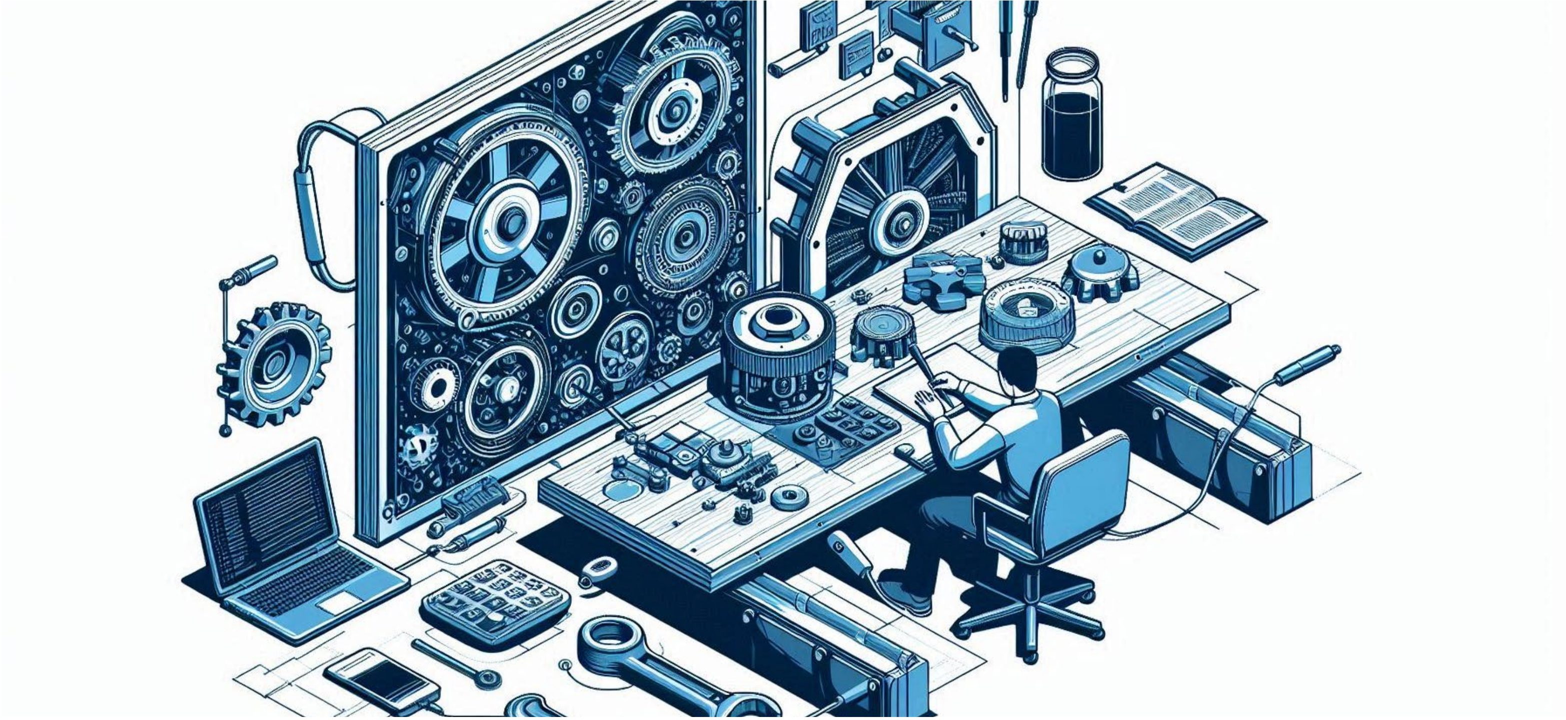

Back to the future: Reverse engineering TSFs for the end land use

ESG in the Minerals Industry Challenges and Opportunities

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Background on the closure of tailings storage facilities

