



Trends in Mine Closure

SveMin Environmental Conference
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Boliden Mines

Outline

- Mine closure, more popular than ever?
- Closure and the mining lifecycle
- Closure objectives
- Cover Design, Water Management, Land-use
- Risk analysis/Opportunity

Spoiler Alert!!!!!!

- There is no silver
- No “one-size” fits all solution



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However, there are some things worth noting

- Mine Closure 2019 conference in Perth Australia “Sold Out” 600 participants
- Increasing levels of:
 - transparency,
 - workshops,
 - good examples,
 - Guidelines/best practices documentation.
- Increasing understanding of what mine closure really means to mining companies and their stakeholders.
- **Mine Closure is not just for the Environmental Dept. anymore!**

Closure in the Mining Lifecycle

- Concept “Mine design for closure” has been around for a while.
- Companies are going beyond that.
- The mine’s closure and remediation plan is not only coupled to Environmental Impact Assessments and Sustainability Indexes....
- A part of the Life of Mine Plan (LoMP), and responsibility and accountability for a successful closure is spread across the business.
 - Late stage exploration
 - Development projects
 - Mine planning
 - Milling/Concentrator
 - Water Management
 - Environment
 - Infrastructure
 - Stakeholder dialogue

Closure in the Mining Lifecycle

Table 9-2: Technical Disciplines Involved in the Development of an ARD Management Plan

Discipline	Typical Involvement
Geology	To define the geological distribution of rock types and mineralogy, for developing the geological model on which the geochemical zones and their characterization are developed.
Mineralogy	To identify minerals that control the oxidation and neutralization potential and products.
Geochemistry	To evaluate the oxidation and neutralization processes, dissolution, and solubility controls that determine mine water quality, modeling of ARD, and the determination of ARD control requirements.
Mining engineering and planning	To develop the mining methods and schedules for waste extraction and ore placed in stockpiles and waste rock dumps, and for integration of the ARD management plan into mining operations.
Mineral processing/metallurgy	To determine the characteristics of the heap leach, milled wastes or tailings and the control technologies that can be applied in processing to minimize ARD potential.
Analytical chemistry	To support mine and metallurgical operations by implementing proper test methods for sample handling.
Water treatment	To design water treatment plants to remove deleterious constituents in ARD and supervise water treatment plant operations.
Geotechnical engineering	To design pit slopes and waste storage facilities such as tailings dams and waste rock piles, covers, and erosion stability of the post closure drainage system and landforms.
Social sciences	To ensure effective and open communication with stakeholders and to ensure that their concerns are integrated into the management plan.
Hydrogeology	To evaluate groundwater inflows to underground and open pit mines and groundwater flows that have contact with ARD sources.
Hydrology and limnology	To determine flood flows and water balance required for design water management facilities.
Soil sciences	To design and implement surficial soils (covers) in the closure landscape to facilitate growth of self sustaining vegetation.
Agronomy/botany forestry	To evaluate sustainable vegetation to meet the management plan and closure objectives.
Biology/ecology	To evaluate ecological impacts of residual surface and groundwater contamination and establish conditions for ecosystems of restored lands that meets operating and closure objectives.
Environmental law	To determine the regulatory requirements that the mine needs to comply with
Accounting and financial management	To estimate and monitor costs, and make appropriate provisions for funding the management plan and sustain post-closure monitoring and maintenance requirements.
Contract management	To ensure that ARD management plan issues and measures are incorporated into all relevant contracts that the mine enters into with suppliers and contractors.
Project management and supervision	To manage and supervise all aspects of management plan development and implementation, including long-term post closure activities, where applicable.
Senior management	To ensure management plan adherence, implementation and continuous improvement are incorporated into the key performance indicators of all relevant personnel.

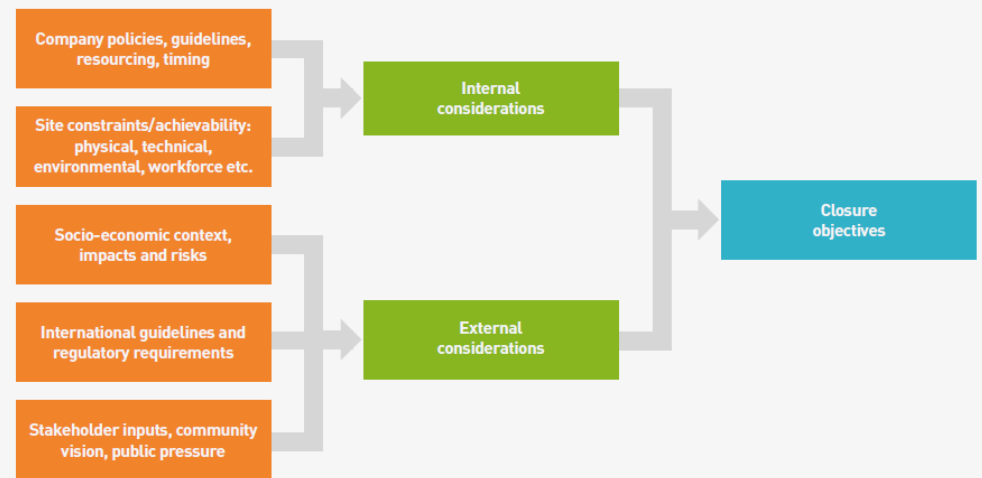
GARD Guide, www.gardguide.com

Closure Objectives

Clearly defined closure objectives for mine sites:

