

Climate Change for Engineers: How to Consider Future Unknowns in the Context of Design Today

Lindsay Tallon, O'Kane Consultants

Andrew Baisley

Graham Hay

SMA Environmental Forum
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Climate Change – A Very Big Deal



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Climate change to cause global beer shortage, study says

By Susan Scutti, CNN

Updated 11:00 AM ET, Mon October 15, 2018



Making beer from river water 01:46

More from CNN

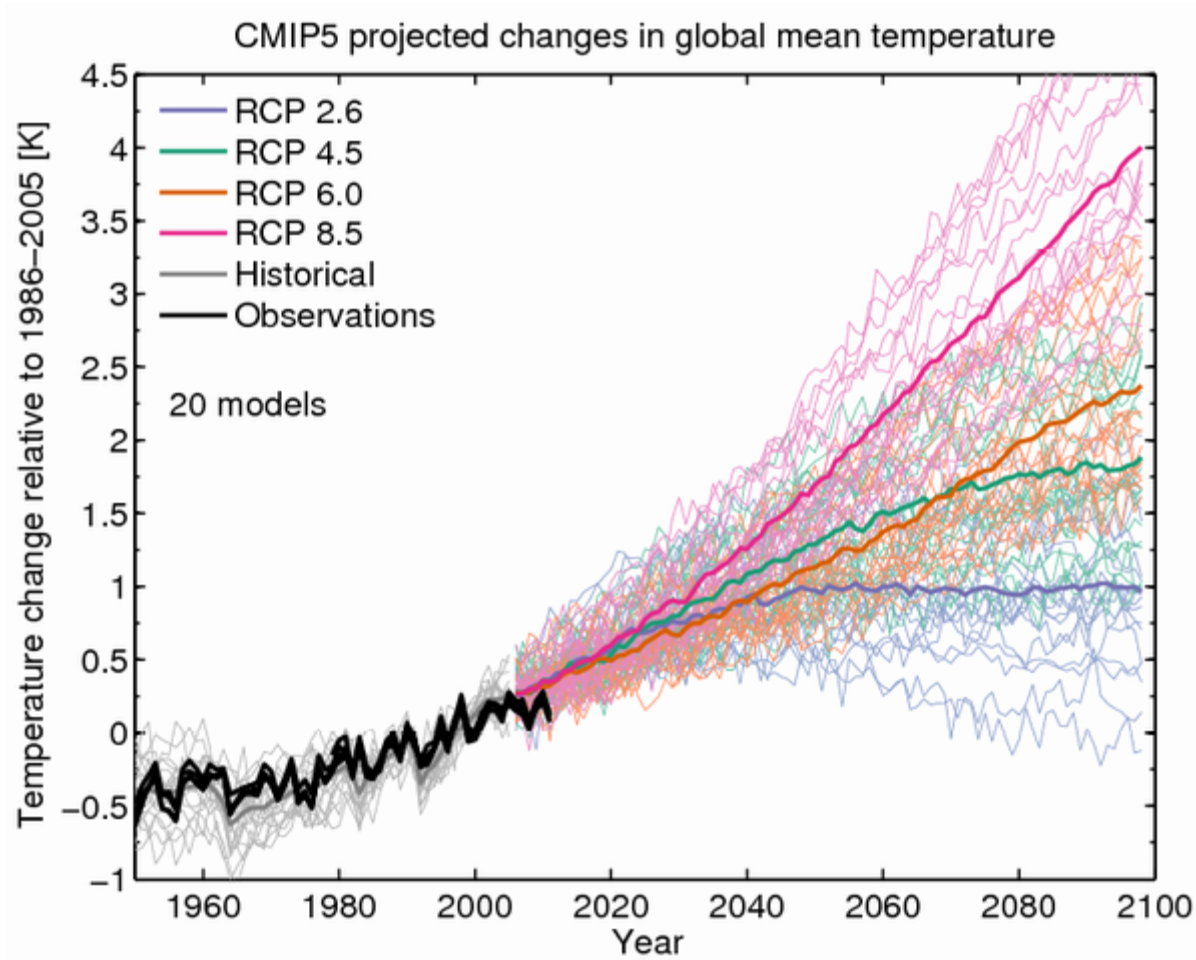