Effective management of tailings	• Long-term responsibility of mining companies • Subject to varying regulatory regimes
Challenges in closure of TSFs	• Environmental, social, governance, and economic risks • Need for long-term monitoring and management
Comprehensive closure strategies	• Require comprehensive planning and financial commitments • Stabilisation of tailings and rehabilitation of environment
Community engagement	• Address social concerns • Promote sustainable development post-closure

Importance of sustainable closure

Beyond regulatory compliance

Requires a visionary approach

Transforms landscapes to regenerate local ecosystems and communities

Incorporates ecological restoration

Fosters biodiversity

Enhances ecosystem services

Socio-economic revitalisation

Provides socio-economic benefits to local communities

Creates habitats for native species

Innovative reclamation strategies

Minimises long-term environmental footprint

Aligns with sustainable development principles

Objectives of this presentation

Proactive closure planning

- Integrate closure planning into the TSF lifecycle from the earliest stages
- Address long-term ESG and economic risks

Minimising environmental footprint

- Design TSFs to minimize environmental impact
- Contribute to ecological regeneration and socio-economic benefits

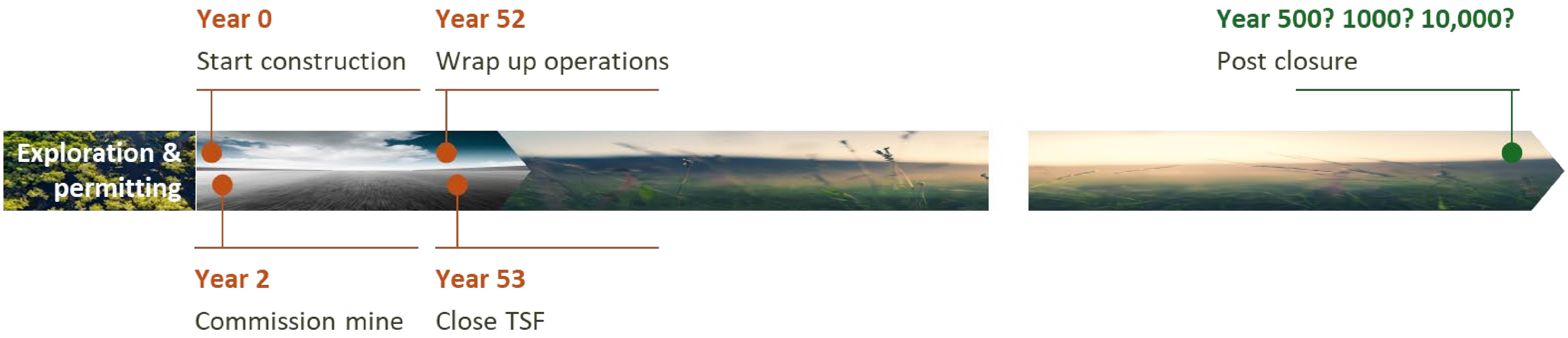
Innovative engineering practices

- Embed sustainability into design, operation, and closure
- Use advanced modelling and monitoring tools