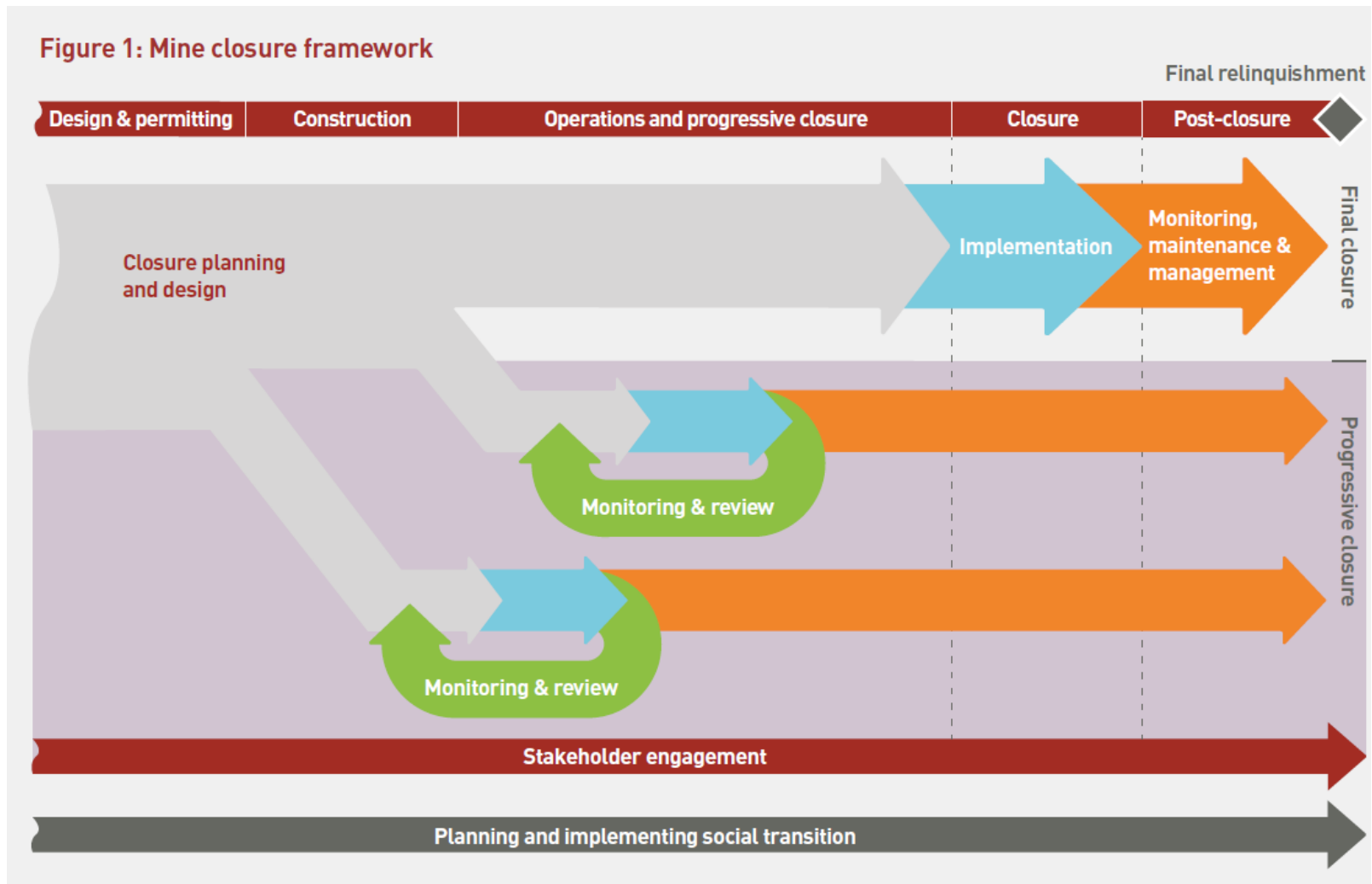
- Environmental goals (EQS, Ecology....)
- Land-use goals
- Goals defined early in the process
- Continuous stake-holder dialogue
- Not only for new or operating mines, but also for already closed mines!

