ASSESSING THE CUMULATIVE EFFECTS OF MINING ON GROUNDWATER AND CONNECTED SYSTEMS

Author/s: Chris Moran¹, Paul Howe², Sue Vink¹, Alana Horan², Greg Hoxley²

Affiliations: ¹Sustainable Minerals Institute, University of Queensland, ²Sinclair Knight Merz Pty Limited

Introduction

Australia has a long history of mining and, over time, the industry has contributed significantly to the National economy, through the provision of raw materials for commodities, employment and generation of export income. To operate effectively, the mining industry often requires access to substantial volumes of water to meet processing, dust suppression and potable water requirements, controlling inflows to mine pits and underground workings, and safe storage of mine wastes (tailings, overburden and barren ore body). There is growing concern within regulatory authorities and the broader community that mine approvals occur without due consideration of the effect that multiple mine operations have on groundwater resources. A recent Commonwealth Senate enquiry finding that, whilst water consumption by the mining industry is significantly less than that used by agriculture, the effect of mining operations on local water availability can be significant.[1].

The National Water Commission (NWC) recognises that a rigorous and consistent management approach is required for the use of groundwater by mining operations, and commissioned a program of work to develop a nationally consistent framework for assessing potential local and cumulative effects of mining on groundwater resources, and to develop tools to assist prediction and assessment of these effects.

Development of the framework is consistent with the National Water Initiative (NWI), a blueprint for the reform of Australia’s water management for the next 10 years and beyond. The NWI acknowledges that all water users require an equitable basis from which to share groundwater and surface water resources.

Cumulative Effects Assessment

Within the regulatory environment, an increasing emphasis is now being placed on the assessment of cumulative effects in relation to mining activities through either mine approvals legislation or water management policy, although little quantitative assessment of cumulative effects has been undertaken to date [1]. A recent review of Australia’s Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) [2] examined the effectiveness of natural resource conservation measures governed by the Act in regard to promoting sustainable economic development. A particular concern raised by the review was the possibility of what might be considered a minor effect on its own (e.g. drawdown around underground workings) combining with other effects (e.g. drawdowns associated with water supply wellfields and other mines in the same catchment) to present a significant future risk to natural resource condition.

An important outcome of the EPBC Act review [2] is the growing acceptance within the regulatory community that risk based approaches can be used to undertake and communicate environmental impact studies, where the level of understanding of how a particular development might interact with the natural environment is determined by the level of adverse environmental effects that might arise as a result of the development proceeding. This acceptance of risk-based approaches to mining approvals, however, is constrained to some extent by a concern that the level of risk posed by a development only really becomes apparent as the data gathering and analysis exercise evolves during the approvals process.

The following provides a definition for cumulative effects adopted for the framework:

- Cumulative effects are the successive, incremental and combined effects of an activity on society, economy and environment [3]
- These effects can be both positive and negative
- Each individual effect may be minor on its own, but collectively can become significant

Specifically, in relation to mining, cumulative effects can arise from [4]:

- The compounding effects of a single mining or processing operation
- Interference effects between multiple mining and processing operations.
- Interaction between mining and non-mining activities

The minerals industry recognises the need to undertake comprehensive assessments of cumulative effects. This forms an integral component of the sustainable development framework developed by the International Council on Mining and Metals [8], which is advanced in the Enduring Value framework developed by the Minerals Council of Australia [9]. Consistent with this recognition, the mining industry should be committed to, at least, the following in regard to cumulative effects assessment:
1) Identifying other existing or proposed activities in the area with similar environmental, social or economic effects, or that are likely to impact on environmental, social and/or economic users of groundwater.

2) Assessing the extent to which the area affected by the proposal is already stressed, and is likely to be stressed.

3) Identifying any probable long-term and short-term cumulative effects, such as issues associated with groundwater-surface system interaction, public health, heritage, and third party water requirements.

4) Identify both life-of-mine (eg. wellfield development) and enduring (post-closure) effects.

5) Consideration of the receiving environment’s ability to achieve and maintain environmental objectives.

6) Consideration of options for integrating operations with adjoining mines, where they exist, to obtain operational synergies, reduce costs, mitigate adverse environmental effects or lessen land degradation (eg. backfilling of pits, wastewater exchange for reuse, integrated rehabilitated landforms, joint handling or treatment facilities, integrated and shared monitoring networks and programs).

The Framework

Risk assessments, which are widely used by the mining industry to assist in identifying and assessing potential effects of their activities on likely receptors (environment, social and economic), should provide a systematic approach to identifying and communicating the nature, scale and magnitude of risks associated with threatening activities (hazards). They should present a complete set of information to risk managers (policy makers and regulators) to allow the best possible decisions in regard to mine approvals and risk management to be made using the available data [5].

A mining risk framework has been developed to provide a Nationally consistent approach to undertaking groundwater impact and risk assessments, and to assist in quantifying and qualifying risk to groundwater resources in response to mining operations. The systematic approach forms the basis from which to undertake cumulative effects assessment, and follows seven successive stages (Figure 1), the first five constituting the groundwater impact assessment and the last two constituting the risk assessment. An eighth step (monitor, evaluate and review) forms the essential link within the framework that provides the capacity for adaptive management.

![Figure 1 Risk assessment framework for cumulative effects assessment](image.png)

Assessing the risk from mining development begins with the hypotheses that the development and operation of a mine will cause a change to the natural (or existing) condition of groundwater resources, and cumulative effects to groundwater may be occurring in response to mining operations in a given area, as well as in response to other users such as agriculture. The risk assessment ends with conclusions made about identified risks, and mitigation measures that might be employed to control or manage these risks if they are deemed unacceptable. Importantly, if an exposure pathway between groundwater effects and a receptor is shown not to exist, the assessment ‘chain’ breaks down, rendering a particular risk redundant [4]

The risk assessment framework presented in Figure 1 is:

- Based on well established science [6,7].
- Provides a defensible basis from which to undertake environmental assessments.
- Is consistent with adaptive management (as opposed to the pre-cautionary principle).
- Should be encapsulated by stakeholder engagement at all stages.

