MINE CLOSURE FOR THE SUSTAINABILITY OF MINING AND ENVIRONMENT

CONCEPTS, CHALLENGES INOVATION

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CONCEPTS

1. We can not walk on the beach without leaving footprints in the sand.

2. When we create an imbalance in nature, the natural processes and biological responses will modify our works towards a different metastable state.

3. Mining is invasive and disruptive. We can do much to repair damage but leave a site that is on a trajectory towards a long-

CONCEPTS

4. **Social license to mine will be granted only if reclamation and the long-term trajectory of recovery meets public approval.**

5. **Social acceptance in the long-term is based on three factors:**
   - **The post mining land use value, both economically and ecologically**
   - **Risk and Safety**
   - **The burden of monitoring and maintenance on future generations**

CONCEPTS

6. **Social acceptance in the short-term is influenced by:**
   - **Economic and development opportunity gains**
   - **Disruption of traditional values and life styles**
   - **Environmental and community impacts**
   - **Risk and safety (tailings dams)**

7. **Environment and safety dominates societal view of mining in the long-term**

CONCEPTS

8. **Mines are getting larger - Impacts are larger and risk and burden on society is increasing**

Milling rates in t/d

100's in 1900

1000's by 1930's

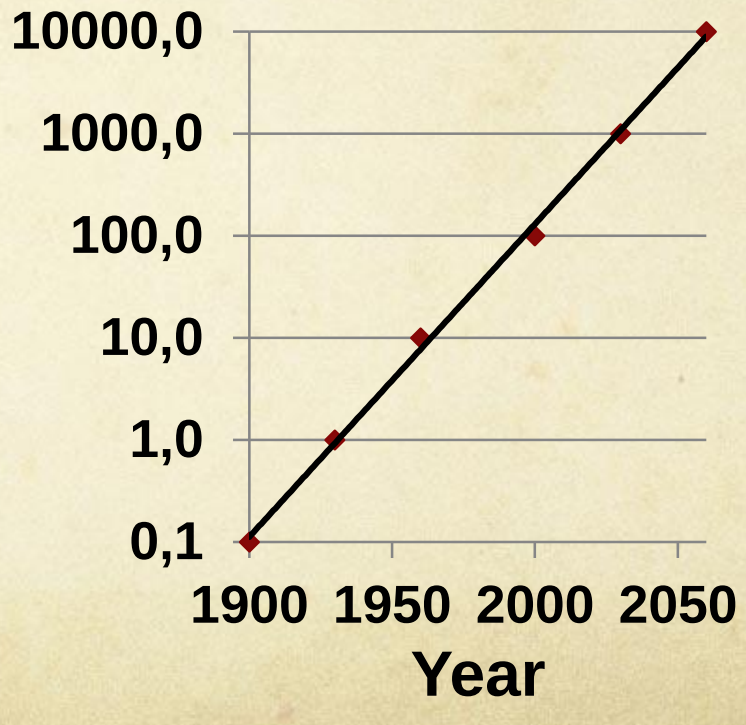
10,000's by 1960's

100,000's by 2000's

Anticipate :
1M's by 2030's
10M's by 2060's

10 fold increase each 1/3 century

Daily Milling Capacity, kt/day (Log Scale)



CONCEPTS

9. **The historic record for mining, that resonates with society is scarred by the history of environmental damage, economic and catastrophic disasters. Mine sites are often examples of environmental damage and continued impact long after mining ceases and the miners depart. Benefits of mining are rapidly forgotten or discounted.**

10. **The license for mining depends on our ability to mine with safety and minimal environmental impact, and particularly on the ability to return the land to a sustainable state of stability and land use that provides a benefit, and not a burden, on future generations. The objective of 'Mine Closure' is not only reclamation from mining damage but also establishment of the trajectory of recovery and beneficial land use.**

CONCEPTS

11. **Mining is a global industry. Catastrophic failures and environmental degradation publicized in global media become the standard by which mining is judged and licensed.**

12. **The extent to which society tolerates risk, particularly long-term safety and environmental risks, for short term gain is changing.**

13. **Tolerance for mining can be maintained only by secure implementation of "Post Mining Sustainable Use Plans"**

CHALLENGES

1. Increasing sizes of mines – Open pits, Tailings Dams, Waste Dumps
2. Increasing speed of development – reduced reaction time
3. Increasing population in communities close to mine structures
4. Increased recognition and intolerance of geochemical effects
5. Long-term degradation of weathering, erosion, leaching & man
6. Inadequate financial provision for perpetual care – burden on others
7. Rising expectations from society (safety, environment, economics)
8. Mining industry loss of trust and credibility – from examples
9. The moving goal posts of legislation – anticipate or suffer

TAILINGS DAMS SIZE INCREASE

Each 1/3 century:

Volume of tailings increases by	**~10 fold**
Area of waste deposits increase by	**~ 5 fold**
Heights of dams/dumps increase by	**~ 2 fold**

Max. Dam heights in 1900	**~ 30 m**
Max. Dam heights in 1930's	**~ 60 m**
Max. Dam heights in 1960's	**~ 120 m**
Max. Dam heights in 2000's	**~ 240 m**
Max. Dam heights in 2030's	**~ 480 m?**
Max. Dam heights in 2060' s	**~1000 m?**