Figure 3: Inputs to closure objectives



ICMM (2018) *Integrated Mine Closure: Good Practice Guide*

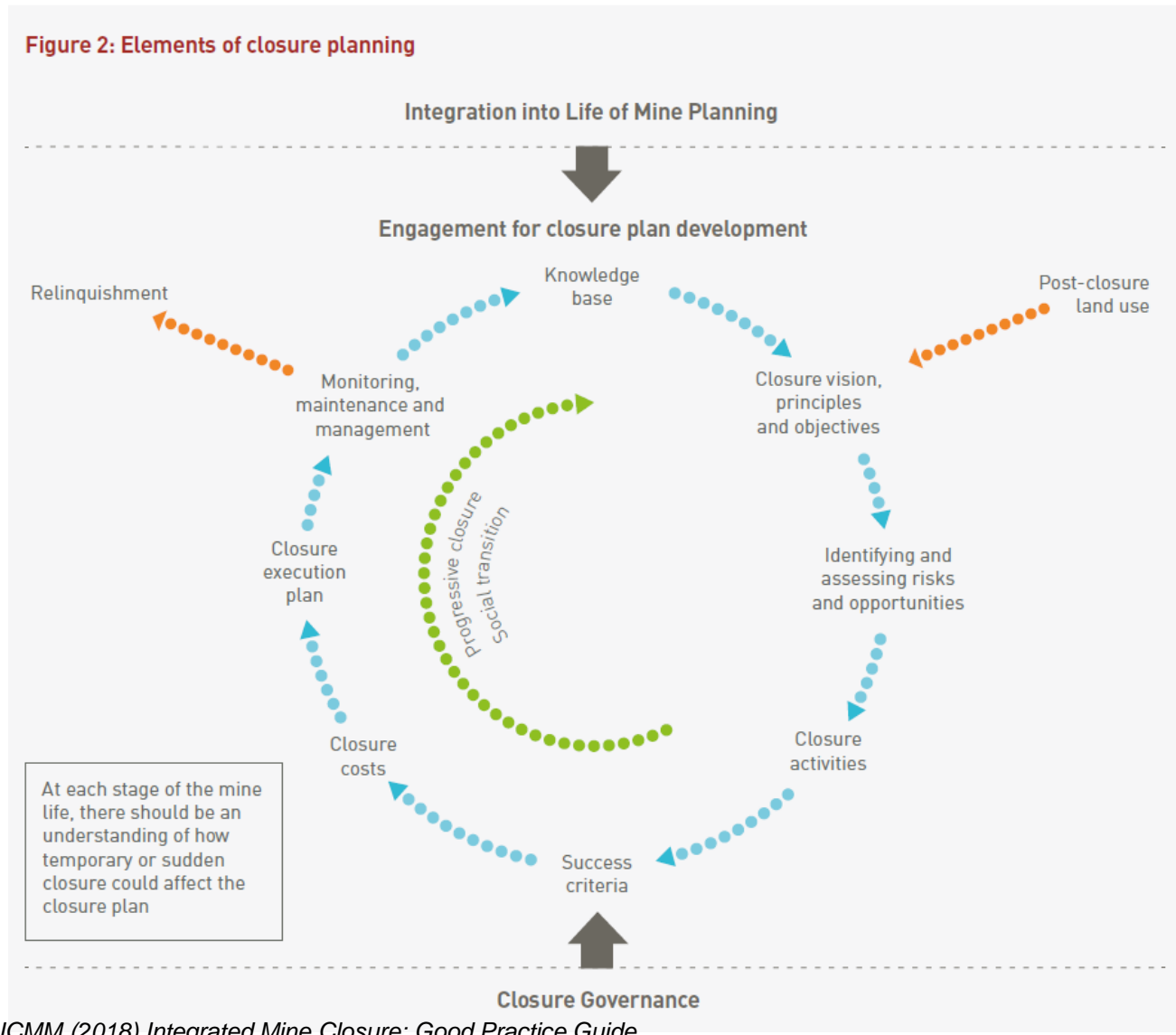
Closure in the Mining Lifecycle



ICMM (2018) Integrated Mine Closure: Good Practice Guide

Closure in the Mining Lifecycle

Figure 2: Elements of closure planning



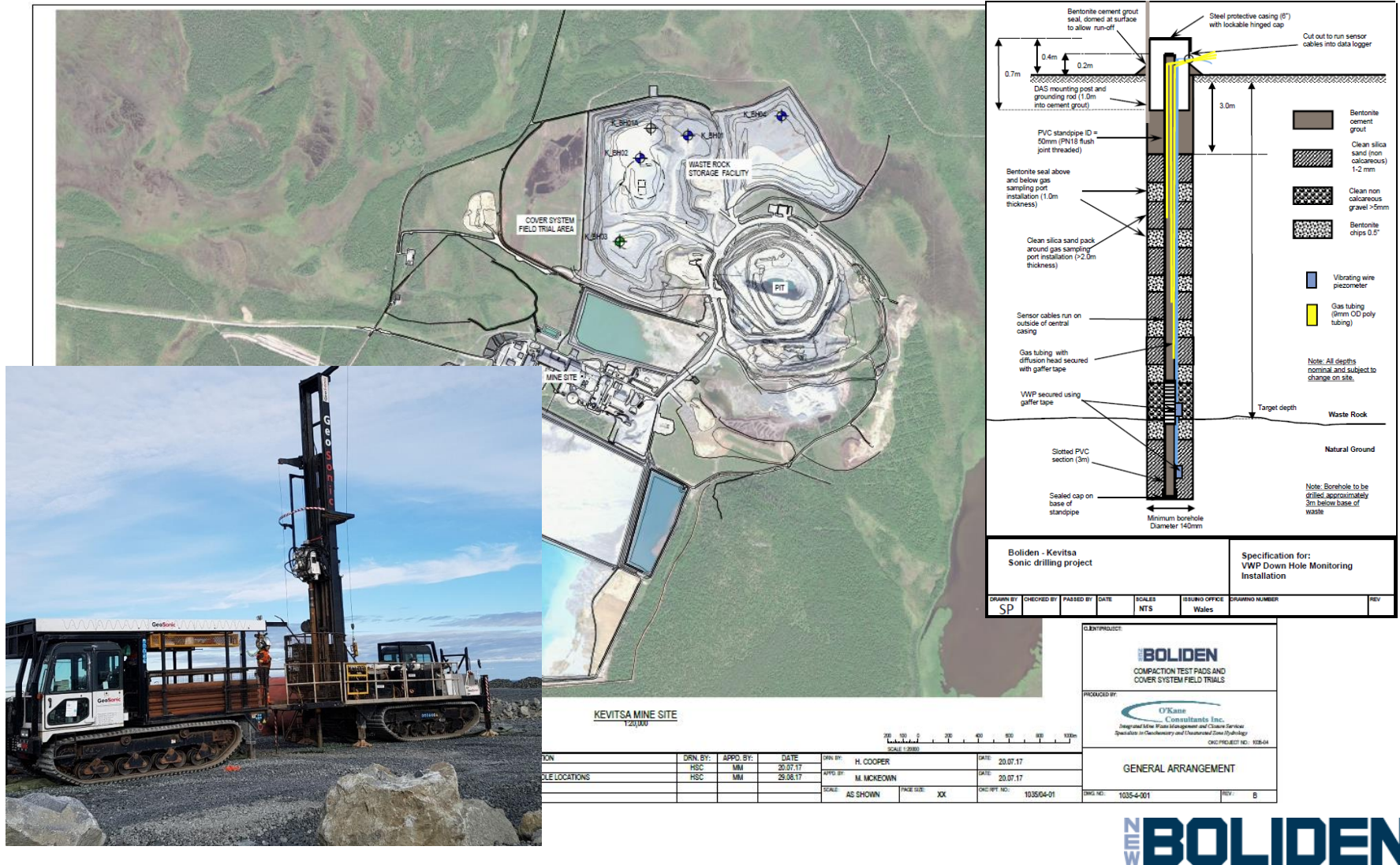
ICMM (2018) Integrated Mine Closure: Good Practice Guide