The groundwater impact assessment component of the Framework comprises five key steps (Figure 1):

- Context setting (regional and project information)
- Management objectives
- Receptor exposure assessment
- Groundwater effects assessment
- Threat & opportunity assessment
- Risk characterisation (significance)
- Risk management

Monitor, evaluate, review
Step 1 Context setting: comprises the components ‘actions’ and ‘exogenous factors’, in addition to identification of potential groundwater receptors (environment, social, economic) that might be impacted adversely by mine development within a region.

Step 2 Management objectives: involves defining those elements of the water regime that are to be protected and a basis from which to measure management success, importantly this requires the identification of the users of groundwater or linked resources and the form of groundwater dependence).

Step 3 Groundwater effects assessment: comprises the components ‘direct effects’ and ‘cumulative effects’ arising from mine water affecting activities.

Step 4 Receptor exposure assessment: comprises the ‘receiving environment / receptor’ component, which considers the degree to which mine water affecting activities might impact on receptors.

Step 5 Threat assessment: brings together the groundwater effects and receptor exposure assessments to identify the level of threat posed to groundwater receptors in response to mine water affecting activities, whether there are any management opportunities and, essentially, commences the compilation of the cumulative effects assessment.

Tools and Methods to Assist in Undertaking a Cumulative Effects Assessment

A number of ‘tools’ have been developed along with the Framework concepts, these include multi-mine water accounting (MWAT) software, cumulative effects assessment (CEAT) software, and a GIS-based groundwater and resource information for development database (GRIDD).

MWAT enables the integrated management and accounting of water resources across multiple mine sites to support the sustainable and efficient use of water resources. The tool requires the development of water accounts for single mines (using Minerals Council of Australia’s (MCA) WaterMiner application, for example) prior to compiling into MWAT. The tool includes a scenario engine for undertaking “what if?” uncertainty analyses, and will greatly assist the context setting component of the Framework. MWAT

CEAT allows a proponent or the regulator to compile and update natural resources information in relation to groundwater and receptor effects, in addition to undertaking threat and risk assessments. The tool provides a starting point for new proponents in terms of assessing the possible effects of their operation on existing resource condition and identified receptors.

GRIDD is a GIS-based tool that has compiled available National-scale mining and natural resources data and information into a single linked-database. The tool incorporates contextual information (eg. climate, topography, geology, groundwater flow systems, aquifer type) and natural resource management information (eg. water planning status, sustainable yield development status), and has been used to assess in relative terms the potential level of threat posed to groundwater systems by mining activities to assist in putting mine development proposals into a National context. This assessment of relative threat is based on the concept of robustness (which considers recharge climate/recharge potential, groundwater flow system type and aquifer type). Figure 2 presents relative groundwater system robustness in regards to development, where high robustness suggests relatively low susceptibility to development stress in comparison to low robustness.

Framework Testing

Four case study regions, selected to provide a range of mining and water planning environments, and water policy settings, were used to assist in testing the appropriateness and applicability of the Framework and tools in undertaking cumulative effects assessments. The regions are shown on Figure 2:

- Hamersley/Pilbara in Western Australia, selected on the basis of (i) data availability, (ii) maturity of, and potential for, mining operations, and (iii) proximity of environmental groundwater users.
- Eromanga in South Australia, selected because of its’ diverse minerals potential and water planning status.
- Charters Towers in Queensland, selected on the basis of (i) geographical / jurisdictional setting, and (ii) the lack of sustainable yield estimate or formalised water planning.
- Hunter Valley in NSW, selected on the basis of (i) the scale of existing and potential development, (ii) the high potential for cumulative effects to arise from mining operations, and (iii) proximity of other anthropological and environmental groundwater users.
Conclusions

A key outcome of consultation activities conducted during Framework development (with community members, regulators and the mining industry) was that a risk-based approach to conducting groundwater effects and risk assessments in support of mining approvals is appropriate, and that the Framework provides a logical basis from which to undertake these types of studies. However, it was also identified that there is still some way to go for stakeholders to develop a deeper understanding and appreciation of the benefit the Framework and tools can provide to the mine approvals process.

Issues around gathering and sharing data, and maintaining the resultant datasets are of concern to stakeholders. Each of these issues will need to be resolved if (i) the Framework is to be adopted; and (ii) cumulative effects assessments are ever likely to be undertaken in a rigorous manner.

Testing of the Framework has identified the following key points:

- An effective assessment of cumulative effects is only as robust as the underlying analysis of impacts.
- A level of National consistency is required for environmental assessments for mine proposals.
- The Framework provides a strongly structured approach to collating information and building an understanding of groundwater and receptor effects within a region in relation to mining, and provides a sound basis for undertaking risk assessment and development of risk mitigation/management strategies where necessary.
- There is already generally good alignment between the Framework and the expectations of regulatory agencies in regards to cumulative effects assessments.
- Water accounting, using MWAT, provides an effective way in which to understand where operational efficiencies can be improved and potential impacts reduced. Collating regional water accounts for mines (and, logically, other water users) is a necessary progression from the development of detailed water accounts for single mine operations, particularly in regard to natural resource management and in maintaining a water-use baseline for a region.
- CEAT enables the capture of the key aspects of water interactions and groundwater effects, and effectively compiles the information required by the Framework to consider local and cumulative effects.
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References


