Five Years Of Hydrogeological Consulting For A Mining Company: Lessons Learned For Successful Work

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Abstract

Mining operations face different groundwater challenges, often addressed by various consultants with differing scopes. This leads to repetitive work and knowledge loss with consultant turnover. Five years of consulting experience at a large open pit mine highlighted some key lessons. Critical data review, even repeated data, is crucial due to potential inconsistencies. Permanent peer review improves work quality, identifies issues, and generates new ideas. Long-term engagement fosters deep understanding of hydrogeological conditions, enabling knowledge sharing and building internal expertise within the mining company to address future challenges.

Keywords: Consultancy, Data Review, Mining Operation.

Introduction

Chile's expansive copper mining sector relies heavily on open pit operations, most of which penetrate below the natural water table. This necessitates significant groundwater management, presenting a range of complex challenges, as seepage in pit slopes (Fig. 1) or the reduction of pit slope stability due to pore pressure (Hoek & Bray 1981; Sullivan 2007).

Figure 1 *Pit floor flooding due to seepage.*

These challenges span different aspects such as:

- Data acquisition: This includes piezometer installation and monitoring through time, water quality sampling, and geophysical surveys.
- Hydraulic testing: Pumping and slug tests.
- Seepage and pore pressure control: Design and implementation of depressurization and drainage systems (D&D) and cut-off walls.
- Groundwater modelling: to predict inflows, pore pressures, assess environmental impacts, and optimizing water management.

Mining operations frequently engage external consultants to address these multifaceted issues. However, this often leads to a fragmented approach, with consultants tackling specific scopes, such as regional groundwater modelling for environmental impact assessments or mine-scale models for slope stability. While sometimes unavoidable, this piecemeal strategy can create inconsistencies and redundancies, especially with consultant turnover. This paper leverages five years of continuous consulting experience at a large Chilean open pit mine to discuss key lessons learned regarding data management, the importance of peer review, the advantages of long-term engagement, and the critical integration of diverse data sources.

Consultant Turnover and Knowledge Loss

Hydrogeological studies at large mines are inherently long-term endeavours, often spanning decades. Certain tasks, such as groundwater monitoring data collection, numerical model calibration and updates, and reporting, are typically repeated annually, forming a continuous cycle of investigation and refinement. This cyclical nature, coupled with the complex and evolving hydrogeological systems characteristic of mining environments, necessitates a consistent and comprehensive understanding of the site. However, the mining industry frequently experiences consultant turnover, often driven by competitive bidding processes and economic factors. This frequent change in consulting personnel presents a significant challenge to maintaining continuity and preserving institutional knowledge, leading to several detrimental consequences.

When a new consultant team takes over a project, they face a significant learning curve. They must familiarize themselves with the site's specific hydrogeological characteristics, the existing data, the conceptual and numerical models, previous reports, and the rationale behind past decisions. This process often involves repeating previous work, such as re-evaluating existing data or re-running model simulations, to gain a sufficient understanding. This duplication of effort wastes valuable time and resources, affecting project timelines and budgets. Furthermore, the time spent getting up to speed delays progress on critical tasks and potentially postpones crucial management decisions.

It must be noted that in some cases keeping a consultant for many years without implementing new technologies, or without generating extra value to the company it is not the best case, consultants should be continuously adding value to their work, being able to implement new methodologies to improve efficiency and safety to the mine operation.

The Importance of Rigorous Data Review

A critical lesson learned emphasizes the vital importance of reviewing all data, regardless of apparent similarity to previous datasets. Even when data is received repeatedly for recurring tasks, inconsistencies can arise (Fig. 2). Values for previously recorded data points may differ, suggesting potential errors in measurement, recording, or data management. Therefore, a thorough review, including comparison with historical data, is essential.

This review process not only identifies errors but also offers valuable insights into the evolution of the hydrogeological system, highlighting potential areas of concern such as changes in water levels, water quality, or seepage patterns. For example, discrepancies in piezometric data might reveal previously unknown fault zones or shifts in recharge rates. Neglecting this crucial review step

can lead to flawed models and incorrect interpretations, ultimately affecting decision-making related to mine dewatering, slope stability, and environmental compliance.

The example (Fig. 2) in particular shows incoherency in data after a period of time without records, at the end this difference in measured values was caused due to change in the calibration parameters of the instrument that recorded the water levels measures, leading to different values with the new set of parameters.

The Value of Consistent Peer Review

Consistent peer review has proven invaluable, as mentioned in various groundwater numerical guidelines (Barnett *et al.* 2012), providing a crucial external perspective that identifies potential improvements and uncovers overlooked issues. Peer reviewers offer fresh ideas for fieldwork, refine conceptual models, and enhance numerical models. A structured, regular peer review process ensures the quality and robustness of hydrogeological studies, helping identify potential biases or limitations in the existing approach.

Our experience demonstrates that consistent peer review, even for repeated tasks, significantly improves overall work quality and fosters innovation. Furthermore, it facilitates the sharing of best practices and the adoption of new technologies in hydrogeological investigations.

Benefits of Long-Term Engagement:

Long-term engagement with the mine has proven crucial for developing a deep understanding of its complex hydrogeological conditions. This extended involvement allows for the observation of seasonal variations, the identification of long-term trends, and the development of a comprehensive conceptual model. This deep understanding facilitates more effective problem-solving and enables the development of tailored solutions.