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Cover Design, Water Management, Land-use

- You can't just cover it up, and one size does not fill all
- Cover designs developed using site specific criteria to meet the closure objectives:
 - Waste material physical properties (Tailings ≠ Waste Rock)
 - Waste material chemical properties (Tailings ≠ Waste Rock)
 - Local climate, climate change
 - Land-use desires, opportunities
 - Cover material physical and chemical properties
- Cover test trails, once the research curiosity, are the norm
- Precision in construction (GPS), QA/QC, performance monitoring

Cover Design, Water Management, Land-use



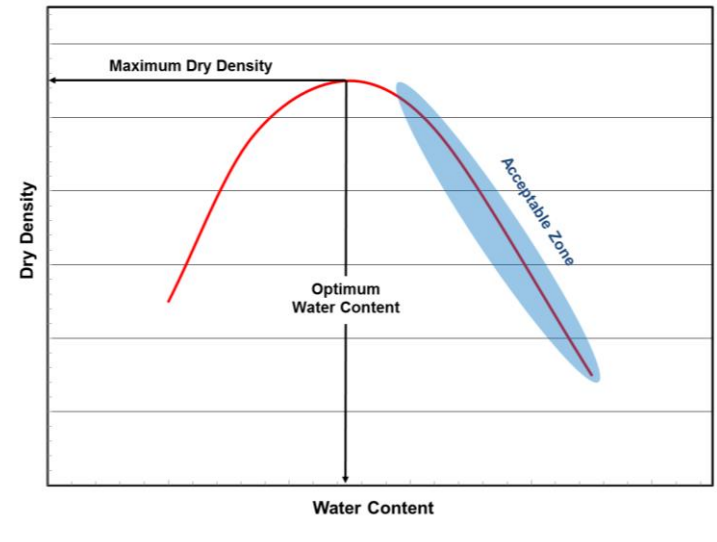
Cover Design, Water Management, Land-use



Cover Design, Water Management, Land-use



Courtesy of O'Kane Consultants Inc.



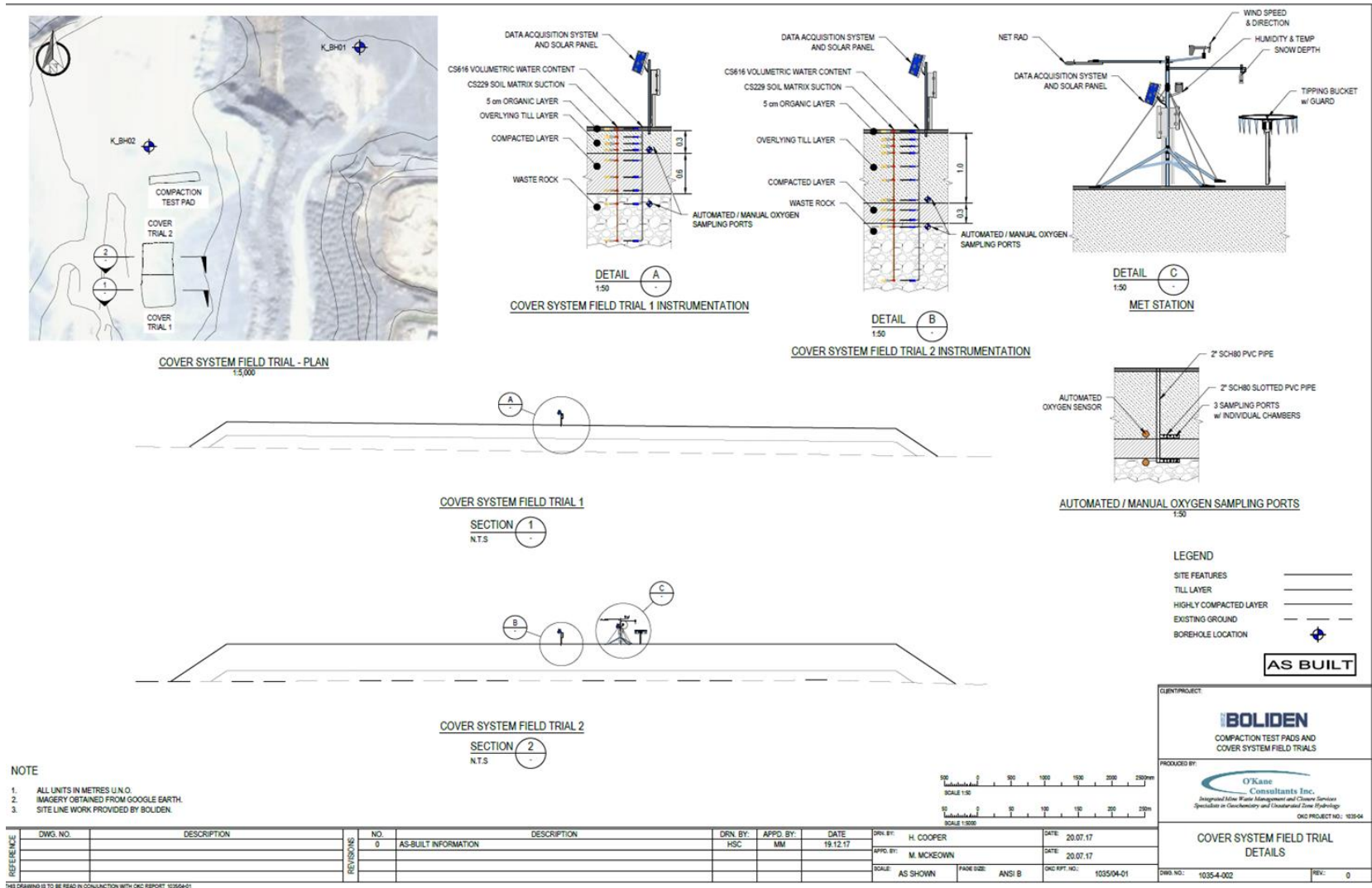
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Cover Design, Water Management, Land-use



