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Towards an Australian groundwater quality assessment program

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Society increasingly demands that resource management decisions reflect ecological sustainability criteria. The current strain on the global environment makes it essential that environmental factors are considered along-side economic and social factors. This places increased emphasis on resource management as opposed to resource exploitation.

Parallel to this trend is the requirement that Government policies and programs be more accountable; politically, economically and socially. This is leading, within Australia, to the use of rigorous performance indicators, as measures of the success of management practices.

Australia, through various natural resource agencies, is moving towards more sustainable water resources management. The knowledge and information requirements to support these initiatives are, at present, ill-defined, but are likely to prove formidable. This means that public policy relating to water resources management will be framed with inadequate scientific information.

The Australian Geological Survey Organisation is developing an Australian Groundwater Quality Assessment Program, within the framework of the National Landcare Program and as part of the National Water Quality Management Strategy. This Program will seek to cooperatively meet the information needs of the Strategy by a number of survey and research studies.

Introduction

We are currently witnessing a unique period of human history. The rate at which resources are being consumed, and the consequent degradation wrought by that consumption, is at its highest in Earth's history. Increasingly, environmental impacts are assuming a more significant place in policy development. Patterns of natural resource development, production and use are changing in response to their impact on the environment, as well as in response to economic forces.

Environmental policy development is increasingly directed towards integrated approaches to the development, management and use of natural resources. Water resource issues are inextricably linked to the natural resource debate, because they are an integral component of total catchment management practice. One key outcome of an effective water resource policy will be enhanced water quality appraisal and management. This will not only link land and water management at a catchment scale, but will also integrate surface water and groundwater management requirements, emphasising that management linkages must reflect the biophysical linkages in a bid to effect management based on the reality of the process.

In defining a modern role for national geological surveys, Price (1992) analysed the natural resource management debate from a Government perspective. He observed:

> '... to govern, governments require information. They require information to identify and analyse national problems and opportunities, to make sound public policy decisions, and to carry out these decisions. To be most effective, the information must be impartial and trustworthy. Moreover, in a democracy, the essence of the information also must be available and understandable to the people for whom the governments act and to whom they are accountable.'

Price's analysis presents several principles that guide the information requirements for the development of natural resource management policy. These cover the ideas of:

- national problems and opportunities,
- impartiality and independence,
- information transfer, and
- public accountability.

There is an important reliance between the development of effective natural resource management policy, and the availability of sufficient, reliable, technical information. This reliance is necessary to underpin an understanding of the biophysical processes that the policy will address. An important prerequisite must be adequate knowledge of the fundamental interactions between land and water, including those that control groundwater quality.

However, the ideal situation is not always achieved. Gaining an understanding of the natural processes operating in a landscape is a time-consuming and costly exercise, and is not always in concert with policy development. Frequently, the time required for research, including systematic studies to define problems, is longer than the lifetime of many national policy issues. More often than not the *precautionary principle* applies when policy is developed; i.e. policy is made recognising that not all the necessary technical information is available, but the best available information has been used. The challenge for natural resource researchers is to coordinate research so that data needs for sound policy development are met quickly.

Australian natural resource policy development is currently ahead of a fundamental scientific understanding of the biophysical processes that need to be addressed. Groundwater quality monitoring will underpin this natural resource management policy. The scientific objectives of a national groundwater quality monitoring program would be:

- to collect information on the natural, and contaminated, levels of groundwater constituents, and
- to assess the current state and long-term trends in water quality

as a knowledge base for a national strategy for water resource development and protection. An effective monitoring program will provide information to improve the development, protection and management of surface water and groundwater resources, and to assess groundwater pollution problems.

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Strategic overview

A model to indicate resource performance

(A) Principles

A variety of natural resource management policies are currently being developed and implemented in Australia. These policies and strategies invariably include some form of performance assessment. One model or paradigm being proposed to enable consistency of measurement is the *Adaptive Management Cycle* — with elements of planning, implementation, monitoring, evaluation and reporting (Fig. 1). The successful use of this *cycle* relies on the collection of adequate information, of adequate integrity, which will allow outcomes to be assessed. The outcomes and activities from a policy process can be large in number and usually form a progressive hierarchy. A generalised hierarchy of outcomes is shown schematically in Figure 2.

