Sustainable Minerals Institute

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

CREATE CHANGE

HRO and Environmental Management

Exploring how strengthening the environmental function within the mining industry can lead to higher reliability

.

Introduction

Developing approaches for implementing high reliability practices ("towards HRO") is currently largely driven by safety considerations, as it stems from the Queensland Government review of fatal accidents. Typically, in the mining industry, safety considerations and risk management are the responsibility of the Safety, Health and Environment function, referred to using the SHE or HSE acronym. SHE will be used in this discussion paper. The SHE function is supported by teams at corporate and mine level, with various configurations for reporting lines. A common structure is for the mine SHE team to report to the mine SHE manager, who is a member of the leadership team, with a similar structure at corporate level. Interactions between mine and corporate SHE teams tend to rely on collaboration and communication rather than authority.

Environment is a core component of the SHE function, but it has not received much attention from the perspective of implementing high reliability practices, which has been discussed almost exclusively through the prism of safety. In this discussion, we provide a general background about the role of the environment function, its tasks and responsibilities and examine how it is perceived and integrated within companies. Using the findings from the other discussion papers, we assess how the mining industry currently demonstrates the features that characterise higher reliability, but strictly from an environmental perspective, which leads to the concept of "environmental reliability". We identify the opportunities for achieving greater environmental reliability and discuss how these could be promoted and implemented.

The role of the environment function

The environment function is responsible for managing the environment portfolio which usually comprises approval of new projects, operational support, compliance with environmental conditions, and planning for rehabilitation and closure. The number of environmental obligations with which a mine must comply has steadily increased in the last few years. Commitments arise from government-issued permits, plan of operations, water licenses and diversions and audit findings. They cover a wide range of technical areas: water, tailings and residue management, rehabilitation, closure planning and financial assurance, airborne contaminants, noise, vibration, greenhouse gas emissions, biodiversity (Table 1). The level at which a technical discipline is represented will depend on the level of risk. For instance, if a mine operates in an environment with no significant groundwater resources, skills in hydrogeology are not essential.

Table 1 - Technical disciplines of the environment function

Water	Residue Management	Rehabilitation	Closure planning	Other
Catchment and regional initiatives Surface water and hydrology, groundwater and hydrogeology Water balance and accounting Water quality Monitoring and data analysis Erosion and sediment control	Disposal strategy Geochemical aspects and pollution risks Acid Mine Drainage Geotechnical stability Tailings to Soils Mine waste	Baseline assessment Material characterisation Landform design and construction Ecological engineering Ecosystem establishment Species selection and propagation	Financial provisioning and residual risks Closure plan development and review Mine waste characterisation, final landform, post-closure water balance Ecosystem resilience	Air contaminants Noise Vibration Blasting Cultural heritage Biodiversity Greenhouse gas emissions Waste and Circulate Economy

The technical fields and associated complexity keep expanding but this is rarely matched by a step change in support and resources to environmental teams. There is no publicly available research that examines the impact of the SHE structure on environmental performance, but there is anecdotal evidence it is not well suited to promoting environmental excellence. Adoption of the SHE structure presumes that managing environmental risks follows a process similar to that for managing risks to people and communities. This is not necessarily the case, as many environmental risks are controlled by conducting extensive technical studies and implementing technical findings. There is a tendency to hire generalists (graduates with degrees in environmental sciences or environmental management) rather than recruit technical experts who can provide high-calibre technical guidance to the organisation. At many mines, the highest function an environmental professional can reach (if they choose to remain in the environmental field) is superintendent or equivalent, with no position in the leadership team. This means that in many cases, the function relies on the SHE manager to communicate environmental issues.

Public perception of the mining industry's environmental reliability

In the public discourse, the industry is infamous for three types of environmental impacts: tailings dam failures, acid mine drainage and insufficient commitment to the rehabilitation of mined land.

Tailings dam failures have disproportionately shaped the reputation of the industry, with three significant disasters in the last five years: Mount Polley in Canada, Samarco and Brumadinho in Brazil. Beyond the human fatalities, the volume of pollutants released to the environment and the extent of ecosystems affected reached unprecedented proportions (Rotta et al., 2020). As defined by Roberts and quoted in Susan Johnston's paper examining what we really know about HROs (Johnston, 2021), one the six actions for managers seeking to improve the reliability of their organisation is to "consider the cost of safeguards against accidents versus their costs (in money, lives and public outcry)". Tailings dam failures are a perfect example of when that was not considered. There have been 46 failures in the past 20 years with the number rising steadily. We have to ask ourselves what conditions are causing these accidents to occur year after year (Armstrong et al., 2019). This question has a strong parallel with that posed for fatalities, along with the suitability of striving towards HRO as a potential solution.