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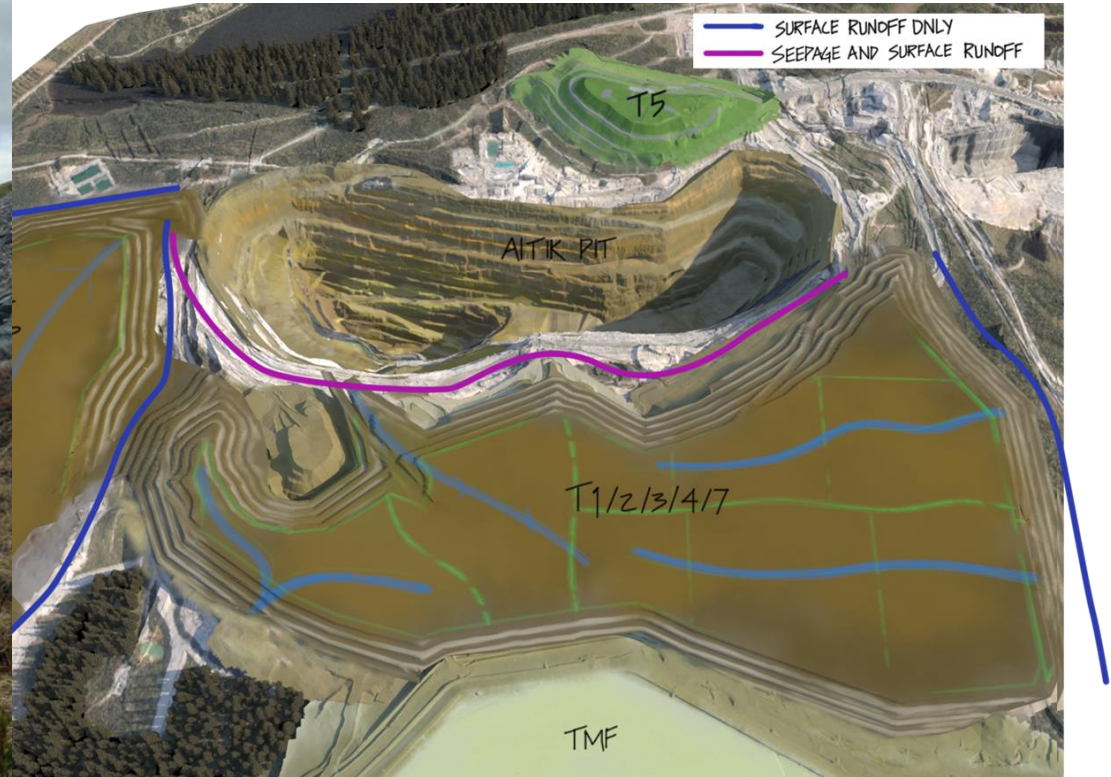
Cover Design, Water Management, Land-use



Cover Design, **Water Management**, Land-use

- Separating the clean and impacted water (operations and closure)
- Designing water bearing structures (canals, ditches, trenches, ponds) with climate and site land-use closure goals in mind.
 - Placement of runoff collection channels relative to aspect
 - Single discharge point
 - Creation of water features
- Water treatment
 - EQS set the scene
 - Whilst closure measures reach full results

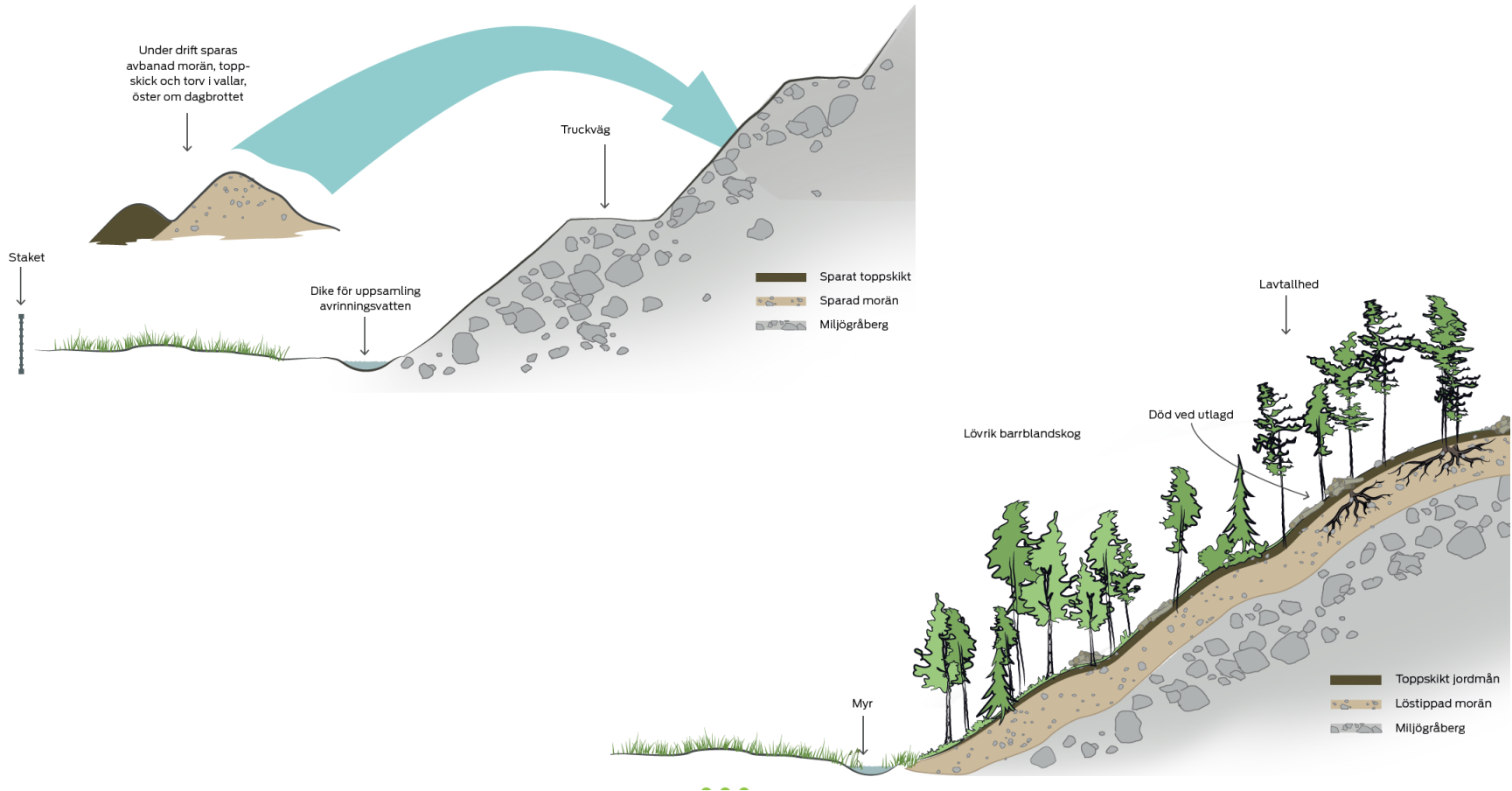
Cover Design, **Water Management**, Land-use



