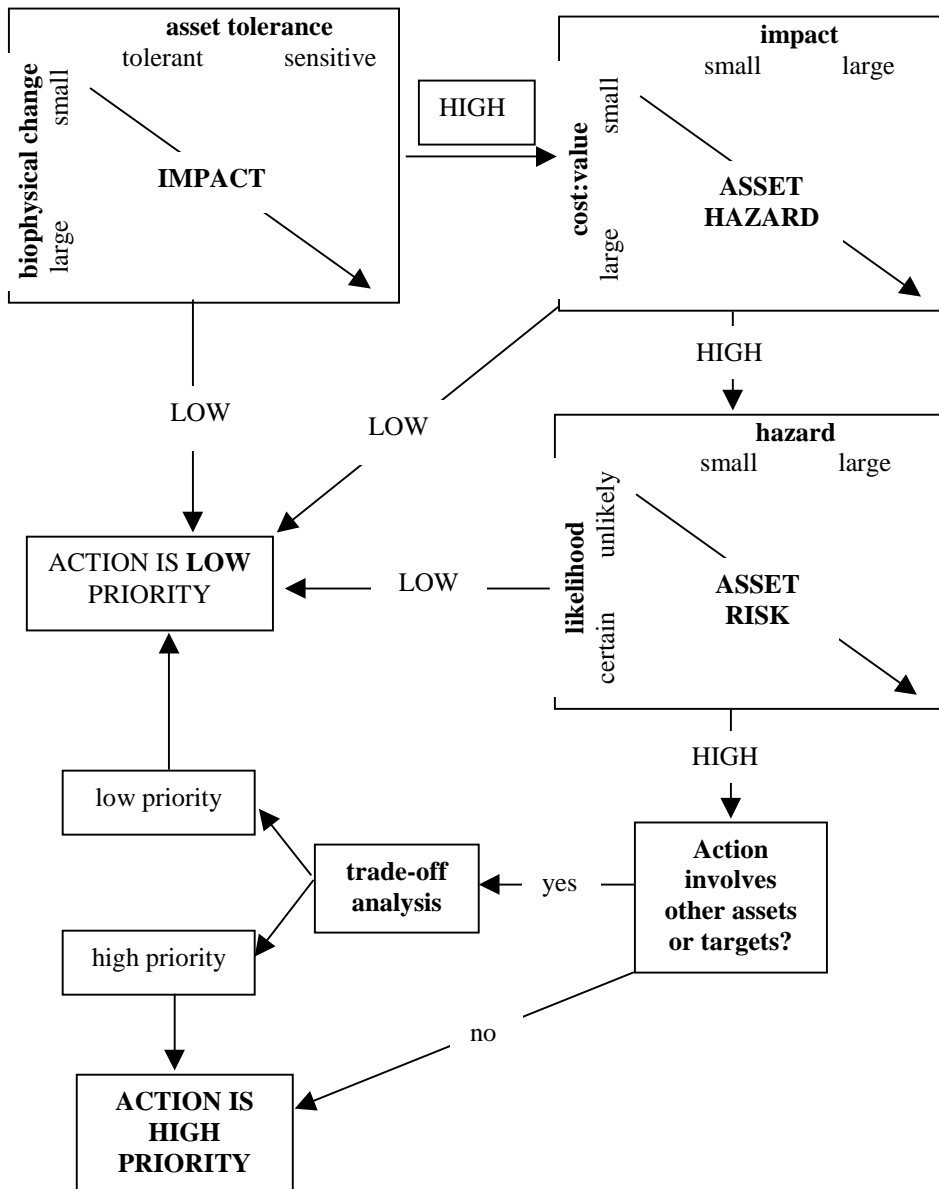


Figure 7. Trade-off analysis informed by risk assessment to determine priorities for action

Appendix 11. Management options for salinity and water quality

A11.01 Salinity control options

A large degree of unofficial agreement has been reached concerning the major options available for salinity management. Documents containing such sections have been produced by the National Land and Water Resources Audit, Murray-Darling Basin Commission, and each State jurisdiction (see bibliography).

A11.02 Water quality control options

A robust structure for water quality management options has not been derived. The draft list below shows some of the options available; it requires a great deal of work over the period to December 2001.

1. Matching land use and land capability: ensuring that inappropriate land use is not resulting in excessive nutrient or sediment loads to waterbodies.
2. Optimising land management: major issues include fertiliser management (particularly in horticultural enterprises near waterways under irrigation), stock control (access to waterways) and high salt and nutrient waste disposal in intensive livestock enterprises, e.g. dairy, beef feedlots, piggeries. Agricultural chemicals (pesticides and veterinary medicines) pose a major water quality problem that requires monitoring and action through optimised chemical usage patterns and procedures.
3. Industrial and urban waste control: treated effluent is high in both nitrogen and salt. Land disposal as an option has been studied and national guidelines are available.
4. Urban fertilisation of gardens and parks plus pet excretions (this may be only an issue in very large urban areas).
5. Vegetation/crop/pasture management to ensure cover of soil under most erosive conditions.
6. Riparian vegetation management: a set of national guidelines on design of riparian buffer systems is recommended.
7. Flow regulation to minimise temperature problems and algal propagation (probably covered under environmental flow management guidelines that are fast becoming out of scope for these standards).
8. River restoration: reestablishing natural ecological filtration and carbon and nutrient cycling.
9. Wetland protection (this is already treated under salinity but also can be important especially for nitrogen management).