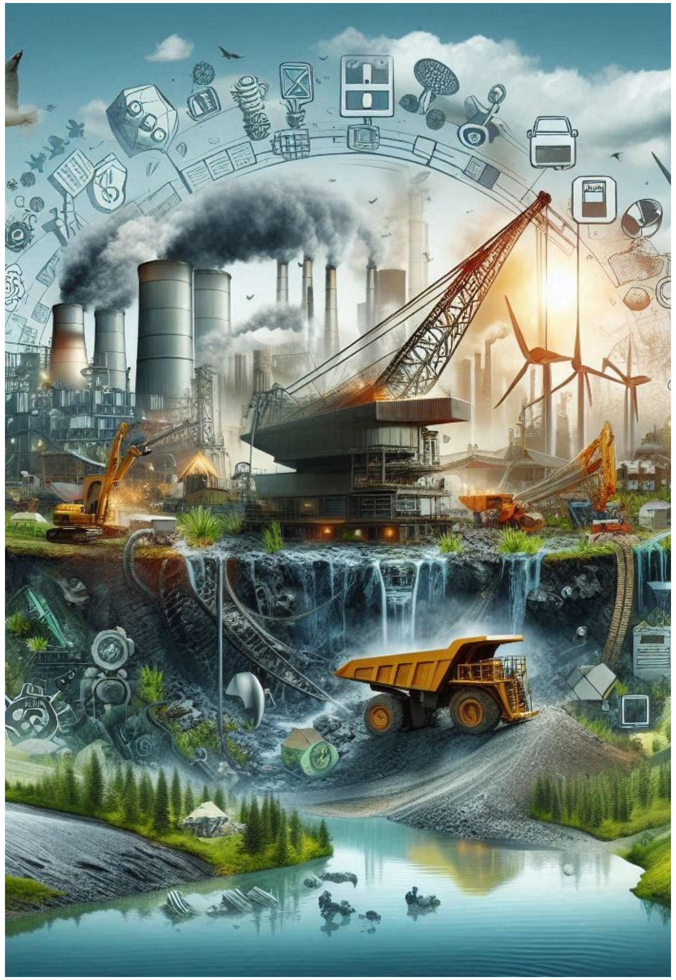
Comprehensive stakeholder sngagement

- Engage stakeholders throughout the TSF lifecycle
- Promote a transformative shift towards resilient post-mining landscapes

Overview of challenges



Environmental risks



- Contamination prevention
  - Hazardous substances in tailings materials
  - Potential migration into surface and subsurface environments
- Long-term stability
  - Physical stability of TSFs
  - Preventing failures and catastrophic releases
- Environmental management challenges
  - Erosion and hydrological changes
  - Vegetation growth
  - Continuous monitoring and adaptive management

Social Risks

- Impact on local communities
  - Prolonged exposure to environmental risks
  - Health, safety, and livelihood concerns
- Community engagement
  - Addressing community concerns
  - Ensuring PCLU aligns with community needs
- Post-closure land use
  - Transforming TSFs into recreational areas
  - Creating socio-economic opportunities

Governance Risks

- Regulatory compliance
  - Ensures adherence to regulations
  - Avoids legal penalties and reputational damage
- Corporate governance
  - Guarantees accountability and transparency
  - Mitigates planning and financial risks
- Financial assurance
  - Secured through bonds or trust funds
  - Prevents incomplete closure due to mismanagement
- Stakeholder engagement
- Institutional capacity
- ESG alignment

Economic risks

Regulatory Methods

- Standardised methods of determining financial provisions
- Financial quantum should be supported by appropriate closure plans and designs

Financial Commitments for Closure

- Comprehensive closure planning and implementation require substantial financial commitments
- Post-closure life of a mine outweighs the operational portion

Costs Involved

- Stabilisation and rehabilitation costs
- Long-term expenses for ongoing monitoring, maintenance, and potential remediation

Strategic Planning

- Ensuring financial commitments are met requires strategic planning
- Establishment of financial assurance mechanisms to cover full costs

Integrated challenges

- Holistic approach to TSF closure
  - Recognises interdependence of ESGS and economic dimensions
  - Aims for sustainable outcomes
- Innovative engineering practices
  - Essential for effective TSF closure
- Comprehensive stakeholder engagement
  - Crucial for addressing diverse concerns
- Advanced modelling and monitoring tools
  - Ensure smooth transition from operational facilities to rehabilitated landscapes
  - Provide environmental, social, governance, and economic benefits

Importance of stakeholder engagement

Tailings engineers

- Primary concern: Physical stability of TSFs
  - Designing and maintaining facilities to safely contain tailings material
  - Minimising the risk of failure
- Detailed engineering analysis
  - Application of advanced modelling techniques
  - Predicting and mitigating risks associated with tailings storage
- Environmental pollution consideration
  - Ensuring stability while considering possible environmental pollution

Owners

Imperative for demonstrating effective rehabilitation

- Owners need to show that TSFs are rehabilitated effectively
- Ensures no latent liabilities remain