Cover Design, Water Management, **Land-use**

- Identifying possible Land-Use and discussing with stakeholders early and often
- Creating closure measures that agree with the land-use/land-scape
 - Appropriate protective cover thickness
 - Cliffs, boulders
 - Varying slopes
 - Creating micro-environments

Cover Design, Water Management, **Land-use**



Cover Design, Water Management, **Land-use**



S. Pearce, 2019

Risk Management and the Creation of Opportunity

Risk / Opportunity Assessment and Management is the appropriate tool to set out how to plan and operate for integrated closure¹

- ***International Network for Acid Prevention***
 - *Global Acid Rock Drainage (GARD) Guide²*

Integrated mine closure

[Environment](#) / [Mine closure](#)

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Risk Management and the Creation of Opportunity

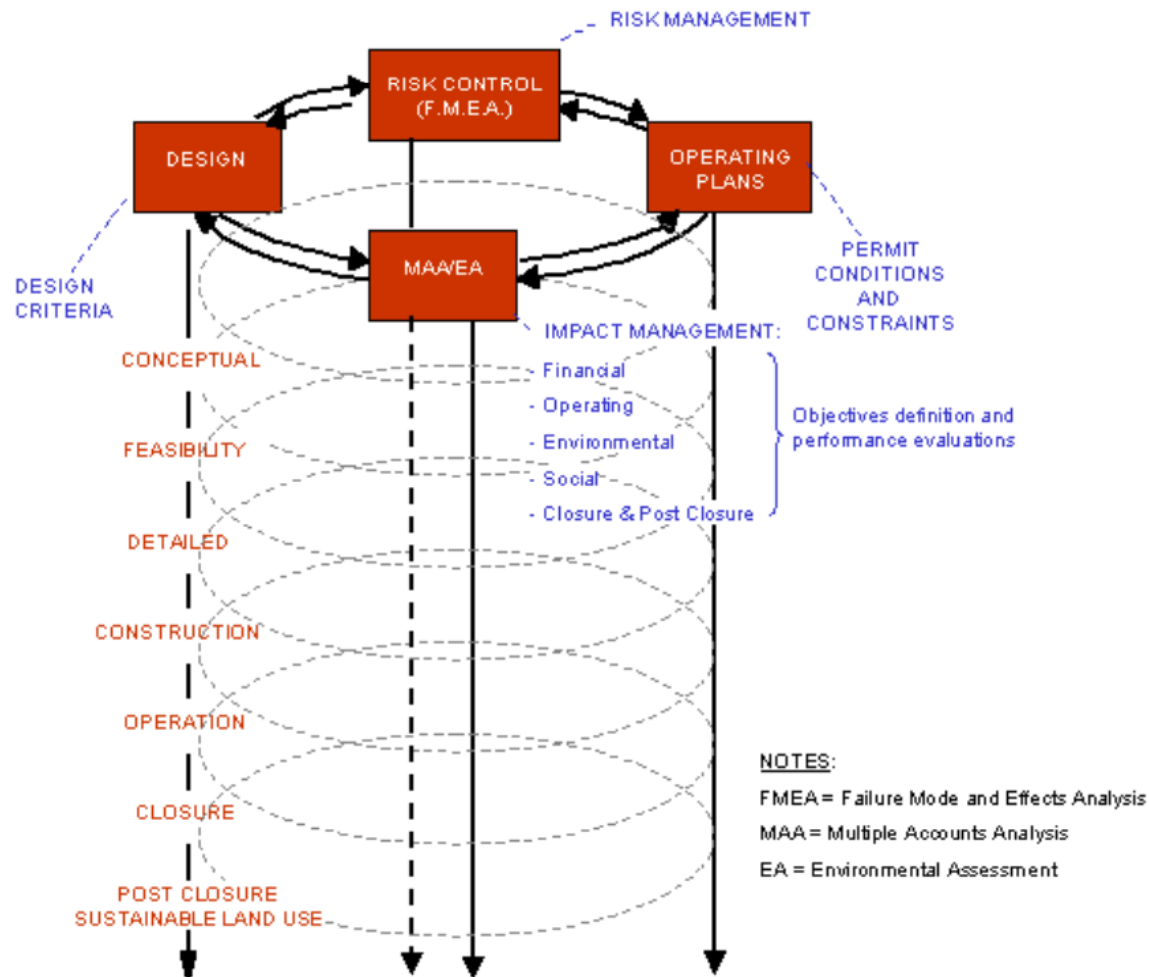


Figure 2. Cyclic Development of Plans and Designs at Various Stages of a Mine's Life.
Robertson and Shaw, Mine Closure, InfoMine E-Book.