Most papers on this subject focus on the technical reasons for the failures. For Mount Polley, the root cause was identified as a weak, soft layer of glacial till that had not been detected by engineers when the dam was first designed and built in the mid-1990s, with water management issues exacerbating the instability. Investigations into the Brazilian disasters are ongoing but there is a general finding that the dams that failed were built using a construction method that is both the cheapest and the one considered to be the most dangerous and risky ("upstream dam"). Managing high-risk structures requires highly-skilled technical personnel and the discussion about maintaining a high level of technical expertise within environmental teams is pertinent to this problem. However, a recent paper that investigated non-technical aspects of the Mt Polley, Samarco and Brumadinho failures showed that production had been increased and/or cost cutting measures had been put in place before the accidents. The paper also postulates that the compensation packages offered to middle management, which actively encourage managers to cut costs and increase production so as to increase their annual bonuses are a key factor in the rising number of serious accidents (Armstrong et al., 2019). In this case, there seems to be evidence that the organisational structure and associated incentives did not prioritise the management of environmental risks (and in this case, almost more importantly, safety risks). There is a strong message that senior leadership must increase their awareness of potential risks. The recently released Global Industry Standard on Tailings Management addresses this aspect, with strong guidance for developing an organisational culture that promotes learning, communication and early problem recognition with stronger governance processes.

The second topic is acid mine drainage (AMD), the outflow of acidic water from metal mines or coal mines. This liquid often contains toxic metals, such as copper or iron, combined with reduced pH, which leads to detrimental impacts on the receiving environment. The issue is so prevalent, and the environmental consequences so severe that is has occupied technical teams of geochemists, hydrologists, water treatment specialists and engineers for many years. They have produced technical guides (GARD [1]), numerous research projects and associated findings, have promoted and delivered workshops and conferences, and have published 1000+ research papers. Despite all this effort towards understanding the scientific processes, identifying solutions and communicating them at a range of forums, acid mine drainage remains an unresolved long-term risk. Why is this? It is clearly not because of a lack of investment in technical research. If organisations were mindful of the long-term potential for environmental impact, AMD would be controlled, as technical solutions exist. This is not about managing the unexpected: we know it exists and there are strategies in place to control operational aspects. The long-term vision of risk management is missing, with little resilience over the life-of-mine.

Requirements for progressive rehabilitation have recently received more attention since a review undertaken by the Queensland Treasury Corporation, at the request of the Queensland government, found a widening gap between the amount of land disturbed by mining and the amount of land rehabilitated (Department of Premier and Cabinet et al., 2017). Low rates of rehabilitation are concerning for governments largely because it leads to an increased risk of disturbed land becoming a financial liability for the state. From a strictly environmental perspective, disturbed land is a greater threat to environmental values, as it can lead to increased export of sediment and contaminants, among other things. The requirement to rehabilitate mined land is not new, it has been a feature of permits and conditions for more than 50 years. Despite this, Queensland had to introduce a new legal act to ensure they could enforce the rehabilitation conditions (the Minerals and Energy Resources Financial Provisioning Act). These changes caught many executive leadership teams by surprise, outlining they were not mindful of the risks posed by slow rates of rehabilitation.

Key challenges related to rehabilitation were also raised by a 2018 Senate inquiry and led to the establishment of a Cooperative Research Centre for Transformations in Mining Economies in 2020, which will conduct collaborative research programs to address the identified issues. Interestingly, one of the key topics that was identified as requiring research input was acid mine drainage. When such initiatives are required, it does indicate that the industry has not reached maturity with respect to environmental management, and has to expand more effort to reach reliability. It has not “operated nearly free of environmental incidents over long periods of time”. If senior leadership took environmental commitments seriously, perhaps the industry would not be associated with environmental damage.

These topics are largely responsible for the industry’s environmental reputation, but they do not reflect the reality of day-to-day mine environmental management, which can demonstrate compliance with a large number of conditions almost all of the time. Whilst the industry is not yet environmentally reliable, there are aspects of environmental management that indicate many opportunities for greater reliability.