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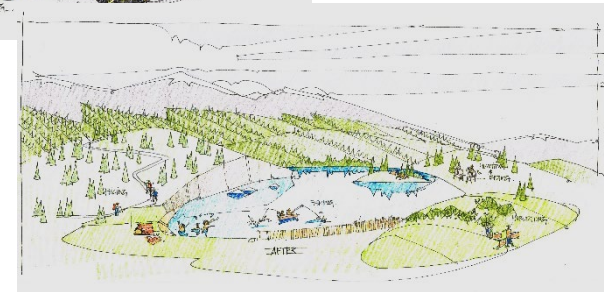
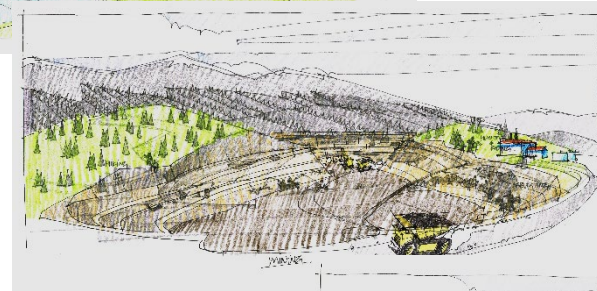
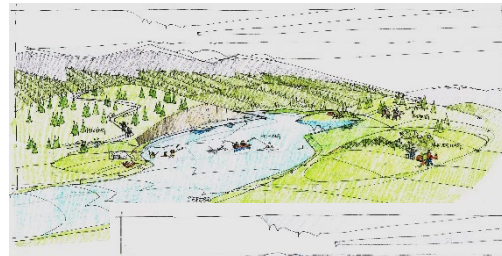
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Revert To Your Training



Advancing a Design

- What is driving the design?
 - Uncertainty?
 - Technical work?
- Place in the proper context
- What supports an engineering design?
- What has worked



Trying to Go From This...



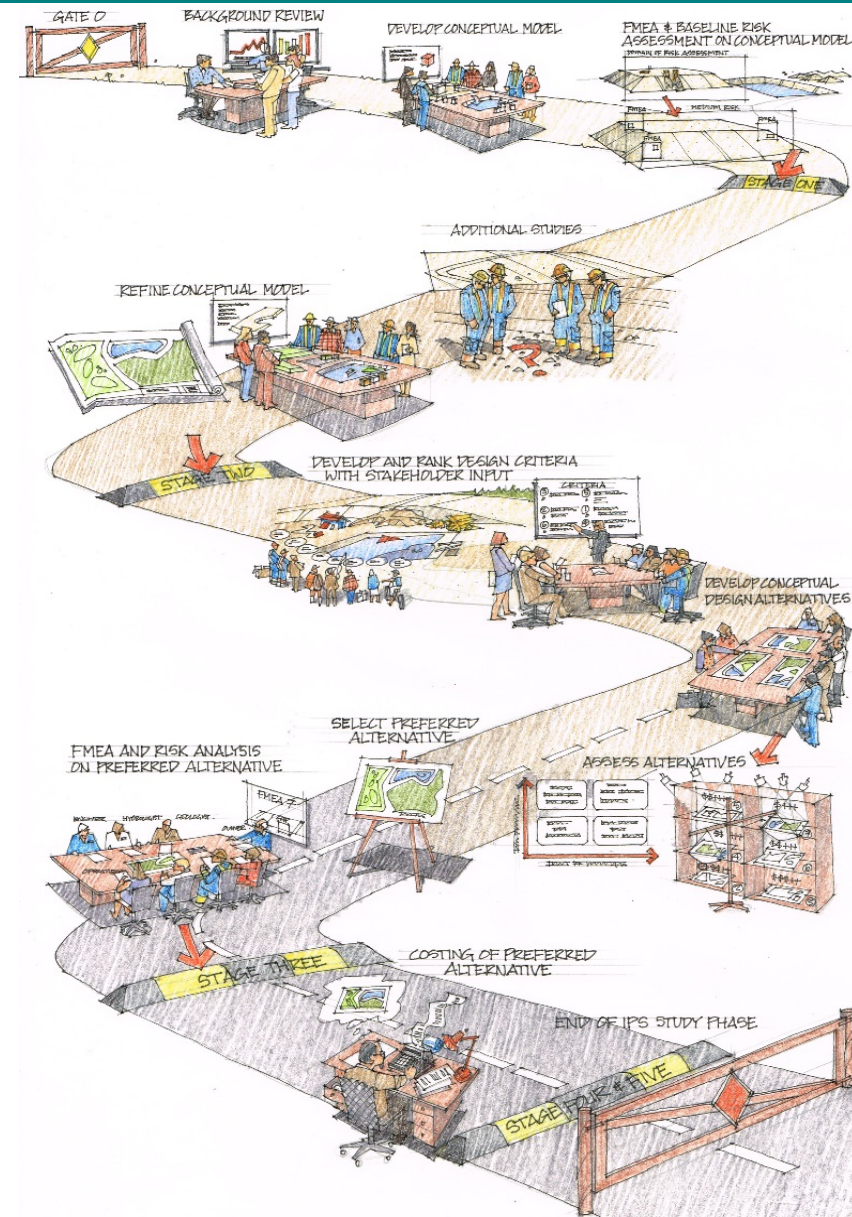
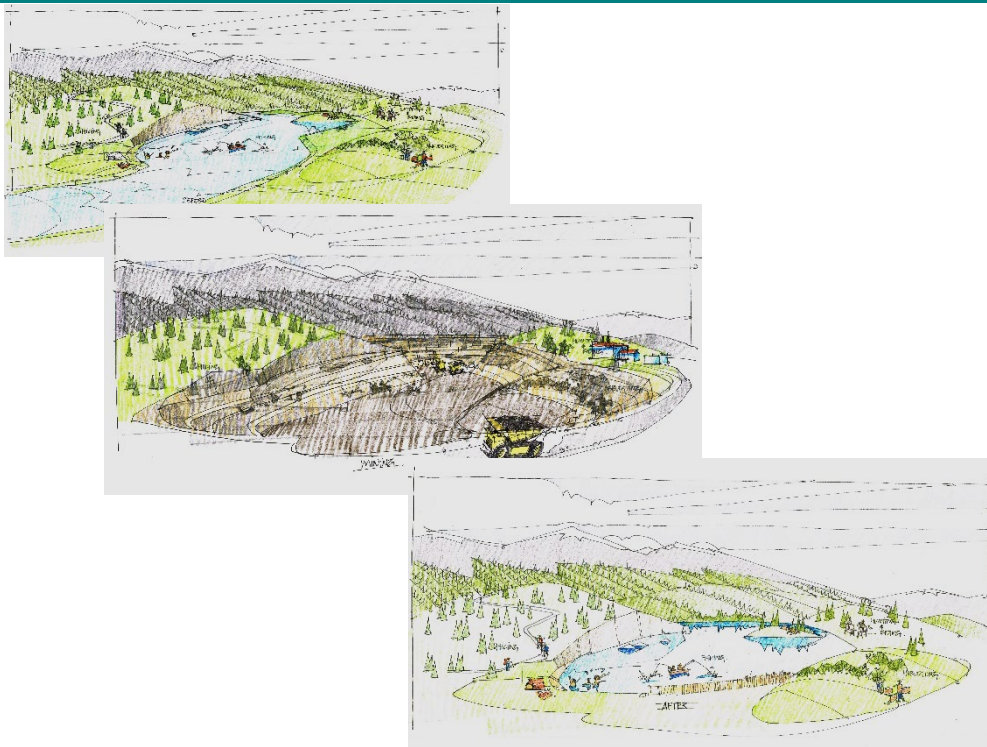
...To This...