Risk Management and the Creation of Opportunity

Risk management ↔ mitigation alternatives/investigations/research

- Increase knowledge base (monitoring, characterization, cover trials....)
- Modify waste management practices
- Modify cover designs from cover trials
- Modifying water management practices on site
- Progressive closure
- Water treatment requirements over time
- Community engagement and land-use

Risk Management and the creation of Opportunity



Éléonore Tailings Facility

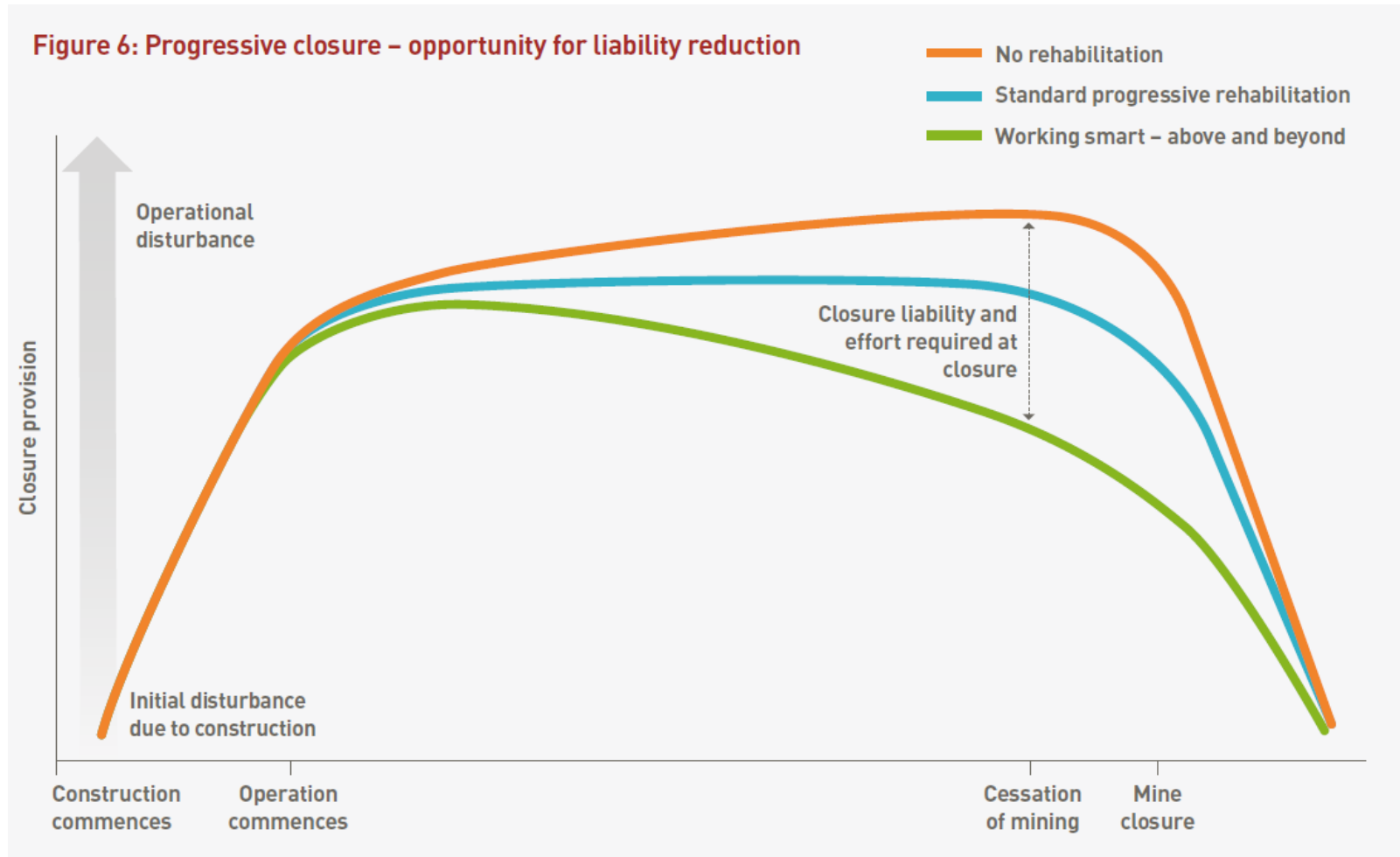
NewmontGoldcorp/FLSmidth



NewmontGoldcorp/FLSmidth

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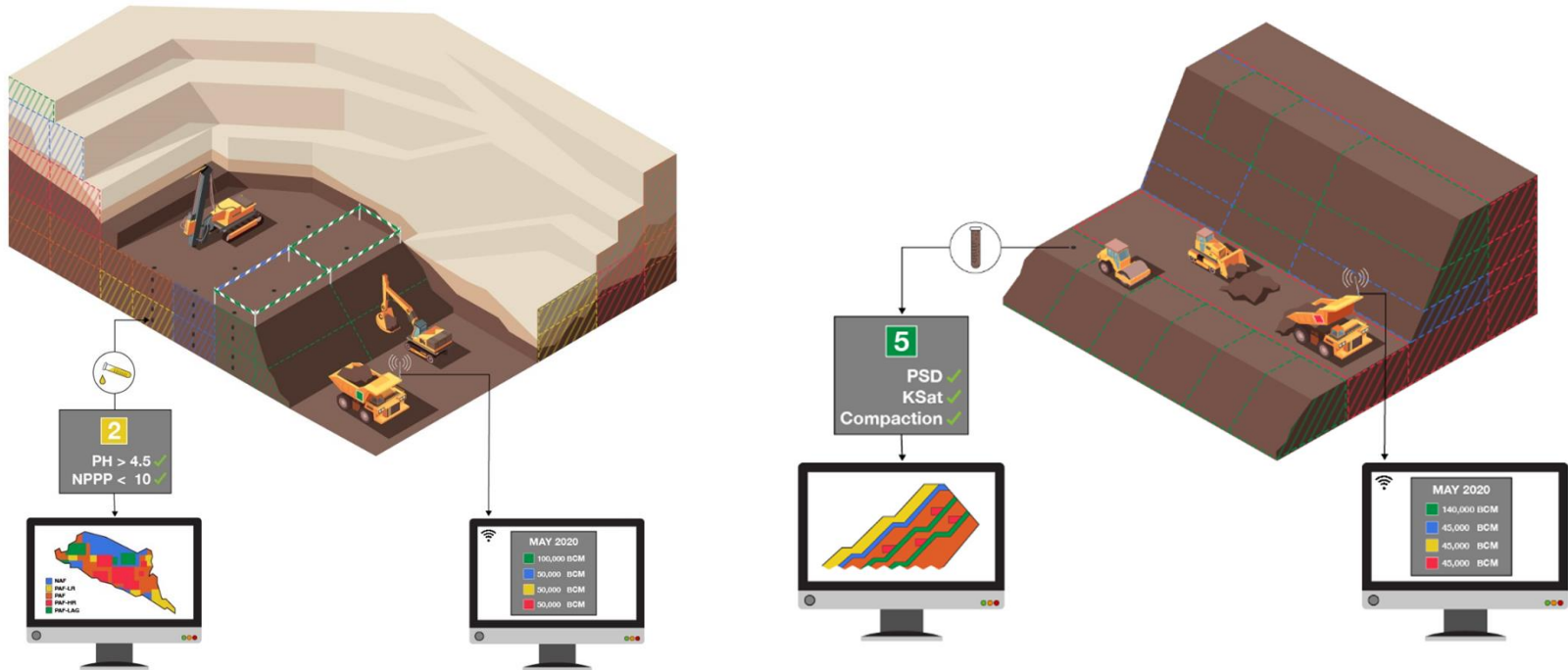
Risk Management and the creation of Opportunity



ICMM (2018) *Integrated Mine Closure: Good Practice Guide*

Source: Anglo American **IDEN**

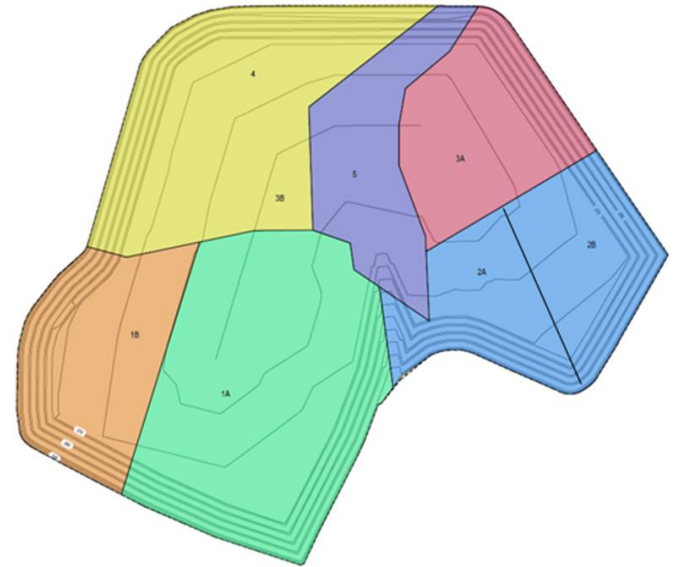
Risk Management and the creation of Opportunity



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Risk Management and the creation of Opportunity