Assessing actual environmental reliability

Johnston (2021) has outlined some features that characterise higher reliability and, in this section, we assess their applicability to the environment function. The features represent what we currently know about HRO, and by applying them to the environmental context, we can provide a preliminary assessment of the industry’s current environment reliability. As quoted by Johnston (2021), Weick and Sutcliffe argue that the

[1] https://www.inap.com.au/gard-guide/

essence of reliable performance can be achieved where an organisation creates a mindful infrastructure that continually does all of the following:

Tracks small failures

When adopting a SHE organisational structure, mining companies also adopt SHE management systems that capture risks related to all three aspects, with standard modules for training and induction, inspections, risk assessments and incident reporting. The processes and systems for reporting environmental incidents are the same as those in place for safety incidents. There is anecdotal evidence that fewer environmental incidents are reported but this is likely to evolve with greater awareness and communication outlining the importance of reporting them.

Operations must comply with their environmental obligations and most companies have systems in place to track compliance performance, such as Approvals, Obligations and Compliance (AOC) modules which store all compliance documents and associated obligations, include automated and manual compliance assessment, and track renewal and amendments to permits. Systems to track small failures are in place. This is critical for environmental management as a small failure often leads to a much larger one, with extensive environmental damage. Evidence of seepage from a dam wall (small failure) can lead to piping erosion and dam wall collapse. Failure to maintain and clean out a sediment control structure can lead to significant sediment export during a storm. Tracking small failures represents a core function of environmental teams, and largely it is done well. Environmental teams make a continuing effort to identify the incidents that must not occur and implement strategies to lower the risk triggering these incidents, as demonstrated with the two previous examples. However, being preoccupied with failure should go beyond tracking small failures. It should aim at visualising potentially severe consequences and at adapting decisions accordingly. Senior leadership teams should use the reporting of small environmental failures to visualise the potential environmental disasters that could result from them. There is little evidence this is occurring.

Resist oversimplification

This is an interesting aspect to discuss as the industry holds conflicting views about the role of the environmental function. Some still hold a view that the environmental teams are “tree huggers” whose role is limited to dealing with stray wildlife and planting trees on rehabilitated land. The reality of course is that the function has become increasingly more technical to the point where significantly more effort needs to be expanded for continuous education and professional development of environmental teams. Regulators now expect complex hydrological and hydraulic modelling for assessment of water release conditions and flood mapping; hydrogeological modelling to assess impact on aquifers and quantifying net groundwater flow in or out of pits and underground mines; landscape evolution modelling to assess the stability of post-mining land uses. These are just examples which illustrate that the function has evolved significantly. It could be argued that the level of complexity does not always match the risk level. Nevertheless, this is now the expectation, which requires technical support, in the form of regular professional development and access to technical specialised advice; appropriate budget and resources to undertake the studies that are required; and the ability to communicate the requirements.

There is no oversimplification of the tasks themselves and the way they are performed, but there is oversimplification in the perception of the duties. This needs to be addressed through fostering understanding of the work undertaken by the function and increasing engagement with leadership teams, ideally by incorporating an environmental presence in these teams.

Remains sensitive to operations

Environmental teams are responsible for mitigating environmental harm from mining activities and are fundamentally anchored to the operations. This is where the action is: they are focused on actual situations because it is their role. Due to increased complexity, they require specialised technical support, usually located away from operations, but with adequate engagement and communication, this rarely poses problems.

The area for improvement relates to reducing silos: ensuring the various technical teams on a mine communicate and collaborate on critical matters. For instance, strategic mine planning currently does not have robust tools to include environmental considerations in the optimisation process or to estimate the impact of operations on environmental outcomes. Environmental considerations are not integrated in strategic mine planning.

Water management and rehabilitation planning represent a large proportion of the environmental workload. On these topics, integration with the work of other technical teams is fundamental so as to identify best options for areas to be rehabilitated, equipment required, scheduling of rehabilitation, sizing of pipes and pumps etc. There is little evidence of effective team integration. For instance, it is not unusual for different teams to use different software to manage the same data. Another example is the management of spatial data. There is no publicly available example of mining companies that have implemented GIS Enterprise platforms to store, share and disseminate geospatial information products within the entire organisation and beyond. There are plenty of examples in other sectors. For an industry that is essentially entirely based on spatial information, this is highly surprising and points towards low reliability. Management of core data is an essential feature of reliability.

