FACT SHEET 5 - AMD RISK ASSESSMENT

AMD MANAGEMENT TRAINING SERIES

SUMMARY

An informed acid and metalliferous drainage (AMD) risk assessment provides guidance on the necessity for AMD management requirements for the project (e.g., prevention, minimisation, control, and treat) including further prediction / characterisation work where significant uncertainty is present.

An informed AMD risk assessment is a fundamental step in prediction and should be based on scientific and engineering data. It will be revisited many times over the project life for a variety of reasons, including for instance:

- In support of regulatory approvals for project development or mine closure.
- In response to community concerns.
- When new data becomes available that is materially different to previous data.
- In response to significant changes to the mine plan.
- When performance monitoring identifies a divergence from expected conditions.
- When routine review is required, which is dependent on the risk profile of the site.

A source-pathway-receptor (SPR) risk assessment should be undertaken, which is based on a suitable conceptual site model to provide context for the AMD risk assessment process.

SOURCE PATHWAY RECEPTOR RISK ASSESSMENT

The SPR risk assessment is a fundamental approach to assess risks for the environment and community. Utilisation of the SPR risk assessment framework requires a conceptual site model that identifies:

- The hazard source model, which includes defined boundaries, topographical features, surface and groundwater sources, and the potential AMD sources including all key mine domains (current and future) such as waste rock dumps, tailings storage facilities, and pits;
- A transport model that considers flow across and/or within the hazard source model and the quality of the transport medium, such as water quality or air quality; and
- Identified receptors such as environment and/or community receptors.

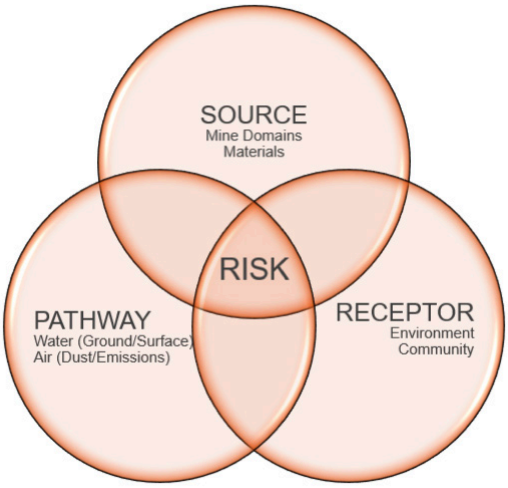


Figure 1. Source – Pathway – Receptor (SPR) assessment framework

The conceptual site model is also an essential communication tool for risk assessments with internal and internal stakeholders and:

- Supports the process of risk assessment by providing a clear visual guide;
- Facilitates a process for identifying potential risks and data gaps; and
- Provides a structure to develop performance and compliance monitoring programs.