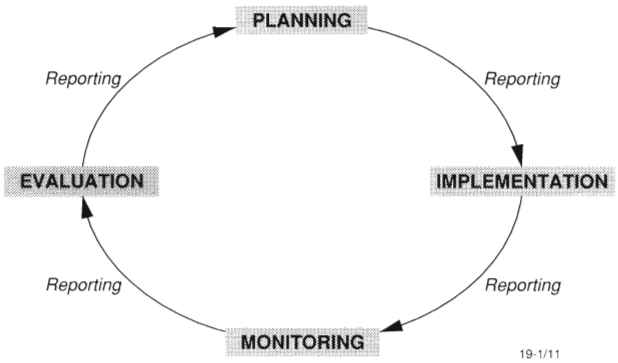

Figure 1. The Adaptive Management Cycle. A feedback model for assessing and managing natural resources.

It is necessary to obtain successful outcomes for each step prior to effecting the next step in the hierarchy; for instance, a change in the understanding regarding a phenomenon or process will not occur without adequate knowledge. Achieving successive outcomes increases in complexity through the hierarchy. As well, general control of the progression through the outcomes moves away from the program managers — more reliance is placed on activities outside the manager's realm of experience, e.g. marketing, promotion and knowledge transfer.

To successfully progress through the hierarchy, a range of information is required (monitoring, technical advice, research and modelling information, dissemination, marketing) depending on which outcome, within the hierarchy, the performance measurement is focussed. A different result will be achieved if the outcome of the process is chosen part-way down the hierarchy. For instance, setting the performance measure of a policy as the degree to which the knowledge is accepted (an interim outcome) achieves a different result (and requires the collection of different information) from setting the performance measure of the policy as actual change in the environment.

An example to illustrate these principles can be made with the current strategy to manage salinity in the Murray–Darling Basin: A range of strategies and initiatives have been adopted for the management of land salinisation in the Murray–Darling Basin (see below). The final measure of

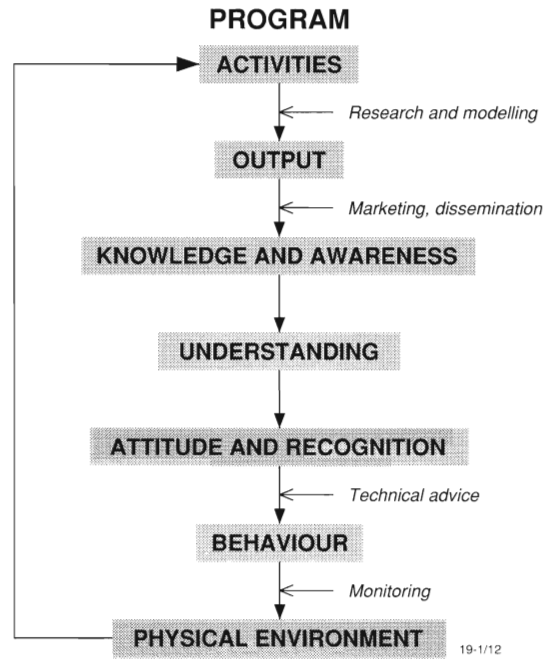

Figure 2. A hierarchy of outcomes (or achievements). Within this framework success can be measured against increasingly more complex — and more difficult to achieve — outcomes. (After D.P. Bailey, pers. comm., 1993)

the success of these strategies will be whether the area affected by salinity actually decreases. However, to achieve this outcome, a number of intermediate outcomes need to be realised, and a vast quantity of monitoring data needs to be collected. The intermediate outcomes that would be applicable, in terms of the hierarchy presented above, would include (a) a range of policies and programs aimed at understanding the process (both socio-economic and biophysical) that controls the salinisation of land; (b) a program of information transfer to the community and natural resource managers to achieve a change of attitude and behaviour; and (c) a program of data collection that would monitor trends of land salinisation. If performance success (of the broader program) was measured by the satisfactory inception of a framework to allow transfer of knowledge, it would still be difficult to decide whether the broader program was closer to achieving its goals. While the success of these intermediate goals is critical for achieving the long-term strategy, the final outcome sought is not necessarily assured until the apex of the hierarchy is reached. This discussion emphasises the criticality of monitoring progress and performance, ultimately in terms of changes in the biophysical parameters which provide a measure of the natural resource. Without a base of data and information to be able to assess change in these parameters, no meaningful comment can be made regarding the success, or otherwise, of a set of actions.

