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**Geoscience Australia**

# Guidelines for Groundwater Protection in Australia – end-user analysis report

MILESTONE REPORT

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by

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# 1. Introduction

The National Water Quality Management Strategy (NWQMS) provides national policies, guidelines, information and tools to help government and communities manage water resources to meet current and future needs. The Guidelines for Groundwater Protection in Australia (NWQMS Guidelines #8) were published in 1995 (ARMCANZ/ANZECC, 1995). The primary purpose of the Guidelines was to provide a national framework for protecting groundwater from contamination in Australia. Many jurisdictions and natural resources and catchment management authorities have used the Guidelines to develop groundwater policy, regulations and strategies designed to improve the management of groundwater resources.

In order to focus on the development of broad-scale protection strategies across Australia, a specific goal for groundwater protection was formulated:

*“The goal of groundwater protection is to protect the groundwater resources of the nation so that these resources can support their identified beneficial uses and values in an economically, socially, and environmentally sustainable and acceptable manner”* (ARMCANZ/ANZECC, 1995).

The goal recognises that not all groundwater is of the same value and that the focus for action is to get strategies in place for protecting all major aquifers.

Chapters 1 and 2 of the Guidelines introduce the objective, scope, and context, and outline the need for groundwater protection. The underlying principles of the Guidelines, being the concepts of beneficial uses and values, and the polluter pays principle are described in chapter 3. The approaches to groundwater protection, namely: three forms of “intervention”: first, intervention by command, that is, by laws which directly control actions and activities; second, intervention through market mechanisms; and third, intervention through public participation and education are described in chapter 4. A general approach to groundwater planning, which involves assessing the resource, setting beneficial uses and accompanying criteria, developing protection measures, setting contingency measures and monitoring requirements, and implementing the plan (chapter 5).

Scientific knowledge of groundwater systems in Australia has grown significantly since the Guidelines was first developed in 1995. Science has provided new insights into connectivity between aquifers and links between groundwater and surface water systems. In addition, recent drought-related reductions in surface water availability have resulted in greater use of groundwater resources. Previously unknown fauna and ecosystems have also been described.

From time to time, components of the various NWQMS documents have been reviewed in the past. However, no systematic review of the Guidelines for Groundwater Protection in Australia has been undertaken since its development in 1995. In order to assess the need to revise the existing Guidelines and make recommendations for future development, it is also necessary to understand end-user views and needs. The purpose of the end-user analysis is to rapidly establish the extent to which the current Guidelines are adequate for supporting end-user needs and to make recommendations for future developments.

## 2. End-User Survey Methodology

In order to assess the need to revise the Guidelines for Groundwater Protection in Australia, it is necessary to understand the target audience (“end-users”) and their needs. A methodology has been developed to assess end-user needs and the steps involved are as follows:

- establish a network of key jurisdictional personnel, researchers and natural resources and catchment management authorities involved with use of the groundwater quality protection guidelines
- design a survey questionnaire (with DEWHA) based on the literature and regulatory review
- email the survey questionnaire to the selected end-users
- follow up telephone interviews with the selected end-users based on their response to the survey questionnaire; and
- end-user analysis and report on the findings to DEWHA.

### 2.1 END-USER SURVEY QUESTIONNAIRE

An end-user survey questionnaire has been developed in consultation with, and endorsement by, DEWHA. The aim of the questionnaire was to get the maximum feedback and to get some consistency in responses from the end-users. The questionnaires also encouraged respondents to provide additional feedback on the use of the current groundwater quality guideline, in particular, whether there is any need for updating the guidelines.

**The end-user survey questionnaire on the Groundwater Quality Guidelines sought feedback with specific questions including:**

- Do you or your organisation use the Groundwater Guidelines?
- How relevant and useful are the Groundwater Guidelines as a key reference document for the protection of the quality of groundwater from contamination?
- Are the Groundwater Guidelines adequate for managing groundwater quality?
- Do the Groundwater Guidelines adequately address issues such as surface and subsurface groundwater dependant ecosystems, connected surface and groundwater resources and other current and emerging groundwater quality issues?
- Do the Groundwater Guidelines interface well with other NWQMS Guidelines?
- Do the Groundwater Guidelines interface well with State and Territory guidelines and are there links that should be included in the Groundwater Guidelines?
- Is there a need for updating the current Groundwater Guidelines?
- What types of information would you like to see updated?