Comprehensive closure planning and execution

- Facility should integrate visually with the environment
- Facility should functionally blend with surroundings

Passing regulatory and community scrutiny

- Rehabilitation must meet stringent regulatory standards
- Community acceptance is crucial

Regulators

Regulators' Critical Role

Oversee closure process to ensure compliance

Focus on environmental standards and public safety

Liability Management and Risk Assessment

Require detailed closure plans from mining companies

Demand financial assurances

Continuous monitoring to mitigate long-term risks

Local communities

- Transformation of TSFs into community assets
  - Conversion into recreational spaces
  - Development of agricultural areas
  - Creation of wildlife reserves
- Enhancement of local quality of life
  - Improvement in sustainable development
- Importance of stakeholder engagement
  - Aligning post-closure land use with community needs
  - Ensuring community interests are considered

Receiving environment

- Importance of receiving environment
  - Includes local ecosystems and biodiversity
  - Implicit stakeholder in TSF closure process
- Focus on biodiversity and regeneration
  - Ensuring rehabilitated TSF areas support native species
  - Contributing to ecological balance
- Sustainable closure practices
  - Prioritising ecological restoration
  - Mitigating long-term environmental impacts of mining

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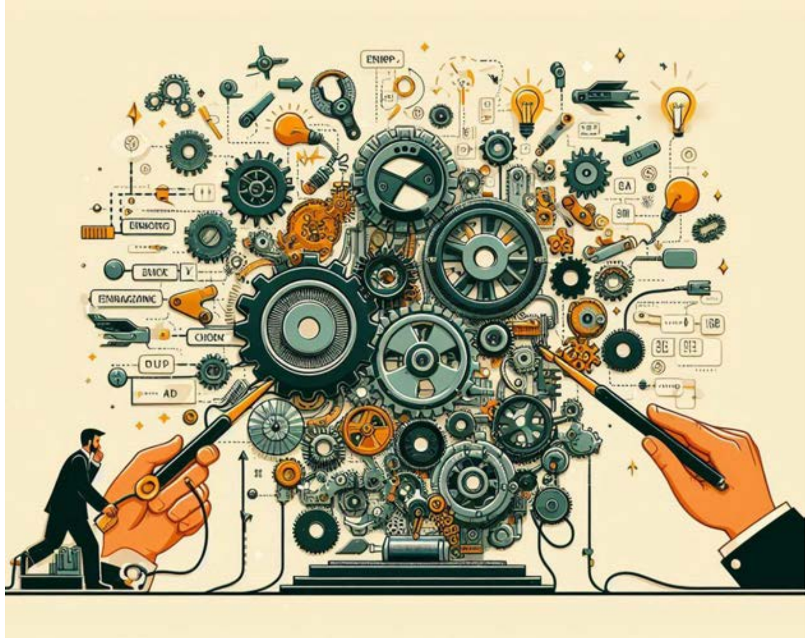
Concept of reverse engineering in TSF closure



Proactive integration of closure considerations

- Incorporates closure and post-closure needs into upfront design
- Ensures easier and cost-effective closure

Traditional vs. reverse engineering approach

- Traditional: Closure designs considered after mining activities cease
- Reverse engineering: Integrates closure objectives from the outset

Emphasis on sustainability and stakeholder engagement

- Focuses on environmental robustness
- Engages stakeholders throughout the TSF lifecycle

Use of advanced monitoring and modelling tools

- Ensures smooth transition from operation to closure

Integration of closure planning into the TSF lifecycle

Early closure planning

- Develop detailed closure plans alongside TSF design
- Anticipate potential ESGS and economic challenges
- Modify outer slope geometry, place cover materials, include operational spillway

Continuous monitoring and predictive modelling

- Assess TSF's performance
- Inform adaptive management strategies
- Modify closure designs during operational phase