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Risk Management and the creation of Opportunity



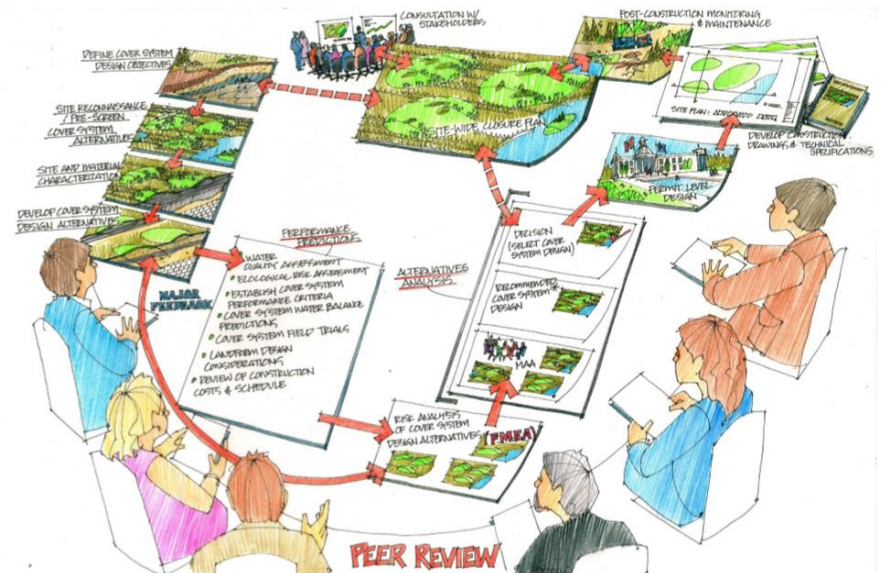
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Stakeholder dialogue



MEND, 2012



MEND, 2012

A photograph of three surgeons in an operating room. Two women and one man are wearing blue scrubs and green surgical caps. They are looking down at something out of frame. Handwritten chemical symbols are placed around them: 'Cu' near the top left, 'Ag' near the bottom left, 'Zn' in the center, 'Au' near the middle right, and 'Pb' near the bottom right. The background shows surgical lights and medical equipment.

Johanna wants to save lives. She couldn't without metals.

Devoted people, advanced healthcare and medical research all play a vital role in the development of modern society. Much of this development is dependent on metals, which are used in medical equipment, hygiene solutions and protection against radiation. Johanna is ready to do her part, and so are our metals.