RISK OF TAILINGS DAMS

Risk = Likelihood x Consequences

For dams:

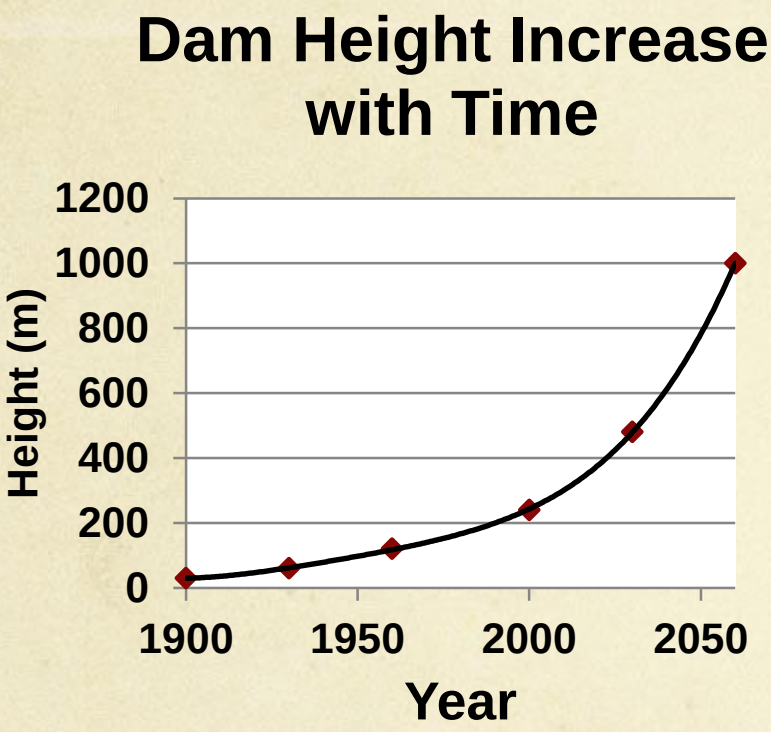
Likelihood -- 'somewhat' proportional to height

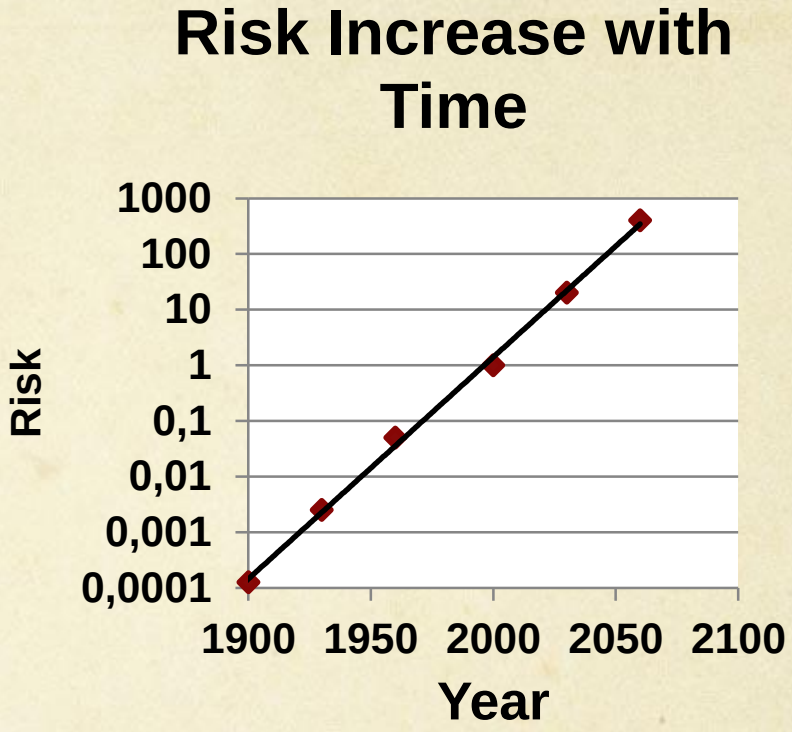
Consequences -- 'somewhat' proportional to volume

Increase in inherent 'safety risk' per 1/3 century is:

-- 2 X 10 = 20 fold

RISK INCREASE WITH TIME





Our dams are amongst the highest risk structures on earth

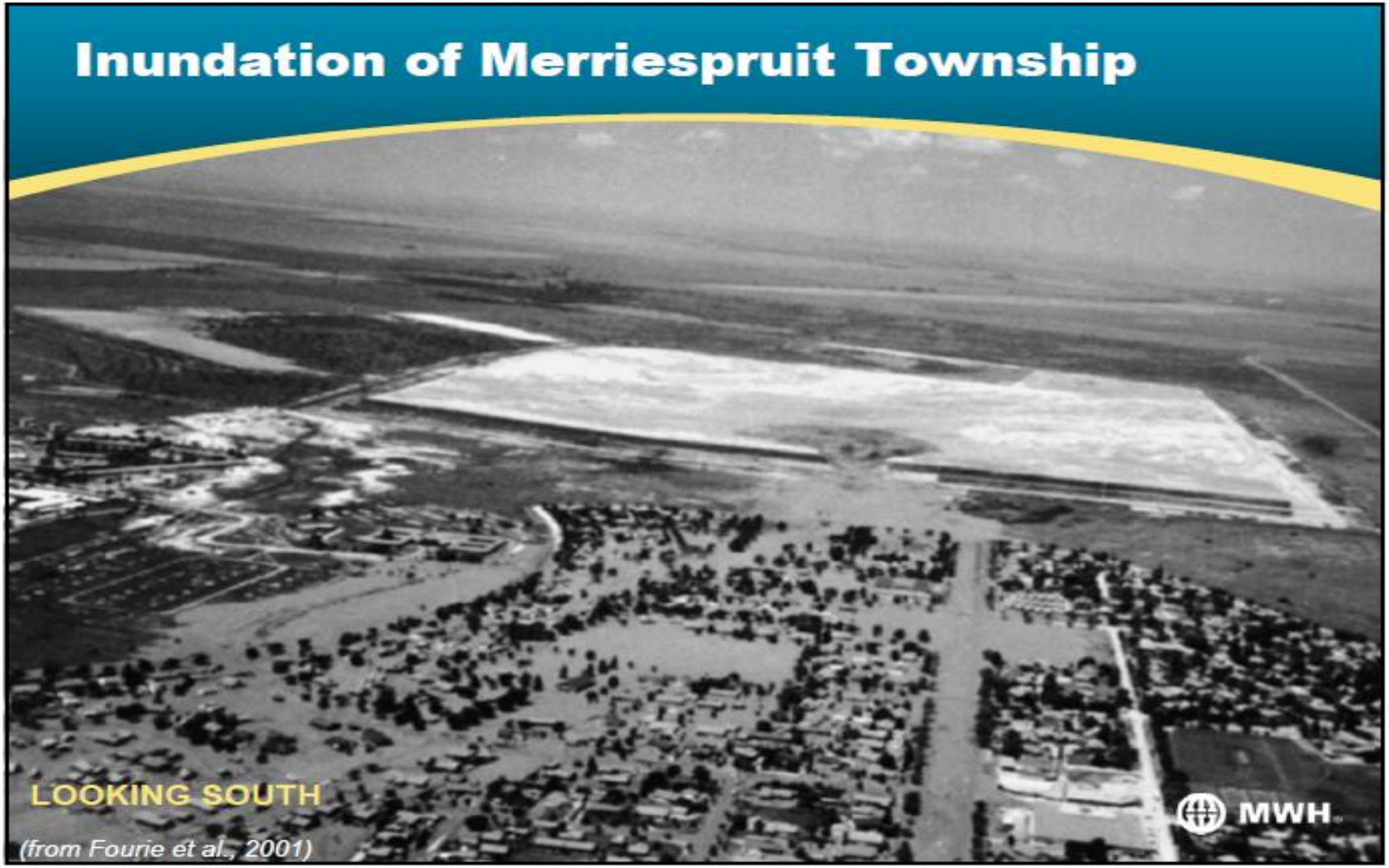
We may be in the last decades when society will tolerate tailings dams if we cannot demonstrate our ability to prevent failure.

BIG DAMS – BIG DUMPS – BIG PITS

HIGHER, BIGGER, FASTER

CLOSER TO COMMUNITIES

WE ARE NOT INFALLIBLE – FAILURES DO OCCUR!



HIGHER, BIGGER, FASTER, LOWER COST!

WE ARE ‘TICKING THE DRAGON OF RISK’

GEOCHEMISTRY AND WATER QUALITY

- Mining opens Pandora's box of problems:
  - Erosion and suspended solids
  - Oxidation and acid generation
  - Leaching and contaminant migration
  - Anthropogenic contact with metals harmful substances
- Contamination and transportation of our surface and groundwaters is troubling to a public increasingly sensitized to water quality and bottled water.

PERPETUITY IS A LONG, LONG TIME

- **Closure is not an event – it is forever**
- **Erosion, weathering, oxidation, leaching, contaminant generation & migration, floods, fires and earthquakes never stop.**
- **Control of the metastable closure landscape increasingly requires perpetual care.**
- **Our dragons are immortal – the burden we place on future societies**

FINANCIAL ASSURANCE

- Unless the financial provisions are made during asset exploitation, the debt obligation of closure and post closure care is transferred to others.
- ‘Limited liability’ protects the shareholder, but not the public.
- Closure and post closure costs are difficult to predict far into the future. Planning for current conditions is as useful as saying ‘I am never going to get older’.
- ‘Post Mining Sustainable Use Planning’ must recognize changing public expectations and the perpetuity of care

