2011 MINE CLOSURE CONFERENCE

6th INTERNATIONAL CONFERENCE ON MINE CLOSURE

Connecting Mine Closure Practitioners Around the World

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TOP 10 THINGS THAT GO WRONG WITH PLANS FOR MINE CLOSURE

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TOP 10 THINGS THAT GO WRONG WITH PLANS FOR MINE CLOSURE

Men do not plan to fail – but fail to plan adequately

Common Reasons:

1. Planning for the incorrect **objectives**
2. Planning with flawed **science**
3. Plan for an event, when closure is a **process**
4. Plan with inadequate **financial provisions**
5. **Murphy** and **Black Swans** are on the 'other team'

TOP 10 THINGS THAT GO WRONG WITH PLANS FOR MINE CLOSURE

We start by evaluating consequences -

Consequences increase with increasing mine size:

Daily milling capacity of largest mines:

100's	of tons at the turn of last century 1899/1900
1,000's	of tons by the 1930's
10,000's	of tons by the 1960's
100,000's	of tons by the turn of this century 1999/2000
Project:	
1,000,000's	**of tons by 2030's**

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Milling:

The largest oilsands mines are approaching 1.0 M t/d

The largest base metal mines are already planning 0.3 to 0.5 M t/d

Total waste:

The largest mines are exceeding 1 M t/d

For 4 cycles the largest mines have increased milling by 10 fold each 1/3 century

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Increase in Closure Liabilities of Largest Mines

Each 1/3 century:

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

Max. Dam heights in1900	~ 15 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

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Closure Risks

Risk = Likelihood x Consequences

For dams: Likelihood ~ 'somewhat' proportional to height
Consequences ~ 'somewhat' proportional to volume

Increase in 'potential risk' per 1/3 century is ~ 2 X 10 = 20 fold

Requires risk management through high standards of:

- Investigation
- Design
- Construction
- Operation - including post closure
- Monitoring - including post closure
- Maintenance - including post closure

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If we examine history then we note that:

Distant past > pre 1930's:

There were tens if not hundreds of thousands of small mines;

There was little requirement for closure measures.

Man did not plan to fail - but failed to plan

Consequences:

Many small impacts – unreclaimed adits, waste and tailings piles and small mines.

Isolated response from affected communities

Little required for closure planning

TOP 10 THINGS THAT GO WRONG WITH PLANS FOR MINE CLOSURE

Intermediate past – 1930's to 1990:

Many intermediate mines and some large;

The Black Swans of Geochemistry and Hydrogeology join Water Quality to become a flock.

Birth of early inadequate closure plans;

Increasing regulatory requirement for closure plans;

Man increasingly plans - but plans inadequately.

Consequences:

Most closure plans were inadequate (deficient **objectives, science, process, financial** and attention to **Murphy** and **Black Swans**)

Widespread and virulent response from affected communities – general dissatisfaction!

Early legislation and guidelines for Closure Plans

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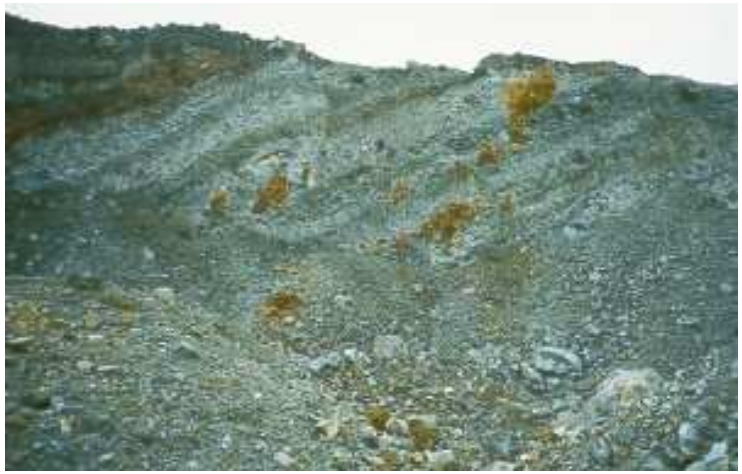

Oxidation of sulphides and Acid Mine Drainage

TOP 10 THINGS THAT GO WRONG WITH PLANS FOR MINE CLOSURE

Immediate past – 1990's to present:

Many intermediate and large mines

Small mines only at artisanal level

Murphy convinces us that closure is a process not an event

Evolution of the Closure Plan, objectives, science, process, financial and better recognition of Murphy and Black Swans

Consequences:

Closure Legislation becomes universal,

Objectives are establishing,

Science is improving,

Financial provisions becoming more robust

Liability concerns all

Murphy and Black Swans are opportunistic

TOP 10 THINGS THAT GO WRONG WITH PLANS FOR MINE CLOSURE

The immediate future: present to 2040's

- Many large and giant mines – very large potential risks
- Evolution of the Closure Plan, objectives, science, process, financial and better recognition of Murphy and Black Swans
- Society conflicted by resource needs vs incremental perpetual risk

Consequences (predicted):

- Increasingly risk adverse based decisions will control mine closure
- Closure conditions will dictate mine technology
- Collect and treat; slurry tailings, high dams, long-term geosynthetics use will join the endangered list.
- 'Closure Liability' becomes as significant as 'ore reserve'

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Or

The 10 biggest reasons for Oopsies

TOP 10 THINGS THAT GO WRONG WITH PLANS FOR MINE CLOSURE

Planning for the incorrect objectives

1. The changing goal posts of legislation: The time between initial formulation of Closure Plans and the implementation of Closure Plans is decades. Legislation and interpretation of legislation is not stable over this period. If you can't accurately anticipate future requirements, there will be wrong objectives.