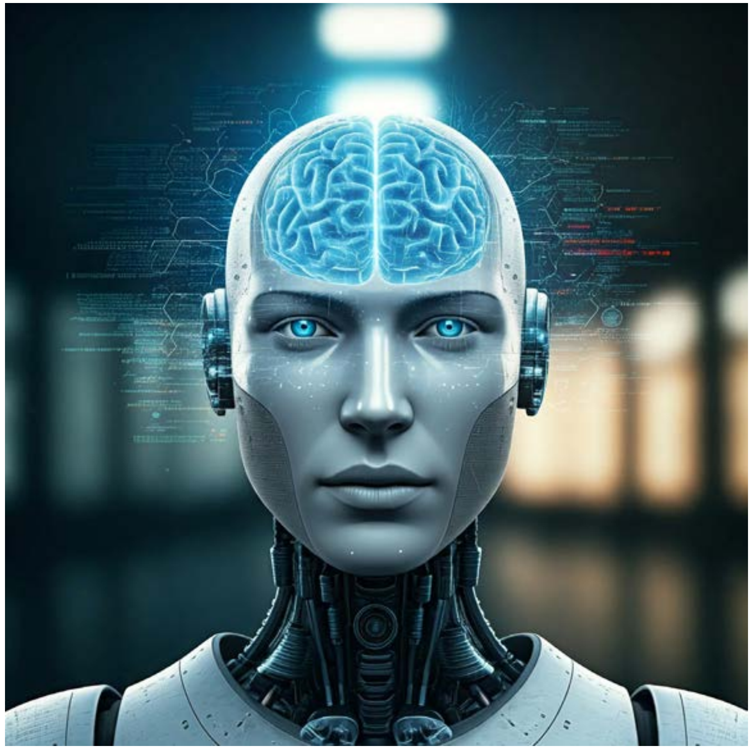
Stakeholder engagement

- Engage local communities, regulators, environmental organisations
- Ensure transparency and address concerns early
- Adapt closure plan and make proactive adjustments

Designing TSFs for minimal environmental footprint and regeneration

Choosing	Choosing materials and construction methods • Enhance TSF's stability • Provide environmental protection
Implementing	Implementing design features • Facilitate land reclamation • Support native vegetation growth and wildlife habitats
Utilising	Utilising advanced technologies and sustainable practices • Rain-on-grid (RoG) modelling • Landform evolution modelling (LEM)
Planning	Planning for post-closure use of TSF land • Benefit local communities • Convert into recreational or agricultural areas

Overview of advanced tools



Application of Advanced Tools and Techniques

- Anticipate and manage environmental and socio-economic challenges
- Enhance ability to model, visualise, and predict outcomes of closure strategies