The assessments of the information from the end-user survey questioner provided constructive inputs to the levels of groundwater quality guidelines implementation and future directions.

### 2.2 SURVEY RESPONDENTS

The questionnaire has been sent via email to sixty five end-user groups. This includes six government, five research, twenty four natural resource management groups and thirty catchment management authorities. Natural resource management groups represented the largest proportion of the total end-users surveyed.

### 3. End-user Survey Findings

The feedback received from the end-user survey has been presented in Appendix A. In general the end-user groups have found the Guidelines for Groundwater Protection in Australia to be a useful reference document in terms of providing guidance on overall groundwater protection. A Catchment Management Authority (CMA) indicated that the authority use the Guidelines occasionally as a reference document to ensure that the appropriate guiding principles are applied in broader plans that provide the basis for promoting coordinated natural resource management. One NRM agency used the guidelines for the purpose of setting indicators and targets for work in the field and as a reference document to research data collection and assembling for the purpose of developing a water management strategy for the region.

The end-user perspectives presented in this report is in agreement with the earlier report by Bennett (2009). While the Guidelines has proved to be a useful reference document for overall groundwater protection, the end-users have identified a number of matters for revision, including:

- Improve the current groundwater guidelines using a risk based approach to management and incorporating the findings of studies over the last decade;
- Update some of the terminologies in the guidelines and make it consistent with that accepted in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMICANZ, 2000);
- Current regulatory situation regarding environmental values – lack of consistency in the methods being used by State jurisdictions and recommended a single nationally endorsed approach to deriving guidelines for environmental values;
- Consideration and guidance needs to be given on groundwater sampling and analysis in the guidelines. This is to make sure that the results reflect the environment we are seeking to protect, i.e. groundwater in its aquifer state or groundwater as an input to receiving surface waters, or for use in its oxidised state;
- The use of attenuation zones where water quality may exceed water quality objectives. A proposed solution is the use of three different management contexts: (i) MAR guideline usage (excluding waste disposal); (ii) areas exempt from protection (including managed waste disposal); and (iii) natural attenuation zones (where water quality naturally recovers towards water quality objectives);
- Groundwater extraction policies need to link more closely with GDEs and the groundwater guidelines could suggest ways in which allocations could take account of GDEs;
- Research is needed to clarify whether terrestrial vegetation is protected by current guidelines relevant to primary industries; Terrestrial fauna (not an ecosystem type per se) may also be protected by water quality guidelines for stock watering, but given the large size difference between domestic cattle and many native animals, this may need some review;
- Inclusion of guidelines for non-surface expressed GDEs in accordance with the existing guidelines for aquatic ecosystem protection (ANZECC and ARMICANZ 2000), including trigger

values for physico-chemical stressors and toxicants based on an understating of the related hydrogeology;

- Methods of accounting for impacts on streamflow in connected streams could be provided, or linkages made to 'connected waters' website;
- There needs to be an appropriate cross-reference to the Managed Aquifer Recharge guidelines (#22 – Module 2);
- Consider the impacts of stock and domestic wells and wells in urban areas (where the density of wells can exceed the rate of aquifer replenishment);
- Consider emerging water quality issues such as acid sulfate soils, surface water-groundwater interactions, mining impacts, managed aquifer recharge and climate change;
- Link to groundwater modelling guidelines that have been developed by the Murray-Darling Basin Commission; and
- Update groundwater use information, recent references, water quality standards and state and territory legislation regarding development etc.



## 4. Summary and Recommendations

### 4.1 SUMMARY

The Guidelines for Groundwater Protection in Australia are part of the National Water Quality Management Strategy (NWQMS). The objective of the Guidelines is to provide a national framework for protecting groundwater from contamination in Australia. The Guidelines have enabled State and Territory agencies and also natural resources and catchment management authorities to develop policies and strategies which are tailored to their specific legislative and resource management situations. Although the Guidelines have proved a useful reference document, end-users have indicated that the Guidelines be revised to:

- Include a risk based approach to management and incorporate the findings of studies over the last decade;
- Update groundwater use information and recent relevant references;
- Include appropriate links to other NWQMS guidelines and state and territory legislation;
- Ensure the Guidelines addresses new issues such as groundwater-surface water connectivity, acid sulfate soils, managed aquifer recharge and climate change.