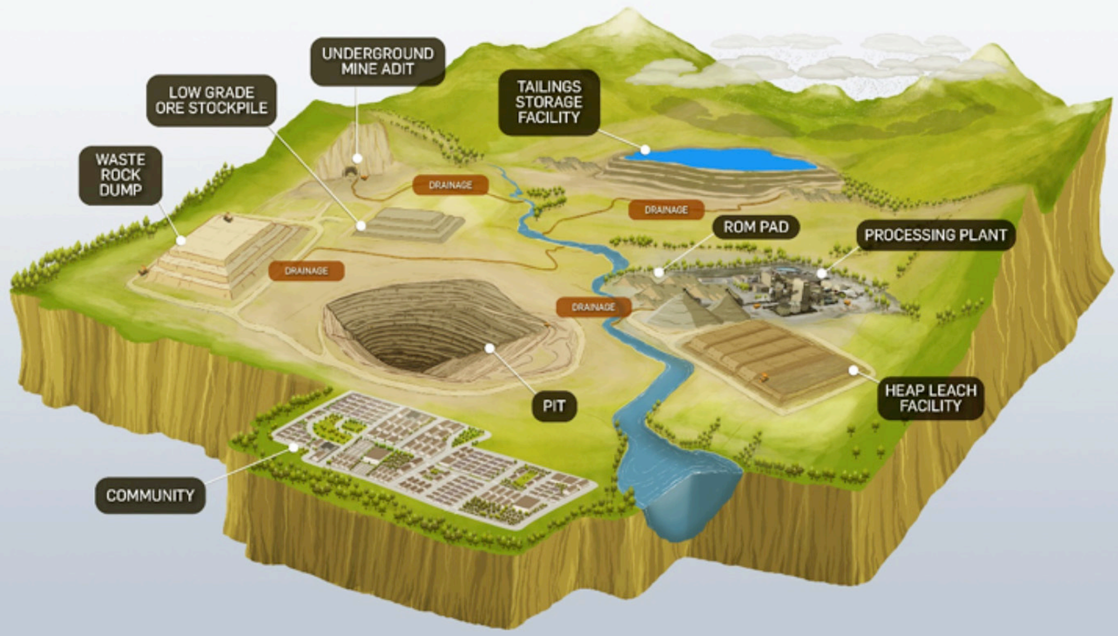


Figure 2. Conceptual site model example

Specific mine domain models should also be developed for mine domains that contain materials that are a potential AMD source hazard. The details of these mine domain models will reflect project maturity and domain specific risks and could include, for instance:

- Waste rock dump models / cross sections that show materials placement, engineering design, water management, cover design, etc; and
- Pit lake models linked to pit shell geology and material AMD characteristics and water balance modelling.

SOURCE ASSESSMENT

A potential AMD source is associated with sulfide minerals or sulfide mineral oxidation products. Often these are contained in a mine domain such as a pit wall, waste rock dump, marginal ore stockpile, heap leach facility, spent ore stockpile, underground working, or a tailings storage facility. Such mine domains are discussed in Fact Sheet 3 – Potential Sources of AMD.

Assessment of potential AMD sources relies on source hazard characterisation, which is undertaken by materials characterisation (e.g., Fact Sheet 4 – How to Predict AMD). Key components of source hazard assessment are:

	Component	Explanation
Source Hazard Assessment	Geo-environmental models	Deposit type, geology, lithologies, mineralogy, weathering, and alteration
	Analogue models	Adjacent mines, locality specific operations targeting similar commodities.
	Materials characterisation	Sulfide mineral type and content, acid neutralisation capacity, leach testing, kinetic testing (see Fact Sheet 4 – How to Predict AMD).
	Total volume of disturbance	Volume of materials and disturbance footprint include volumes of materials that can generate AMD.

AMD RISK ASSESSMENT

PATHWAY ASSESSMENT

Assessment of pathways using a conceptual site model provides guidance of the potential receptors that could be affected by the source hazard. The assessment of pathways often requires analysis using numerical models to understand effects.

The dominant pathway associated with AMD is water, being the mobilisation mechanism for stored oxidation products contained within mine domains. This includes surface water and groundwater.

Mobilisation water can include run-on water, net percolation of rainfall through the mine domain, or tailings process water draining through the tailings storage facility.

Other pathways can also be important for AMD including emissions to air, dust, and visual aesthetics.

	Component	Explanation
Pathway	Water	• Groundwater • Surface water
	Air	• Gaseous emissions • Dust emissions • Visual

RECEPTOR ASSESSMENT

The traditional approach to identification of receptors in a typical SPR risk assessment based on the conceptual site model. Receptors commonly associated with AMD can be grouped into either environment or community.

Risk-management strategies need to account for stakeholder perceptions of risk. Due to the complexity and longevity of AMD impacts on communities, the effects can be inter-generational, with current mine closure objectives potentially being lesser than the expectations of future generations.