Innovative Technologies

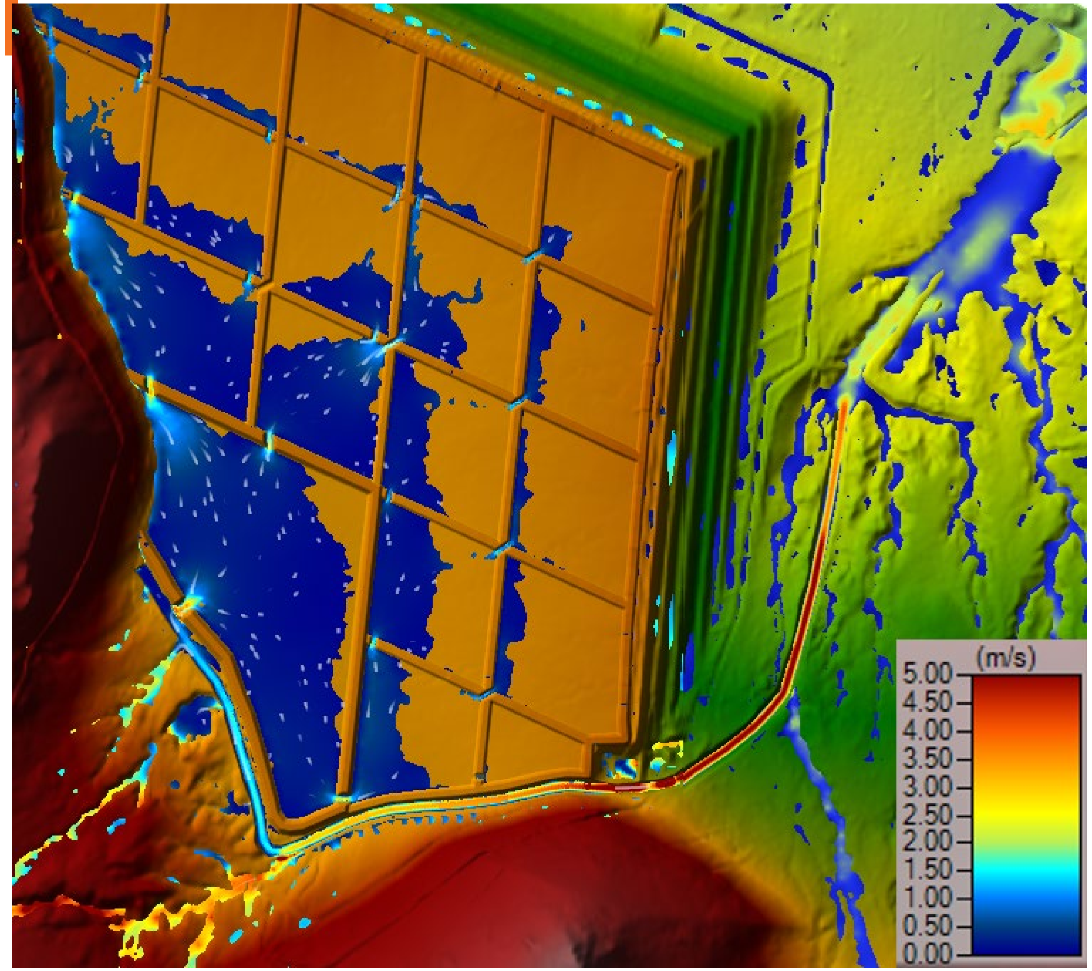
- Dam breach assessments (DBAs)
- RoG and LEM modelling
- Rendered images and videos

Insights from Natural Systems

- Develop robust closure plans
- Align with ESGS goals
- Facilitate effective communication with diverse audiences

Dam breach assessments

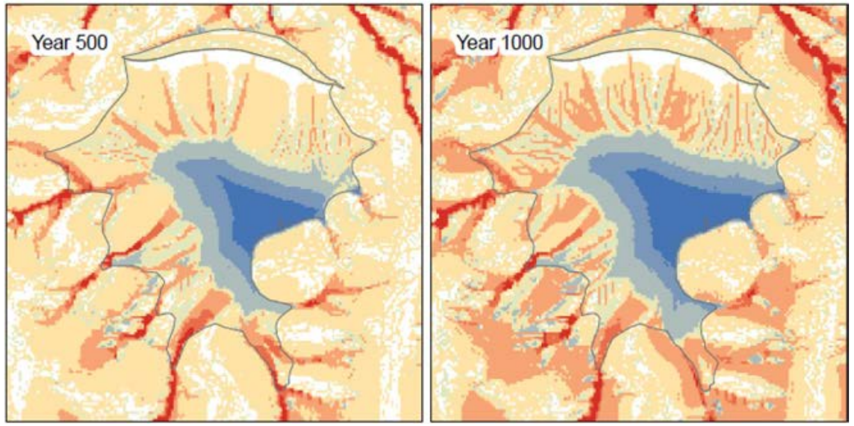
Predicting consequences of potential failures	Model dynamics of dam breach scenarios Estimate flow paths, velocities, and inundation extents
Understanding risks to downstream Areas	Assess risks to communities and ecosystems Ensure appropriate mitigation measures
Improving safety and resilience	Identify vulnerable areas Evaluate potential impacts
Enhancing emergency response planning	Develop better emergency response plans Assess downstream mitigation options