With the implementation of the MERFP Act in Queensland, some companies realised that they required greater integration of environmental and mine planning teams and at some mines, moved the environmental personnel out of the SHE teams into the Technical Services team. Organisational structure is one method but to reach reliability, it is not sufficient. It does not achieve increased mindfulness of the environmental function across the whole organisation.

Maintains capabilities for resilience

The research into HRO defines resilience as the ability to absorb strain and keep working, even when things are hard; to bounce back from crises and learn from them; and to adapt continually to changing circumstances.

The mining industry can be exceptional at responding to crises. During the floods that occurred in Queensland in early 2011, companies quickly triggered emergency responses, ensuring the safety of their workers and providing extensive support to affected communities, such as evacuation and temporary relocation. Whilst there was no significant safety incident, the operations were severely affected as they collected large volumes of flood water in pits, which could not be released to the environment. Evidence from the subsequent Queensland Floods Commission of Inquiry established that mines were insufficiently prepared, despite several warning forecasts issued by the Bureau of Meteorology. The industry needs to broaden its assessment and awareness of what constitutes a crisis so that it can be prepared for a range of conditions, not just the ones that fit their mental model. This relates back to the discussion on tracking small failures and the need to visualise environmental disasters: whilst leadership teams could visualise the consequences of extreme rainfall on some aspects of their operations, they had not visualised the impact on mine site water management.

Similarly, a shift in regulation should not create major issues. Ideally, regulatory changes would not occur because all conditions are met and all conditions are well aligned with site conditions. This requires that leadership teams have a full awareness of the conditions, as well as their applicability to specific site conditions. If they are not applicable, they can be changed by submitting information and technical studies to the regulators. As environmental teams are often under-resourced, their ability to effect change can be limited. This would be easily addressed if leadership teams were more mindful of the conditions under which they are expected to operate.

Takes advantage of shifting locations of expertise

Fostering higher reliability includes striving for a "just culture" in which workers can bring issues to management attention with the knowledge that the response will be neither punitive nor disinterested. This is heavily challenged in the mining industry, with a tendency to seek people to blame for environmental impacts when they occur. The investigation in the Mount Polley disaster quickly delivered blame on the engineers who designed the dam, rather than the water management strategies implemented by the operational team.

The industry does not have much trust in environmental experts, as they are perceived as blockers who stifle their operations through "green tape". This view is largely moulded from the experiences of seeking approval for new operations, as approval processes are convoluted, lengthy and at times, prove to be very expensive. The solution lies in cross-functional collaboration and the development of an organisational culture that welcomes the identification of problems and protects whistle-blowers.

The environmental function must be considered as a fully integrated part of mining activities. Environmental teams know all facets of the operations and the legal conditions under which they must operate, and manage a large amount of data about the operations and their surrounding environment. There is great potential for the function to drive higher reliability through integration of knowledge. They have technical skills that can influence other areas, leading to productivity improvements: the forecasting and mapping of flood risks can reduce operational losses due to rain; including progressive rehabilitation in strategic mine planning can reduce financial liability; improvement in data management, communication and transparency can build community trust.

Importantly, there is an opportunity for the industry to position itself as a leader in the field of environmental management. The quality of the technical work that is produced by mine environmental teams has no equivalent in other sectors. Examples include erosion modelling, water balance modelling, soil science and soil hydrology, geochemical analysis and modelling, ecosystem restoration, environmental effects monitoring. With ongoing support and professional development, this can be expanded and communicated more widely.

Towards greater environmental reliability

Johnston (2021) quotes Weick and Roberts who concluded that high reliability performance required "a well-developed collective mind in the form of a complex, attentive system of human interrelationships tied together by trust". This research finding is of great interest to improving environmental reliability. The key finding from our discussion is the requirement to better integrate environmental considerations in mining activities, so as to develop teams that are collectively mindful of their risks and commitments. Achieving this will require research at both industry and operational levels.