For instance, a long-term perspective allows for accurate assessment of the long-term effects of mine dewatering on regional groundwater resources. Furthermore, it fosters strong relationships with mine staff, facilitating open communication and collaboration, which is crucial for effectively addressing hydrogeological challenges and ensuring studies align with the mine's operational needs.

Integrating Diverse Data Sources and Advanced Modelling:

Effective hydrogeological management requires the integration of diverse data sources, including geological data, hydrochemical

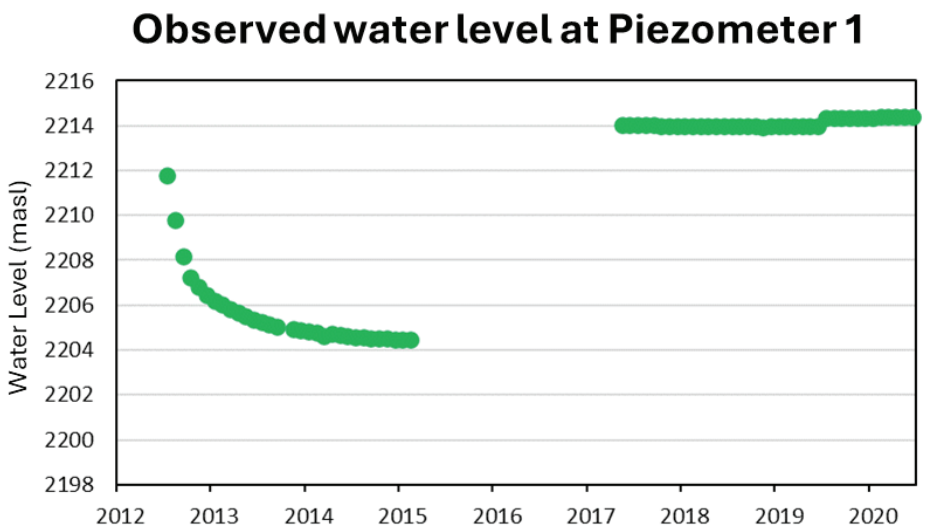

Figure 2 *Inconsistencies in measured water levels*

data, geophysical surveys, and remote sensing data. Our long-term engagement has allowed us to effectively integrate these data sources into comprehensive hydrogeological models. Furthermore, we have utilized advanced modelling techniques, such as stochastic modelling approaches, to better understand the complex interactions within the hydrogeological system. These advanced techniques allow for a more robust assessment of uncertainty and provide valuable insights for decision-making (Fig. 3).

Knowledge Transfer and Internal Expertise Development:

A significant benefit of long-term engagement is the ability to transfer knowledge to mine personnel and new consultants. We have been able to assist in training new staff, providing context for existing data, and explaining the rationale behind previous studies. This knowledge transfer helps build internal hydrogeological expertise within the mining company, enabling them to better manage groundwater-related challenges. This internal expertise is invaluable for addressing future issues, reducing reliance on external consultants for routine tasks, and ensuring continuity in hydrogeological management. This also empowers the mine to critically evaluate the work of future consultants and ensure that it aligns with their needs and objectives.

Conclusions

Our five years of consulting experience at a large Chilean open pit mine have highlighted the importance of rigorous data review, consistent peer review, long-term engagement, and the integration of diverse data sources. These practices are essential for overcoming the challenges associated with consultant turnover and ensuring the effective management of groundwater resources. By embracing these lessons, mining companies can build internal expertise, improve the quality of hydrogeological studies, and make more informed decisions regarding groundwater management. This ultimately contributes to the long-term sustainability and success of the mining operation. Further research could explore the development of standardized data management protocols and knowledge transfer mechanisms to further enhance the efficiency and effectiveness of hydrogeological consulting in the mining industry.

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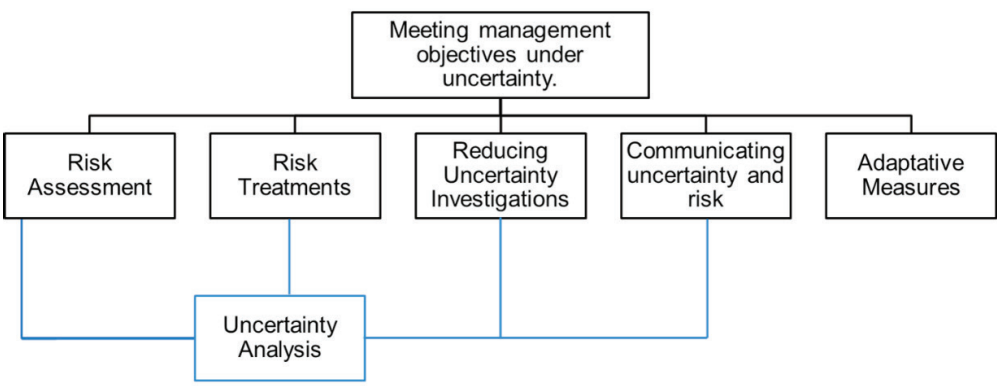

Figure 3 Decision-making under uncertainty could be supported with long-term tasks. (Adapted from Walker 2017)

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