Rain-on-grid modelling

- Hydrological Simulation Technique
  - Evaluates interactions between precipitation and TSF surfaces
  - Generates synthetic rainfall events over a digital terrain model
- Simulates Runoff, Infiltration, and Erosion
  - Uses synthetic rainfall events
  - Analyzes runoff, infiltration, and erosion processes
- Application Example
  - Intense rain event causing pools in TSF basin paddocks
  - Flow vectors drawn down using spillway

Landform evolution modelling



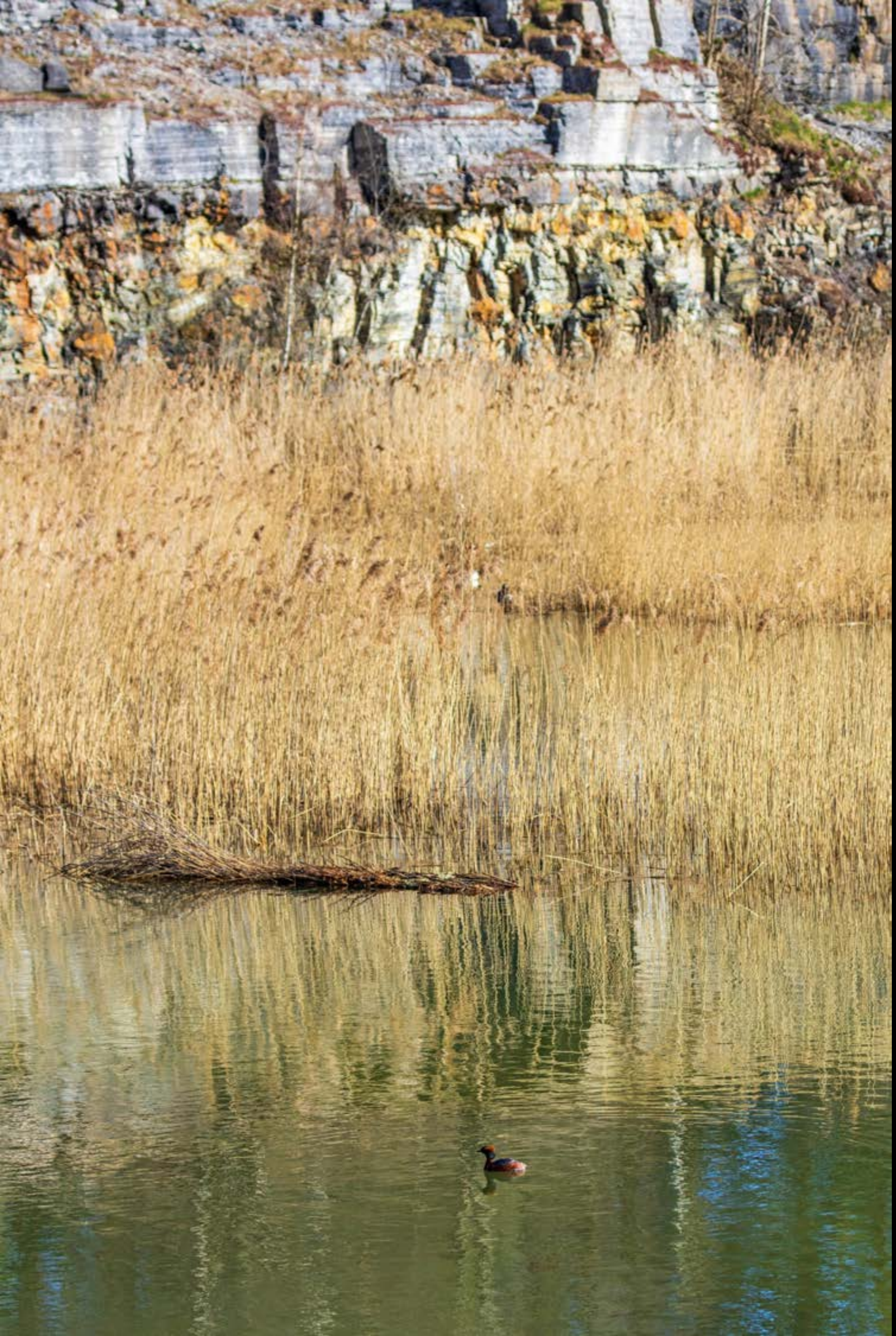
- Predicting long-term morphological changes
  - LEM uses computational algorithms to simulate erosion, sediment transport, and vegetation growth
  - Enables visual understanding of landscape evolution
- Designing stable post-mining landforms
  - LEM helps create stable and aesthetically pleasing post-mining landforms
  - Supports ecological restoration and biodiversity