Leading for higher environmental reliability at industry level

For the mining industry, an environmental incident occurring at one mine from one company leads to the reputation of the whole industry being damaged. The tailings dam failures discussed earlier are good examples. Despite a rise in failures, most companies operate various mines with no tailings issue, but the industry reputation is forever associated with these accidents. In Queensland, it is the flooding of one mine in

2008 that led to profound reforms of water conditions, which themselves led to serious economic impacts during the 2010-2011 floods (Sharma and Franks, 2013). Industry needs to develop a collective mind on environmental performance tied by trust. There is research required to explore how this trust can be built, or re-built, and how the industry can develop a collective mind which includes the environmental function. There are examples of initiatives that were designed to promote the industry's commitment to environmental aspects (among other things). In 2005, the Minerals Council of Australia and its member companies launched the Enduring Value framework, providing a range of tools and guidance materials to ensure projects would be safe, financially profitable, technically appropriate and environmentally and socially responsible. Whilst the framework was widely adopted, it has not achieved a step-change in environmental reliability. Research is required to analyse why and to identify the type of approaches that would deliver greater environmental reliability.

Leading for higher environmental reliability at operational level

Environmental managers are rarely picked as leaders. There are examples of environmental professionals reaching position of leaderships but they usually have to take on a broader role as SHE managers. The research question to explore relates to the kind of leadership the industry requires for their environmental function, which will embed the function in the collective mind, create the organisational mindfulness of the function, and continuously analyse its capabilities, weaknesses and management strategies to address them.

If we are to move towards a broad view that higher reliability is predicated on how the people within an organisation relate to each other then we need to address the relation of the organisation with its environmental teams, and at the very least re-value the work they perform. Environmental personnel need to be heard and be much more visible. Remaining buried within a SHE structure does not communicate the importance of the work they do and certainly does not create any organisational mindfulness about the importance of the function.

One of the recommendations from the research is to "create a separate executive intelligence system to assess changes needed to design for excellence, recruit respected high-calibre people to staff the organisation, train and educate them in organisational science and practice". For the environmental function, there is a more prosaic goal to train the teams and provide technical support, and invest in their professional development.

The concept of shared vision is critical. There can be a tendency to exclude environmental teams from the vision and associated objectives. For instance, if an objective is "increased production", the role of the environmental function towards achieving that objective must be articulated. It might require some adaptation of the objective, for instance rewording it as "increased production with no increase in financial liability". As mindfulness needs to be built on deep collaboration, mines must achieve greater integration of the environmental function with the other teams.

Role of regulation

This will remain an important topic as most environmental improvements have been driven by compliance. The view that the regulators' primary role in any drive to reliability should be limited to removing any unnecessary requirements that obstruct progress towards high reliability is highly unlikely to be applicable to the environmental space, at least in the short to medium term. Regulation has a role to play, but as demonstrated in this discussion, is not sufficient.

Measurement and innovation

There is currently no method for measurement of environmental reliability, beyond the assessment of compliance status and various annual reports establishing the performance of environmental management systems. These do not provide any indication of environmental reliability. This is a completely new field that deserves to be explored.

Conclusions

This discussion has established that the concept of high reliability should be extended to environmental management and provided an assessment of the industry's current environment reliability. It outlines the key barriers to achieving greater environmental reliability and proposes research questions to address them. A commitment to greater environmental reliability presents a great opportunity for the industry to position itself as a leader in the field of environmental management.

References

Armstrong, M., Petter, R., Petter, C., 2019. Why have so many tailings dams failed in recent years? Resour Policy 63, 101412. https://doi.org/10.1016/j.resourpol.2019.101412

Department of Premier and Cabinet, Queensland Treasury, Department of Natural Resources and Mines, Department of Environment and Cultural Heritage Protection. 2017. Better Mine Rehabilitation for Queensland - Discussion Paper. Report prepared for the Queensland Government Interdepartmental Committee on Financial Assurance for the Resource Sector.

Johnston, S. 2021. What do we know about HROs? Paper compiled as part of HRO forum.

Rotta, L.H.S., Alcântara, E., Park, E., Negri, R.G., Lin, Y.N., Bernardo, N., Mendes, T.S.G., Filho, C.R.S., 2020. The 2019 Brumadinho tailings dam collapse: Possible cause and impacts of the worst human and environmental disaster in Brazil. Int J Appl Earth Obs 90, 102119. https://doi.org/10.1016/j.jag.2020.102119

Sharma, V., Franks, D.M., 2013. In Situ Adaptation to Climatic Change: Mineral Industry Responses to Extreme Flooding Events in Queensland, Australia. Soc Natur Resour 26, 1252–1267. https://doi.org/10.1080/08941920.2013.797528