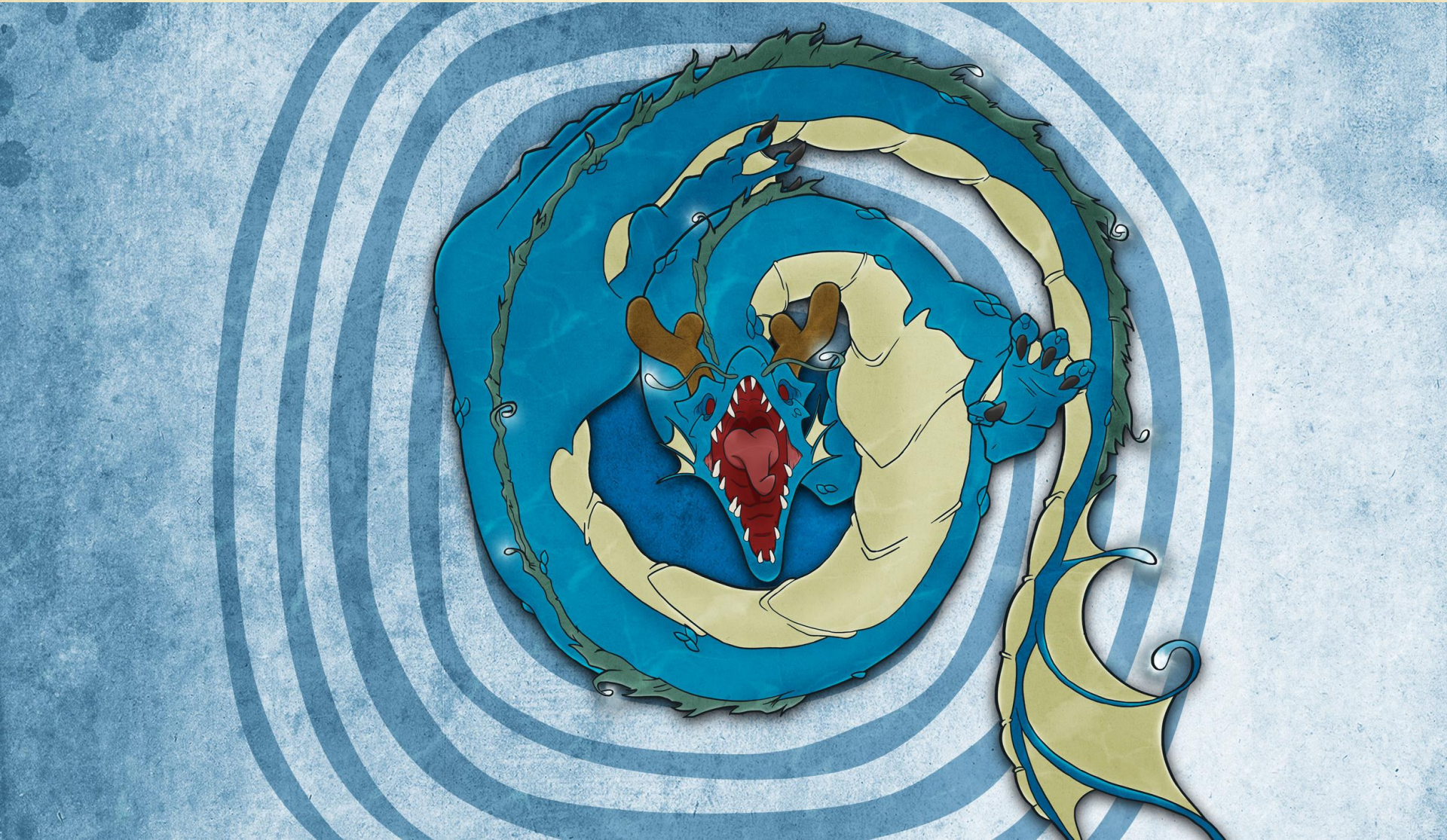
PUBLIC TRUST

- Mines do not plan to fail – but fail to plan accurately and reliably.
- Many ‘Closure Plans’ are mere concepts to satisfy permits and minimum financial obligations
- Failed Plans are the rocks on which public trust has been wrecked.

- The need for rigorous planning, based on reliable science, costing and financial assurance has been recognized.
- Implementation is more advanced in some countries than others.
- Public stakeholder involvement is central to re-building trust

REGULATORY GOVERNANCE, CORPORATE GOVERNANCE & PUBLIC ENGAGEMENT

“Taming the Dragons needs Innovation”



INOVATION

Where innovation is needed:

1. **Regulatory Governance – Regulations that require:**
   - **Post Mining Sustainable Use Plans (PMSUP)**
   - **Financial Assurance and implementation (not promises or insurance)**
   - **Robust Regulatory oversight – similar to Tailings Dam best practice**

2. **Corporate Governance – Similar to new Tailings Dam best practice**

3. **Reliance on demonstrated technology – actively seek innovation but demonstrate it prior to making promises**

4. **Evaluate alternatives with appropriate assessment tools**

5. **Public/community engagement from the start**

POST MINING SUSTAINABLE USE PLANS

- **The value of a resource includes:**
  - **The value recovered during operations**
  - **The positive or negative value of reclamation and closure, including interim or perpetual care costs**
- **Interim care applies until the trajectory of recovery is demonstrably sustainable**

POST MINING SUSTAINABLE USE PLANS

- **Perpetual care of erosion, oxidation, leaching, contaminant migration, water collection and treatment, monitoring and stabilization must be provided for (funded and managed).**

- **If the sustainable use plan does not attract a succeeding custodian, care belongs with the corporation or defaults to the Public**

FINANCIAL ASSURANCE

- **When:** **Financial assurance is a societal demand. Before permit to develop mine.**
- **What form:** **Assurance with initial deposit and fully funded over 50% of asset life.**
- **As Public shares in fiscal risks, a Pooled Over Funding Contribution may be appropriate of, say, 20% after initial funding obligation.**
- **Third party assurance (Company insurance) – recognize and minimize contractual risk.**
- **Closure funding is a social obligation like pensions and worker safety.**