	Component	Explanation
Receptor	Environment	• Water Bodies (surficial and groundwater) • Natural ecological systems (native flora and fauna) • Atmosphere • Rehabilitated systems (e.g., revegetation and rehabilitation of mine domains)
	Community	• Local community (health and wellbeing, visual impacts – aesthetics, social licence to operate) • Global community groups and social media • Future local and non-local communities

AMD RISK ASSESSMENT

AMD HAZARD SCREENING TOOLS

For the assessment of AMD risks for multiple sites and/or multiple mine domains there is often benefit in developing an assessment process to quickly identify higher risk sites/domains. This can involve the development of a high-level comparative screening assessment tool for environmental geochemistry risks.

AMD hazard screening tools can prioritise sites/domains from higher to lower risk. Priority sites/domains are then early candidates for formal risk assessments that also consider pathways and receptors.

AMD RISK ASSESSMENT PROCESS

AMD risk assessments provide quantitative and qualitative evaluations of AMD risk and guide AMD management requirements for the project (e.g., prevention, minimisation, control and treat) including further prediction / characterisation work where significant uncertainty is present. They should be based on scientific and engineering data using subject matter experts and should engage both internal and external stakeholders.

As noted by the International Council on Mining and Metallurgy (ICMM), risk assessment is a key principle of its 10 sustainable development principles:

Principle 4: *"Implement effective risk-management strategies and systems based on sound science and which account for stakeholder perceptions of risks"*

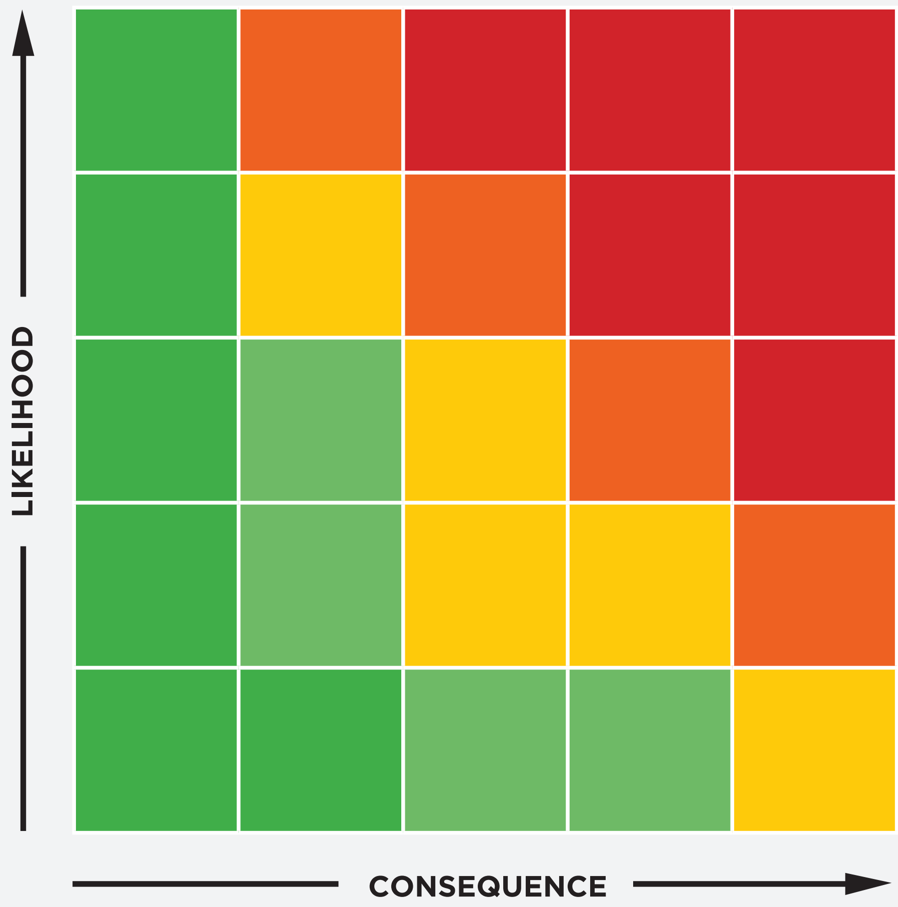
The risk assessment process is revisited many times during the mining lifecycle commencing in project feasibility studies and finishing at mine closure. The risk assessment should be based on the base case mine plan and should be updated each time the mine plan changes or when there is significant change in regards to AMD assumptions and management. The risk assessment process should be supported by:

- Closure objectives (final and/or placeholder criteria).
- A clear and fit-for purpose (i.e., equivalent to project maturity) conceptual site model.
- The current base case mine plan and materials schedules.
- The preliminary environmental geochemistry source hazard model and assessment, which is typically the materials AMD characterisation data together with data for mine domains that contain / or will contain these materials.
- Current and/or proposed AMD management methods for site.
- Hydrology and hydrogeological models.
- Climate models and long-term forecasts.
- Environmental, heritage, community, and social receptor analysis.
- Performance monitoring data (and proposed performance monitoring).
- A facilitated workshop.

AMD RISK ASSESSMENT PROCESS (CONT.)

The workshop should be a team approach using planners, geologists, geochemists, engineers, closure experts, social licence experts, etc. as necessary.

A key outcome of the risk assessment process is quantification of the potential environmental geochemistry risks. This is typically accomplished by the use of a risk matrix, which considers the likelihood of an event occurring versus the consequence of that event. Generally, it is recommended that the company specific risk matrix be used to support corporate messaging using a level playing field. Both likelihood and consequence categories require definition to facilitate fair assignment of values.



Consequence can sometime be weighted for immediate effects (or outcomes that have a higher return frequency). This can skew risk assessments to weighting the risks of AMD as being lesser when the effects may not be seen for many years, but the problem may be persistent thereafter, or affect closure of the site over much longer timeframes.

AMD RISK ASSESSMENT

AMD MANAGEMENT TRAINING SERIES: FACT SHEET 5

AMD LONGEVITY

There are many risks associated with the management and treatment of AMD. For instance, the long-term treatment of AMD often has financial appeal as costs occur a long way into the future, yet often the cost of some key longer-term risks have not been considered.

Such risks can add to unforeseen costs later in the mine life and erode final project value if they were not considered during project planning and financial analysis using net present value (NPV) calculations. Inclusion of costs for such risks in any NPV calculation of options provides a fairer assessment of source control costs versus long term treatment costs.

EXAMPLES

- Event risk as long-term treatment of AMD will have greater exposure to infrequent high-risk events;
- Current datasets may not be appropriate for the effects of climate change.
- Changing community expectations with time (generational expectations) leading to more stringent water quality standards.

AMD RISK ASSESSMENT DELIVERABLES

The risk assessment deliverables need to:

- Be an informative summary of key hazards, risks, and management options.
- Utilise appropriate operational and closure management criteria (e.g., water quality, contaminant loads).
- Identify key AMD risks and potential effects and quantify these risks using consequence tables.
- Provide management options (prevention, minimisation, control and treat) where potential AMD effects are unacceptable and operational and closure criteria may not be achieved. Quantify residual risks after such control activities have been accounted for.
- Identify uncertainty and provide adaptive management processes for this uncertainty (performance monitoring, trigger action response plans). Further information is provided in Fact Sheet 9 - Adaptive Management of AMD.
- Record key risks and management options, including adaptive management processes to manage uncertainty where it exists to inform both internal and external stakeholders.

AUS - Perth Office
Key Contact: Josh Pearce
M: +61 409 882 823
E: josh.pearce@minewaste.com.au

AUS - Brisbane Office
Key Contact: Dr Karan Jain
M: +61 469 348 420
E: karan.jain@minewaste.com.au

NZ - Christchurch Office
Key Contact: Dr Paul Weber
M: +64 272 945 181
E: paul.weber@minewaste.com.au