Modelling residual mine voids for rehabilitation planning

Implications for leading practice

August 2023

- Where an open residual mine void is approved to remain after closure and is filled or likely to fill with water, modelling is to be used to:
  - demonstrate residual mine voids will remain a contaminant 'sink' in perpetuity and not a 'source' of contaminants to the receiving environment,
  - demonstrate residual mine voids will not impact adjacent groundwater and surface water (note that residual mine voids should not overtop and impact surface water or impact surface water via groundwater connectivity),
  - demonstrate residual mine voids will not impact the rights of other water users, and
  - assess whether water held in residual mine voids will be of sufficient quality to support a post-mining land use in the long term.
- Where modelling is used to support closure planning it must be consistent with leading practices such as those described in Tomlin et al. (2023b) including:
  - a project plan that describes the project aims, objectives and hypotheses to be tested and stakeholder engagement,
  - use of site-specific data collected in close proximity to the residual mine void that is reliable and sufficient to represent spatial and temporal variability,
  - a conceptual model describing Pressure/Stressor/Response relationships,
  - stochastic modelling of all relevant physical and chemical processes,
  - calibrated models (using historic data matching[1] of site-specific data and reliable sensitivity analysis),
  - use of probability distributions to assess uncertainty and test hypotheses,
  - consistent timeframes for model outputs (at 10, 20, 50, 100 year intervals and every 100 years until an equilibrium is reached),
  - modelling of short term and long-term climate change scenarios, and
  - a proposal for ongoing data collection and model review (i.e. at 3 year intervals).

Background

The Queensland Mine Rehabilitation Commissioner engaged Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) and WRM Water & Environment (WRM) to provide advice on leading practices for residual mine void modelling used to support rehabilitation and closure planning. This project produced three technical papers. Technical Paper 1 describes current practice for modelling the behaviour of water bodies forming within residual mine voids (Tomlin et al., 2023a). Technical Paper 2 describes leading practice residual mine void modelling approaches (Tomlin et al., 2023b) and Technical Paper 3 presents step-by-step guidance to apply it (Tomlin et al., 2023c). This document briefly describes the implications for leading practice derived from the AGE and WRM Technical papers.

Many residual mine voids that remain open after mining will accumulate water from a range of sources such as groundwater seepage, overland flow and direct precipitation. Modelling of both groundwater and surface water interactions with the void, and the geochemistry of void waters over time, are essential for successful mine closure.

Current approaches to residual mine void modelling

A review of current approaches to residual mine void modelling found several opportunities to improve practices (Tomlin et al., 2023a). For example, the modelling process and assumptions made can vary widely. This can mean results are not comparable between studies and can be difficult to interpret for a range of stakeholders. Residual mine voids have sometimes been modelled with very little or even no site-specific data resulting in very high levels of uncertainty. Stakeholder engagement has often not been undertaken or not completed as part of the modelling process, which can mean the results don't meet expectations. The uncertainty associated with modelling results is sometimes not assessed or not presented leading to a lack of confidence in results among stakeholders. Reporting can be *ad hoc* and give an incomplete picture of the models. All inputs to modelling need to be properly described to avoid reporting results that are not fit for purpose. Modelling is also typically undertaken at project commencement and results are often not verified or regularly reviewed to update models.

Leading practices for residual mine void modelling

Recommendations on leading practice approaches to residual mine void modelling made here are aimed at strengthening the rehabilitation and closure planning process by improving the transparency of the process and reliability of results. Leading practice requires modelling studies be undertaken in eight stages. The initial stage (Stage 1) is seen as being particularly important to improving practices. The intent of this stage is to ensure (as far as possible) that modelling of residual mine voids meets the needs of all stakeholders the first time it is delivered; minimising the need for further work and reducing the timeframe for assessments to be completed. During the first stage, the scope and timing of the modelling effort, as well as the multi-disciplinary project team members is determined. A project plan should be presented to regulatory and other key stakeholders. Documenting the project plan and scientific methodology will also help to achieve greater transparency in the process.

In most cases achieving leading practice outcomes will require the collection of site-specific data for site conceptualisation (Stage 2), model design and construction (Stage 3) and history matching[1] purposes (Stage 4). A key task is to review the existing data sources and define the data necessary to achieve the project objectives. Since no models can predict the future with 100% accuracy, data collection, model design and subsequent modelling activities must aim to minimise and quantify predictive uncertainty (Stages 5 and 6). In practice this means presenting model results as a range of possible outcomes, rather than single predictions, which allows the likelihood and risk of unwanted outcomes to be quantified. Modelling should include consistent timeframes for model outputs (at 10, 20, 50, 100 year intervals and every 100 years until an equilibrium is reached). This in turn will allow for risk-based decision making when preparing mine rehabilitation and closure documentation. Leading practice in residual mine void modelling also requires that the study outcomes are clearly documented in plain English (Stage 7) and regularly reviewed against actual site monitoring data, in order to validate model-based predictions of future water levels and water quality (Stage 8). Where monitoring does not align with modelling predictions, leading practice supports an analysis of the cause and implementing strategies to improve predictions.

The approaches described here are intended to provide a basis to standardise approaches to residual mine void modelling and reporting as they relate to mine rehabilitation and closure planning in Queensland. It is acknowledged that modelling requires a significant investment of time to plan and implement. Such investment is worthwhile and should be used across the life of mine to support planning and ongoing management.

[1] During 'history matching' model parameters are adjusted until model outputs are considered to appropriately fit historical measurements (Barnett et al. 2012)

References

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