ROBUST REGULATORY GOVERNANCE AND OVERSIGHT

- **Three potentially hazardous man made structures remain in the landscape after mine closure: Tailings dam(s), Mine(s) and Waste Dump(s). Safety risks and environmental threats of contaminant release and environmental degradation may exist in perpetuity. Establishment of a Regulatory Governance Structure for regulation and management of these long-term hazards is appropriate.**

- **All the aspects of Capability, Capacity and Continuity of Information have to be satisfied.**

- **The boundary between Regulatory Oversite and Corporate Responsibility and Liability has to be clearly established.**

- **Recent legislation, establishing Regulatory and Corporate Governance, Responsibility and Liability for Tailings Dams can serve as a model.**

CORPORATE GOVERNANCE

- **Following on the Mount Polley and Samarco Tailings Dam failures, there has been the development of Legislation, Regulations, and Guidelines by governments and technical societies such as:**
  - **Province of British Columbia (BC),**
  - **State of Montana etc.,**
  - **International Commission on Large Dams (ICOLD),**
  - **Association of Professional Engineers of BC (APEGBC) and**
  - **Mining Association of Canada (MAC).**

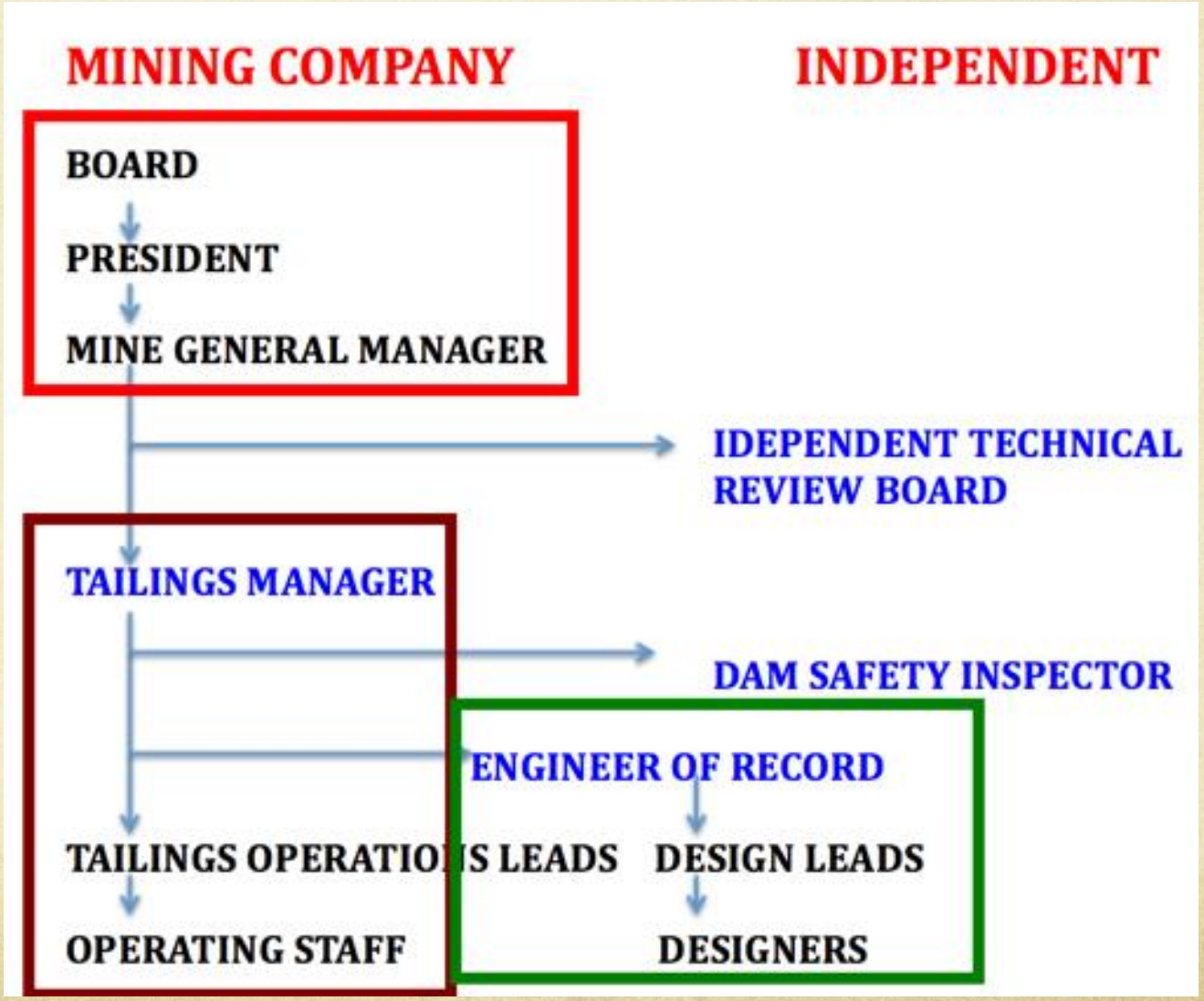
  This legislation and the guidelines have remarkably similar requirements and recommendations.

- **The Tailings Dam Regulatory and Governance Structure that is evolving is imminently suitable for 'Mine Closure' and 'Post Mining Sustainable Land Use.'**

CORPORATE GOVERNANCE

The Tailings Manager has responsibility for all aspects of the Tailings dam management during its life and post closure.