Addressing the above matters will ensure that the Guidelines remain relevant into the future, and provide a useful source of guidance for end-users to develop their policies and strategies in the area of groundwater protection.

### 4.2 RECOMMENDATIONS

It is recommended that the Guidelines for Groundwater Protection in Australia should undergo a **minor revision**. The Guidelines can be improved by updating the groundwater facts, figures and references. It is also recommended to include discussion of emerging water quality issues and appropriate links to other water quality guidelines as well as state and territory legislation.

## 5. References

ARMCANZ/ANZECC (Agriculture and Resource Management Council of Australia and New Zealand/Australian and New Zealand Environment and Conservation Council), 1995. Guidelines for groundwater protection in Australia. National Water Quality Management Strategy.

Bennett, J. 2009. Report on Future Development Needs for the National Water Quality Management Strategy Guidelines 1-22. Report prepared for the Department of Environment, Water, Heritage and the Arts with assistance from DEWHA officers. 3 March 2009.

**Appendix A: Summary of stakeholders' comments on Guidelines for Groundwater Protection in Australia**

End-users	General Comments	Process Matters	Policy Matters	Technical Matters
Research Body #1	<p>The current Guideline was released in 1995 and therefore predate the major revision to the ANZECC/ARMCANZ water quality guidelines (WQGs) that were released in 2000. They therefore fail to include the major new approaches of these revisions, namely the risk-based framework and the closer integration of biological and chemical effects. Any revision should address these issues both in terms of the overall framework but also in the derivation of the actual guideline values.</p> <p>NZ is not mentioned in the Guideline, and consistent with the other NWQMS documents, there should be some consideration of expanding the scope to include NZ.</p> <p>In a number of jurisdictions, stock and domestic wells are capable of harming groundwater-dependent ecosystems simply because these are exempted from extraction constraints and, in urban areas, the density of wells can exceed the rate of aquifer replenishment. Consideration needs to be given as to whether this situation is desired and appropriate statements made in the revised Guideline on the decision.</p> <p>It is suggested that this Guideline cross-reference the guidelines for managed aquifer recharge (MAR). Because the MAR guidelines appear under water recycling guidelines, where they are most appropriate, those who are using natural water and treated drinking waters for MAR may need a cross-reference to help them find these guidelines.</p>	<p>A major limitation of the current regulatory situation regarding environmental values is the lack of consistency in the methods being used by state jurisdictions. Basing environmental values on ambient (groundwater) quality and historical use as outlined in the NWQMS Policies and Principles, seems to have been overlooked or ignored in some states. For example, in SA, the Code of Practice for Water Quality Protection set default environmental values and the process for changing these values has taken more than five years and has been a major deterrent to Managed Aquifer Recharge in brackish aquifers. In contrast, the method adopted by Victoria has saved considerable time by both proponents and regulators. We recommend that more specific guidance be provided in the Guideline on how guidelines for environmental values should be developed. We believe that a single nationally endorsed approach to deriving guidelines for environmental values that includes the derivation of site-specific guidelines (as with the WQGs) should be determined and a set of default guideline values established in any revision of the Guideline</p> <p>In order to address the potential issue of the surface water WQGs not being appropriate, it is suggested that:</p> <ul style="list-style-type: none"> <li>i) a framework to derive guidelines for toxicants and physicochemical properties should be developed that incorporates riskbased principles and a hierarchy for the use of data and methods to derive the guidelines (similar to the framework used to derive the WQGs). It is recommended that the method adopted should be as close as scientifically justifiable to that used in the most recent Australian WQGs for surface waters (this is currently ANZECC and ARMCANZ, 2000 but this could change as this document is also under review).</li> <li>ii) a review of the available sensitivity of groundwater organisms to toxicants and physicochemical properties should be conducted to determine if guidelines can be derived.</li> <li>iii) using the method adopted in (i) guideline values for a suite of toxicants should be developed. Ideally, guidelines should be</li> </ul>	<p>The WQGs (ANZECC and ARMCANZ, 2000) recommend that the numerical limits presented therein “should apply to the quality both of surface water and of groundwater since the environmental values which they protect relate to above-ground uses. Hence groundwater should be managed in such a way that when it comes to the surface, whether from natural seepages or from bores, it will not cause the established water quality objectives for these waters to be exceeded, nor compromise their designated environmental values.”</p> <p>Whether this over-arching philosophy is still the most appropriate should be carefully considered and the results of the consideration be incorporated into any revision of the Guideline.</p> <p>In the Managed Aquifer Recharge (MAR) Guidelines, there is the concept of a finite and transient attenuation zone where water quality may fall outside the objectives for the ambient environmental values. However the ambient environmental values must be achieved continuously outside the attenuation zone, and within the attenuation zone, beyond a short period after cessation of recharge.</p> <p>The MAR guidelines explicitly include the requirement of recovery of water for beneficial use or of intentional aquifer protection (e.g. from saline intrusion). It explicitly excludes waste disposal.</p> <p>This is a very different concept to indefinite aquifer attenuation zones as currently apply in Victoria, which are areas annexed from an aquifer where the function of the aquifer is deemed to be to allow waste disposal, and in such an area the aquifer is exempt from protection and so is allowed to be polluted for an indefinite time into the future. The correct term for these areas is not attenuation zones but areas exempted from protection.</p> <p>There are also cases where natural attenuation has been approved as a means of allowing an area to recover</p>	<p>Much of the terminology in the Guideline needs to be updated to make it consistent with that accepted in WQGs (ANZECC and ARMCANZ, 2000).</p> <p>The WQGs (ANZECC and ARMCANZ, 2000) include a statement ‘that different conditions and processes operate in groundwater compared with surface waters and these can affect the fate and transport of many organic chemicals’ which may have implications for the application of guidelines and management of groundwater quality. Careful consideration and guidance needs to be given to how groundwater samples are collected and stored in order to prevent oxidation of the samples. Similarly, consideration and guidance must be given as to how testing of the groundwater (both chemical and ecotoxicological) should be conducted so that the results reflect the environment we are seeking to protect, i.e. groundwater in its aquifer state or groundwater as an input to receiving surface waters, or for use in its oxidised state. These factors are largely ignored in the current guidelines.</p>