(B) Case studies

Several resource management assessment initiatives and actions are currently underway in Australia and overseas, aimed at sustainable water resources management. Three case studies are analysed below, using the general outcome-oriented model discussed in the preceding section. These examples show the type of information needed to adequately monitor the application of these strategies.

National Water Quality Management Strategy

To obtain national consistency in water quality management, the then Australian Water Resources Council (AWRC) and the Australian and New Zealand Environment and Conservation Council (ANZECC) agreed to jointly develop a National Water Quality Management Strategy. The policy objective of this Strategy is to achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development (AWRC, 1992a).

The Strategy includes a series of national guidelines dealing with key water quality management issues. Those completed to date are Policies and Principles, Sewage Systems — Effluent Management, Sewage Systems — Trade Wastes, Groundwater Protection and Water Quality Management in the Rural Environment. The Strategy is complemented by ambient water quality criteria embodied in Australian Water Quality Guidelines for Fresh and Marine Waters.

Under the National Water Quality Management Strategy, a working group is developing a framework to provide a nationally consistent basis for water quality monitoring and reporting (AWRC, 1992b). This work will focus on resource assessment, including identification and reporting on the status and trends of water quality. It will encompass an examination of biological, physical and chemical water quality indicator requirements. At a later stage it is expected that the working group will evaluate the effectiveness of the Strategy.

The socio-economic objectives of the water quality monitoring program will be to inform resource managers and the community of the water quality status of priority water bodies. The scientific objectives will be to:

- identify and adopt relevant indicators of water quality,
- determine reliable baseline conditions,
- assess the relative priorities for monitoring,
- discern trends in water quality, and
- identify areas of concern.

Murray–Darling Basin Natural Resource Management Strategy

A framework for the management of the natural resources of the Murray–Darling Basin (the Natural Resource Management Strategy — NRMS) has been developed under the aegis of the Murray–Darling Basin Ministerial Council. The objective of the NRMS is to 'promote and coordinate effective planning and management for equitable, efficient and sustainable use of the land, water and other environmental resources of the Basin' (MDBMC, 1990).

The Strategy clearly makes the community responsible for the development, implementation, monitoring and evaluation of natural resource management action plans for their particular regions. Government will support and assist this responsibility where appropriate. This assistance includes the provision of information about biophysical processes. The Strategy emphasises the need for a common basis for identifying, assessing and monitoring resource degradation throughout the Basin, to ensure action is directed at the highest priority areas.

Water quality conditions and trends in the United States

The United States is currently developing a validated information base that will guide the protection of their water resources. One aspect of this initiative is to analyse existing data to decide its value, either nationally and/or regionally, for assessing current water quality conditions and trends. The United States Geological Survey (USGS), in cooperation with other agencies and universities, is undertaking such a study of water data in the States of Colorado and Ohio (Hren & others, 1987; Oblinger Childress & others, 1989; Norris & others, 1991).

Available water quality data (for both surface water and groundwater) were screened according to a range of criteria which included data representing ambient conditions, public availability, quality assurance, computerisation of results, and the use of established field and laboratory protocols and practice. The results of this study provide a cautionary tale for Australian groundwater (if not surface water) quality assessment. The major conclusions drawn were as follows:

- The types of data, and the number and areal distribution of water quality data-collection sites, were insufficient for describing existing water quality conditions throughout each State. In 1984, about US$100 million was spent for water quality activities in the two States. Of this amount, only about half in one State and less than one-tenth in the other was applied to activities that supplied data suitable for inclusion in a national or regional database. Less than 10% of the total data collected pertained to groundwater;
- Only 1% of the groundwater quality data-collection sites in Colorado and 13% in Ohio yielded data useful for deciding groundwater quality trends. These data-collection sites were clustered in response to the regional distribution of water quality problems; and
- Data useful for deciding water quality processes was limited to specific sites.

An Australian Groundwater Quality Assessment Program

This paper seeks to develop an operational framework for an Australian Groundwater Quality Assessment Program (AGQAP) as one contribution for overcoming an anticipated shortfall of knowledge available to the community, resource managers and policy advisers. The objectives of AGQAP would be to (after UNESCO/UNEP, 1988):

- support the groundwater protection guidelines and strategy now being developed;
- provide representative data on the current state and trends in groundwater systems for sustainable groundwater resource management;
- supply appropriate and validated data to help identify existing and potential point and diffuse pollution sources; and
- produce data leading to a sound scientific understanding of the temporal and spatial changes in the quality of groundwater systems due to natural processes.