The Engineer of Record has responsibility for the technical aspects of tailings dam design, construction operation, closure and post closure



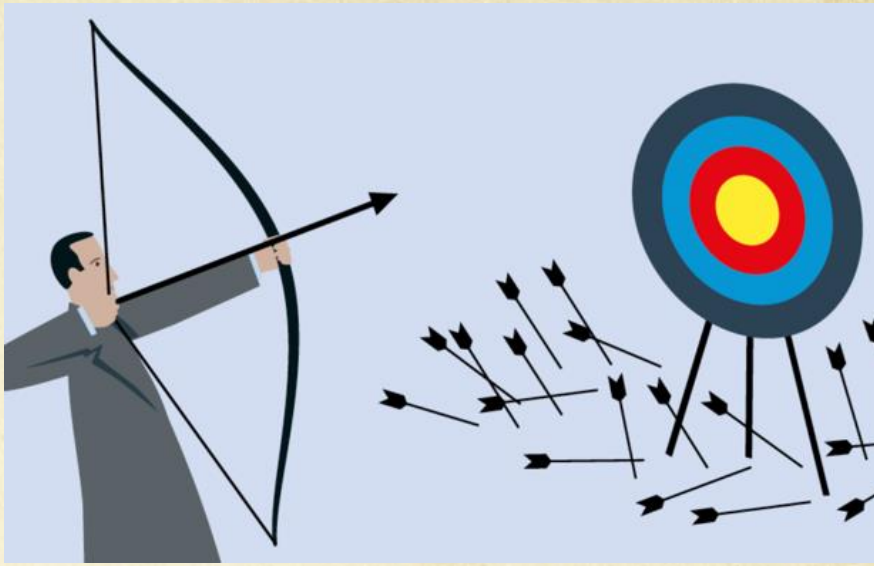
INTERACTION OF REGULATORY AND CORPORATE GOVERNANCE

- Under BC Regulation:
  - the **Responsible Perso**n on the mine is the Mine Manager. There has to be on his staff a 'Competant Person' for the Management of the Tailings Dam.
  - The Tailings Dam has to have an **Engineer of Record**, a competent person for the engineering design and technical aspects of construction, operation, closure, monitoring and maintenance and emergency response planning for the tailings dam.
  - There has to be **Independent Tailings Review Board** to review all aspects of tailings dam from design to post closure.
  - Periodic **Dam Safety Reviews** have to be performed by an Independent Dam Safety Engineer to certify that the dam is safe.

- The BC regulators rely on the reporting of each of these key individuals, in addition to the Board and senior management of the mining corporation

INOVATIVE TECHNOLOGY

- Adopt proven management practices under similar conditions.
- Seek and validate innovation to better address the problems of today when they arise tomorrow, but don't promise what you may not be able to deliver.
- Many innovative ideas are 'game changers' for betterment, but many fail on the slippery slope of good intensions, leave the hard work of remediation to future generations