		<p>derived for the same toxicants that have guideline values in the Australian and New Zealand surface water guidelines (ANZECC and ARM CANZ, 2000).</p> <p>Again, developing a nationally agreed definition of what constitutes groundwater dependent ecosystems (GDEs) would help make applications consistent across states, e.g. in dealing with protection of terrestrial phreatophytic vegetation. Groundwater extraction policies need to link more closely with GDEs and the Guideline could suggest ways in which allocations could take account of GDEs. Methods of accounting for impacts on streamflow in connected streams could be provided, or linkages made to Geoscience Australia's 'connected waters' website.</p>	<p>from historical pollution. Such zones could be ascribed a third name to describe that in these zones ultimately the original environmental values will be restored. However this process may take many years, unlike the attenuation zones in MAR which are well defined in areal extent and typically have attenuation periods of less than 12 months.</p> <p>It is suggested that a nationally consistent set of terms for the above scenarios be identified and distinguished so as to avoid confusion. This would support maximal beneficial uses of aquifers via Managed Aquifer Recharge, and cost-effective remediation of contaminated groundwater where 'natural attenuation' is viable.</p>	
Research body #2	There is a need for updating the current Groundwater Quality Guidelines.			<p>Consider issues such as acid sulphate soils, surface water-groundwater interactions and mining impacts during revision.</p> <p>Link to the Murray-Darling Basin groundwater modelling guidelines.</p> <p>Update water quality standards, state and territory legislation re: development, etc, etc.</p> <p>Update groundwater use information.</p>
Research body #3	<p>It is now timely to consider the ecological aspects of groundwater (non-surface expressed) in any revision of the protection guidelines.</p> <p>The need for groundwater specific guidelines is provided under technical matters</p> <p>A unified framework for water quality for ecosystem protection is provided under process matters</p> <p>Research needs to develop groundwater quality guidelines were also provided.</p> <p>Research is needed to clarify whether terrestrial vegetation is protected by guidelines relevant to Primary Industries.</p> <p>Terrestrial fauna (not an ecosystem type per se) may also be protected by water quality guidelines for stock watering, but given the large size difference between domestic cattle and many native animals, this may need some review.</p>	<p>Water quality guidelines for aquifer ecosystems should be developed in accordance with the existing framework for aquatic ecosystem protection (ANZECC/ARM CANZ 2000). Trigger values should be derived for both physico-chemical stressors and toxicants. Any trigger values for groundwater should adopt a similar riskbased approach, using reference site data for physico-chemical stressors, and toxicity test data and species sensitivity distribution modelling for toxicants.</p> <p>Trigger values for physico-chemical stressors may be readily determined by collating water quality information from the many groundwater monitoring programs currently underway in Australia. Particularly important here is that local hydrology must be considered, as changes in depth, flow and local geology may strongly influence many physico-chemical variables in groundwater.</p> <p>It is clear that maintenance of water quality alone is insufficient for protecting groundwater ecosystems and other GDEs and that maintaining the groundwater regime, comprising the flow, pressure, depth and timing of water</p>		<p>The (current Guideline) focus ignores aquifer (subterranean) ecosystems and other groundwater dependent ecosystems (GDEs) reliant on subterranean water.</p> <p>It is clear that maintenance of water quality alone is insufficient for protecting groundwater ecosystems and other GDEs and that maintaining the other aspects of the whole groundwater regime, comprising the flow, pressure, depth and timing of water availability of groundwater is also essential. These other aspects of the groundwater regime should also be considered in the proposed revision of the guidelines. Methods for determining groundwater regimes are described elsewhere and will not be considered further in this submission. Instead, this submission will focus on the water quality needs of aquifers and GDEs. Importantly however, water quality guidelines for aquifers will feed directly into the setting of environmental water requirements for aquifers and GDEs.</p> <p>The existing guidelines for aquatic ecosystems are unlikely to protect groundwater ecosystems because:</p> <ol style="list-style-type: none"> <li>Groundwater ecosystems contain a unique fauna not found in surface waters, which have not been used in the derivation of trigger values and which may respond differently to toxicants</li> <li>Unique environmental conditions in aquifers may alter</li> </ol>