Rendered images and videos

- Importance of Rendered Images and Videos
  - Visualise and communicate technical data
  - Create lifelike representations of proposed closure designs
- Technologies Enhancing Visualisations
  - Virtual reality for immersive experiences
  - Augmented reality for interactive models
- Benefits for Stakeholder Engagement
  - Foster engagement and informed decision-making
  - Support effective closure planning

Learning from nature

Emulating natural processes and systems	Promoting soil and topsoil formation through natural weathering
	Incorporating organic matter for soil health
Using biodiverse systems	Enhancing resilience through biodiversity
Incorporating redundancy	Mitigating risks with redundant systems
Microbial conversion of tailings	Enhancing nitrogen-rich organic matter formation
	Stabilising soil for ecological rehabilitation
Biomimetic approach	Fostering habitat creation and biodiversity



Importance of integrating ecological and sociocultural considerations

- Ecological Considerations
  - Restoration of natural habitats
  - Promotion of biodiversity
  - Creation of resilient ecosystems
- Sociocultural Considerations
  - Engagement of local communities
  - Understanding and addressing community needs
  - Provision of tangible benefits post-closure
- Symbiotic Relationship
  - Promotes sustainable outcomes
  - Enhances quality of life for residents

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Alignment with ESGS goals

- Long-term responsibility of mining companies
  - Management of tailings during and after mining
  - Subject to varying regulatory regimes
- Challenges in closure of TSFs
  - ESG and economic risks
  - Need for long-term monitoring and management
- Effective closure strategies
  - Comprehensive planning and financial commitments
  - Stabilisation of tailings and environmental rehabilitation
- Engagement with Local Communities
  - Addressing social concerns
  - Promoting sustainable development post-closure

Examples of successful TSF closures

Waihi Gold Mine, New Zealand

- Extensive stakeholder engagement and advanced ecological restoration techniques
- Transformed into a community park with native vegetation, walking trails, and water features
- Rehabilitation included land reshaping, topsoil application, and planting native species
- Resulted in improved biodiversity and a valued community asset

Lisheen Mine, Ireland

- Effective TSF rehabilitation with stabilisation of tailings and capping with topsoil
- Creation of wetland areas to enhance biodiversity
- Continuous monitoring and local community involvement
- Transformed into sustainable land use benefiting environment and local population

Browns Range Rare Earths Project, Australia

- Employing geomorphic design principles to create natural landforms

Lessons learned and best practices

Early planning and integration	Initiate closure plans early in the TSF lifecycle Embed sustainable practices from the outset
Stakeholder engagement	Engage with local communities, regulators, and other stakeholders Foster support and address concerns through transparent communication
Adaptive management	Implement adaptive management practices for continuous improvement Adjust plans based on monitoring and feedback
Innovative engineering and ecological techniques	Use advanced engineering methods and ecological restoration techniques
Socio-economic development	

Conclusion

Challenges of TSF closure	Environmental, social, governance, and economic challenges Holistic and forward-thinking approach needed
Importance of stakeholder engagement	Involvement of tailings engineers, owners, regulators, local communities, and ecosystems Use of advanced tools and modelling techniques
Integration of ecological and sociocultural considerations	Application of biomimetic principles for ecological balance Provision of tangible benefits to local communities
Successful case studies	Waihi gold mine, Lisheen mine, Browns Range Rare Earths Project
Recommendations for future TSF closure projects	