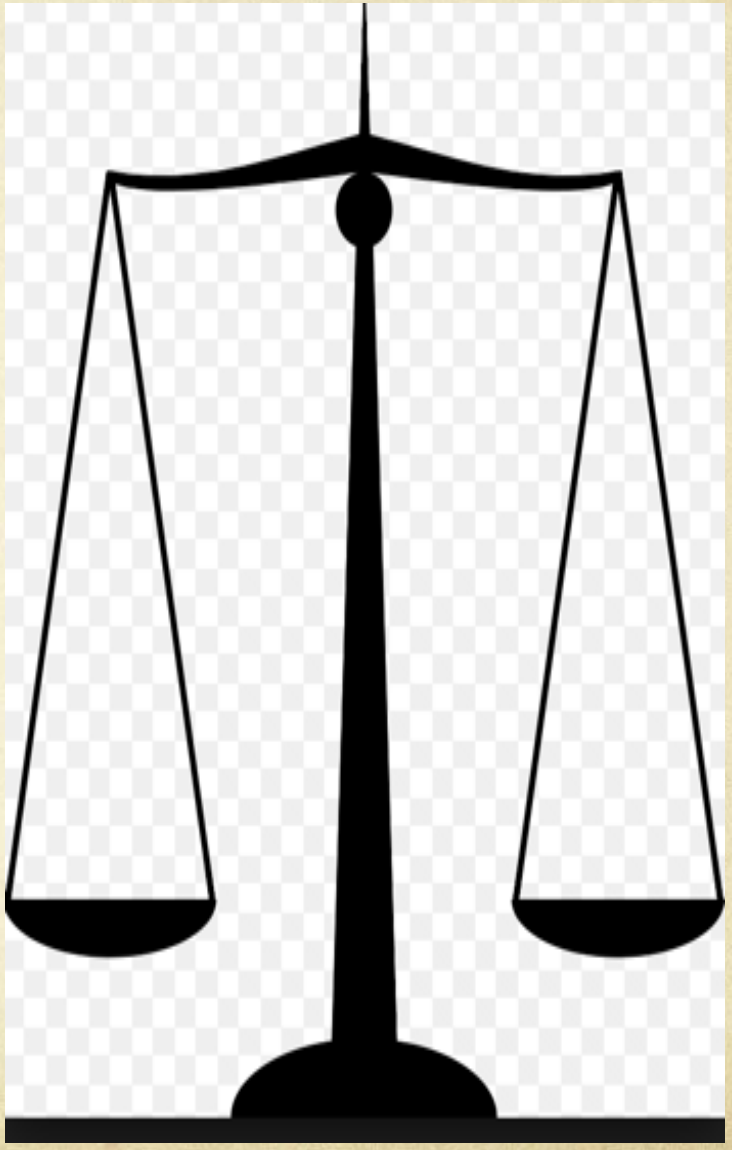
INOVATIVE TECHNOLOGY

- **Some innovative technologies with high potential:**
  - **Filtered tailings as economics of filtration improves**
  - **Co-disposal of tailings and waste in select circumstances**
  - **Backfilling pits where orebody, planning and economics allow**
  - **Landform engineering as means to increaser biodiversity and improved erosion resistance and stability**
  - **Oxidation control for acid mine drainage control by flooding and other methods**
  - **Passive treatment ponds for contaminants**

- **There are many others but all have applicability only in particular circumstances. Important innovation is that all must be screened and those with potential applicability studied with trade-off studies that consider both operating and long-term post closure merits.**

ASSESSMENT TOOLS

- **Technology and sites selection studies.** **All reasonable alternatives.**
- **Trade-off evaluations.** **Between all reasonable and economic options.**
- **Failure Modes and Effects Analyses (FMEA).** **Check that failure consequences are mitigatable or tolerable**
- **Multiple Accounts Analyses (MAA).** **Engagement and scoring tool to take into consideration all stakeholder views and vales – and form basis for selection of Preferred Option.**



MULTIPLE ACCOUNTS ANALYSIS

TABLE 1. SUMMARY OF MAA ACCOUNTS AND SUB-ACCOUNTS.

ACCOUNTS	SUB ACCOUNTS (issues)
TECHNICAL	Spent Ore Heap Leach Pads Leach Pad Dikes Waste Rock Dumps Open Pits Historic Underground Workings Historic Tailings Storm Water Control Ditches Collection & Seepage Capture/Pumpback Systems WTP/LAD Treatment & Release Alternative Water Treatment Technologies Reclamation Covers
PROJECT ECONOMICS	Short Term Reclamation & LAD Costs Long Term Monitoring/Maintenance Costs % of Reclamatioin Attainable within the Bond Long Term Water Collection/Treatment & Monitoring Cost
ENVIRONMENT	Surface Water Quality Protection Surface Water Quantity Protection Groundwater Quality Protection WTP Inflow Water Quantity and Quality LAD Water Quantity LAD Water Quality Re-establishment of Biological/Vegetative Potential
SOCIO-ECONOMICS	Aesthetics Hunting & Recreation Tourism Health & Safety Traditional/Cultural Community Infrastructure Completion Period Mineral Development Potential Future Burden on Society Employment Opportunities

INDICATORS	ALT 1	ALT 2	ALT 3	...
Density of revegetated areas	poor	intermediate	good	...
Ecosystem diversity/sustainability	intermediate	high	low	...
Percent of area with regrowth	45	58	88	...
Compatability with wildlife habitat	low	high	low	...

MULTIPLE ACCOUNTS ANALYSIS

TABLE 2. EXAMPLE OF RANKING, SCALING AND WEIGHTING A SUB-ACCOUNT

ACCOUNTS	SUB-ACCOUNTS	INDICATORS	INDICATOR WEIGHTS	ALT 1	ALT 2	ALT 3	...
	⋮						
ENVIRONMENT	Re-establishment of Biological/Vegetative Potential	Density of revegetated areas	3	1	5	9	...
		Ecosystem diversity/sustainability	5	5	9	1	...
		Percent of area with regrowth	3	5	6	9	...
		Compatability with wildlife habitat	4	1	9	1	...
	SUB-ACCOUNT SCORE			**3.13**	**7.42**	**4.03**	
	⋮	⋮	⋮	⋮	⋮	⋮	⋮
ACCOUNT SCORE							

SCALAR VALUES

MULTIPLE ACCOUNTS ANALYSIS

TABLE 3. SUMMARY OF THE TECHNICAL WORKING GROUP EVALUATION FOR THE ZORTMAN RECLAMATION.

ACCOUNTS		EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE Z1 (Final EIS ALT.3, ROD)	ALTERNATIVE Z2 (Optimize Water Treatment within Bond)	ALTERNATIVE Z3 (Optimize Source Control within Bond)	ALTERNATIVE Z4 (Additional Pit Backfilling)	ALTERANTIVE Z5 (Total Backfill to Pre-Mine Topography)	ALTERNATIVE Z6 (Optimize Source Control and Aesthetics)
TECHNICAL	ACCOUNT SCORE	4.95	5.85	7.45	6.65	6.49	8.14	8.83	7.11
PROJECT ECONOMICS	ACCOUNT SCORE	7.42	7.16	5.73	8.61	8.23	4.47	4.42	7.45
ENVIRON-MENT	ACCOUNT SCORE	5.68	5.87	8.10	6.76	7.17	8.18	8.22	8.38
SOCIO-ECONOMICS	ACCOUNT SCORE	4.66	4.85	5.98	6.13	6.06	7.01	7.48	7.05
MULTIPLE ACCOUNT SCORE		5.61	5.85	6.93	6.94	6.95	7.12	7.39	7.58
SCORE RELATIVE TO EXISTING CONDITIONS		0.00	0.24	1.32	1.33	1.34	1.51	1.78	1.97