		availability of groundwater is also essential. The groundwater regime needed to maintain aquifer ecosystems and other GDEs should be considered in the proposed revision of the guidelines for groundwater protection.		<p>the toxicity or speciation of chemicals and/or the response of biota.</p> <p>Globally, aquifers are being recognised as hotspots of biodiversity (Sket 1999; Humphreys 2006) comprising species that are adapted to the groundwater environment and are not found in surface waters. Groundwater macrofaunas are dominated by crustaceans, but also include gastropods, oligochaetes, mites and occasional insects (see review by Humphreys 2006). The foundation of the ecosystem is the microbial assemblages that, through heterotrophic or chemotrophic pathways, capture energy and form biofilms. These are grazed by the macrofauna, and meiofauna such as turbellarians, rotifers, nematodes and protozoa (Humphreys 2006). Importantly, groundwater ecosystems rarely support vertebrates and generally lack primary producers (such as plants or algae that cannot grow in the dark) (Humphreys 2006). As a result, trigger values based on toxicity data for vertebrates and primary producers may not be relevant for groundwater environments, and future trigger value determinations must include toxicity data for microbial and meiofaunal assemblages and groundwater adapted macroinvertebrates.</p> <p>Considering the truncated diversity of groundwater leads to different trigger values than for the full range of surface species, and further, suggests that groundwater ecosystems may be more sensitive to some pesticides than surface assemblages (Hose 2005). In contrast, recent toxicity data using local groundwater species suggests that groundwater invertebrates are more tolerant of metals than surface-water invertebrates (Hose unpub data). The physical environment of aquifer and cave ecosystems is very different from the surface environment and may alter the toxicity of pollutants. The nature of groundwater ecosystems will also influence the fate and toxicity of chemicals in that environment. The underlying geology will influence the particle size and chemical nature of the substrate, which in turn influences the porosity of the aquifer (and rate of water movement), the speciation or absorption of pollutants and background water quality. As a result, there is an acute need for toxicity information that is site and ecosystem specific.</p>
NRM agency #1	The guidelines are used only for the purpose of setting indicators and targets for work in the field and as a reference document to research data collection we are assembling for the purpose of developing a water management strategy for the region before we proceed to prescription			