Mitigation: Anticipate from trends in other, possibly more advanced regulatory jurisdictions, the objectives that may have to be achieved. Be conservative and build in contingency and flexibility.

TOP 10 THINGS THAT GO WRONG WITH PLANS FOR MINE CLOSURE

Planning for the incorrect objectives

2. The 'community will 'decide' at the time of closure, not at Closure Plan preparation: Both communities and community values change over decades. Closure Plans are a social license that will ultimately be granted by the closure affected community. Failure to anticipate their needs is a 'wrong' for the Closure Plan.

Mitigation: Anticipate community growth, expectation changes and so do conditions at mine closure. Build and maintain community appreciation for the post closure conditions that will prevail. Remember, closure is a process.

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Planning with flawed science

3. Optimism for the effectiveness of new, novel and sensitive technology. With implementation decades away, the scrutiny and evaluation of undemonstrated or novel technology is often not rigorous. There is over reliance that 'time will demonstrate efficiencies. Examples:

- The wetland water treatment will achieve discharge standards
- The tailings will be impermeable and prevent seepage
- The 'clay' covers will prevent infiltration
- Lime addition will prevent ARD and contaminated drainage

To mitigate; limit acceptance of science and application to only that which has been demonstrated in situations reliably representative of the proposed application.

Planning with flawed science

4. Geological, seismic, climatic and other naturally variable systems are imprecisely defined for design purposes, as are performance of these natural systems. Performance outside predicted behavior occurs frequently. Examples are:

- Unanticipated seepage flows in faults or zones;
- Instability due to slip or low strength surfaces or layers;
- Unanticipated geochemical behavior of ores.
- Extreme flood flows

Mitigation is achieved by extensive and full investigations and testing, modeling and monitoring during the operational period.

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Island Copper during flooding

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Planning for an event, when closure is a process

5. Many, if not most, large mines will be closed with an on-going need for interaction to ensure environmental protection and safety. The achievement of 'Closure' is a certificate of custodial transfer, and the continued success of closure is dependent on post closure processes of monitoring and maintenance.

Many Closure Plans do not recognize this need, and fail to achieve conditions under which custodial transfer is durably achieved.

Mitigation is achieved by providing in the Closure Plan for the continued process of closure until such time as the succeeding custodian durably accepts responsibility.

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Planning with inadequate financial provisions

6. Inclusion of the full cost of closure reduces the calculated present value of a mine. Maximizing asset value is an objective of asset managers and there is considerable motivation to be optimistic in estimating Closure Plan costs.

Consequently, under estimation is common.

Mitigation is to ensure costing is realistic and not compromised by conflict of interest.

Planning with inadequate financial provisions

7. The fiscal universe is not stable. Closure funds calculated and structured when the real rate of return was 4.5% may not perform as anticipated while the fiscal axis wobbles during uncertain economic conditions.

Alternative predictions of future economic conditions will undoubtedly identify wrongs in Closure Planning

Mitigation ?

Murphy and Black Swans

8. Murphy's A team – The Perpetual Forces, given the opportunity to attack **in perpetuity**, are a formidable opponent of Closure Plans.

The ravishes of erosion, weathering, frost and desiccation, fires, frost, biotic and anthropogenic activity can be countered only by an equally persistent and diligent program of monitoring and maintenance.

Mitigation is achieved by extensive review by widely experienced personnel and performance of risk assessments incorporating representation from all design and operating disciplines.

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Perpetual forces of erosion an biotic activity

Murphy and Black Swans

9. Murphy's B team – The **Extreme Events**, not only attack structures, but their occurrence changes the graphs used for prediction. Extreme floods and earthquakes have challenged our structures, with success, and **perpetuity** offers many opportunities. The greatest impact of extreme events, even if they do not challenge a single mine site, is their influence on prediction of severity of design events, requiring changes to Closure Plans.

With perpetuity on his side Murphy has infinite patience in trying out combinations of these teams in endless varieties of plays and maneuvers. Our ability to visualize these combinations develops over time, with experience. He has many more lessons to deliver.

Mitigation similar to 'Wrong' No 8

Murphy and Black Swans

10. Black Swans are not predictable beyond that - they will arrive. Perhaps a few Gray Swans are shadows on the horizon:

- High tailings dams may cease to meet the test of long-term risk acceptability.
- Slurry tailings in liquefaction susceptible deposits - ditto
- Sustainability of contaminated water collection and treatment?
- Geosynthetics in construction where durability is required?
- Closure Plans may morph to Post Closure Sustainable Use Plans

TOP 10 THINGS THAT GO WRONG WITH PLANS FOR MINE CLOSURE

If we can't get it right the first time – we must plan to fix it!

There are four perpetual needs:

- Metals and mined products;
- Mines;
- Closure Plans
- Post Mining Sustainable Use Plans

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THANK YOU - QUESTIONS?