MULTIPLE ACCOUNTS ANALYSIS

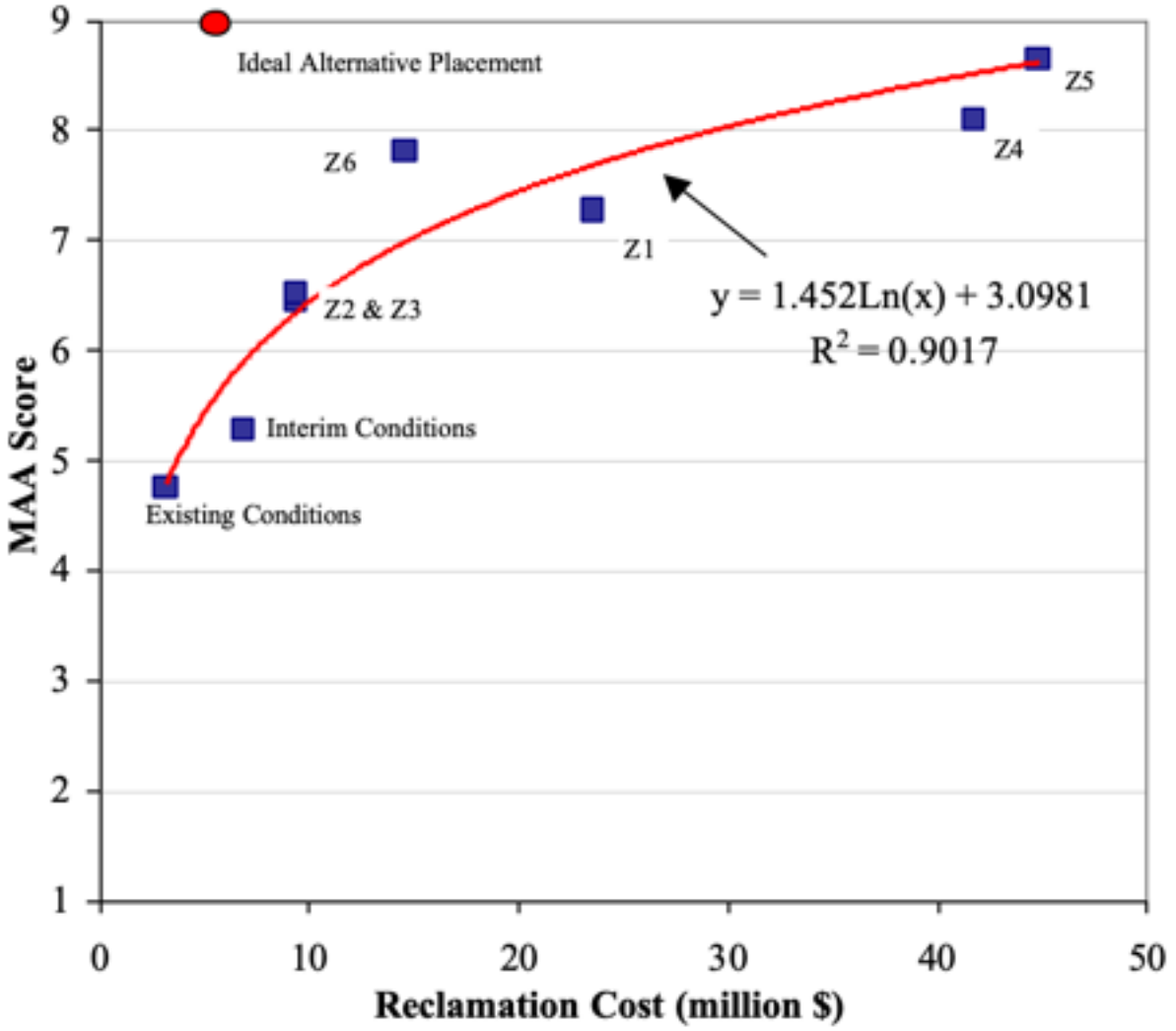


Figure 3. MAA Score versus Reclamation Cost for the Zortman Reclamation Alternatives

MULTIPLE ACCOUNTS ANALYSIS

- **MAA forms a basis for ultimate stakeholder (Mining company, public and government) engage in discussion, valuation and viewpoint exchange.**
- **80% of the value of performing assessment comes from the discussion.**
- **The weightings can be changed to reflect each stakeholders view. If If there is a difference in outcome there can be negotiations based on understanding. If the change makes no difference all parties are satisfied.**
- **Engagement can start early with getting input into accounts, sub accounts and indicators.**
- **Is an essential step in gaining public trust.**

RECCOMMENDATIONS

- **Closure and Post Closure Sustainable Use Plans at permit application time – to be a condition of permit**
- **Financial Assurance a permit condition**
- **Decision making to based on Alternatives Evaluation, FMEA and MAA with Stakeholder engagement.**
- **Corporate Governance a regulatory requirement**
- **Regulatory Governance Structure, Capacity and Regulations to implement and enforce.**

MAY ALL YOUR DRAGONS BE FRIENDLY!