These objectives would form an essential basis for integrated catchment management decisions.

This program would provide regional and catchment scale assessments of the present baseline quality of Australia's most important groundwater resources, particularly those whose degradation would have significant economic, environmental, and social impact. Effective use of the database to be developed under this program is essential for the achievement of groundwater management decisions to enable:

- sustainable development of Australia's agriculture and rural industries with our natural ecosystems, and
- the development of effective programs and policies to meet water quality needs.

The Murray–Darling Basin Commission's Groundwater Working Group is developing similar strategies to this national groundwater quality monitoring program for the Murray–Darling Basin. The Working Group's work will provide a catchment-scale pilot project under which the detailed mechanics of carrying out AGQAP can be refined.

Operational overview

Guiding principles

The proposed Australian Groundwater Quality Assessment Program should conform to the accepted principles of Integrated Catchment Management. Specifically:

- priority should be given to the most vulnerable aquifer systems — however, pristine aquifer types should be identified and sampled as early as possible to provide comparison of baseline data for natural background conditions;
- the recommended study area (building block) is the catchment (drainage basin);
- catchments may be subdivided as necessary for assessment into local and resource capable areas, but the minimum reporting unit should be the catchment;
- regional and national assessments will be assembled from a compilation of catchment units;
- coordination of groundwater and surface water investigations and assessment with land-use data within each catchment is desirable, but may not be readily achievable in the early stages;
- consistent with priority accorded by estimated vulnerability, study areas chosen should reflect the diversity of hydrogeological and agricultural and other land-use characteristics within and between catchments;
- for baseline assessment the widest possible range of groundwater quality parameters should be measured;
- output from studies will be in GIS format, for ready portability and exchange with other linked database components of a AGQAP;
- 'best practice' techniques and methodologies for sample acquisition and analysis (strict quality assurance program) should be used — this includes the development, testing and refining of methods;
- an agreed set of data reliability criteria should be used to assess both historical data from agencies and contemporary data acquired; and
- nationally consistent information should be kept in an integrated database.

Program elements

The program would encompass several key tasks:

- the establishment of an agreed set of protocols for data collection and storage;
- the analysis of existing water quality archive data — held by all levels of Government, tertiary institutions and by private organisations and individuals, to assess their usefulness for national and regional groundwater quality assessment;
- detailed catchment studies, targeted at relevant water quality issues, to establish baseline conditions together with subsequent monitoring of changes in groundwater quality with time, at appropriate intervals, to evaluate assessment of management performance; and
- detailed research and investigation into the key processes affecting groundwater quality.

The program would be ongoing and initially divided into two phases:

- Phase 1 — A regionally-based reconnaissance-scale compilation of existing data at a national level. This program would operate under cooperative agreements between the Commonwealth, State and local authorities within the framework of the National Landcare Program. Interpretation of this data would also address the issue of the value of existing data in terms of national or regional coverage. The consequences of this interpretation are significant, as many data-collecting organisations are data-rich, but information-deficient. A direct result of this process would be the opportunity to modify networks to obtain better information where necessary. This phase would run for five years.
- Phase 2 — A series of detailed studies aimed at getting more comprehensive and validated data for the key groundwater resource areas than that which already exists. High priority regions identified are the Murray–Darling Basin, the populated region of southeastern Australia, the populated regions of southwestern Australia, and northern Australia.

It is proposed that priorities identified from Phase 1 of the program, will be included within Phase 2 — i.e. it would be possible for the latter Phase to run concurrently with Phase 1. Each regional study will be a cooperative project undertaken with the relevant local authorities, and would run for around three years.

Evaluation of program effectiveness

The Program will be accountable for a range of outcomes according to the performance models already discussed. These will be developed as part of the future planning process, but would include evaluation of:

- program procedures for effectiveness — ranging from observation well installation, sampling, analysis, GIS output, to value to water resource managers and quality assurance at each stage;
- database management system, assessment of the value of database and interpretative reports to water resource managers; and
- effectiveness of monitoring and interpretation of groundwater protection strategies that have been carried out in response to baseline data.

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