...While Thinking About This?



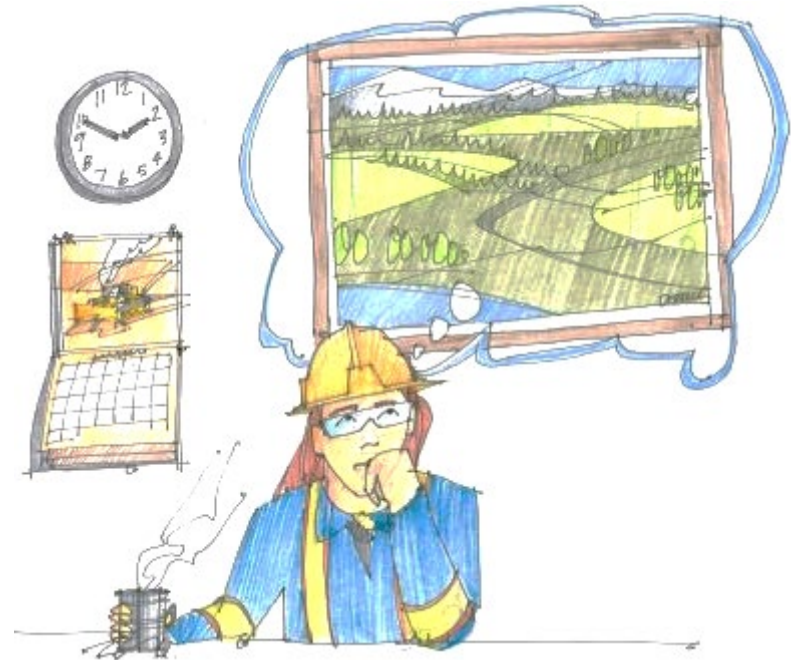
How Do We Get There From Here?



- **Road Map to Closure...**

Conduct A Gap Analysis

- Northern Saskatchewan mine
- Closure Design
- Consider future climate scenarios
- Important themes



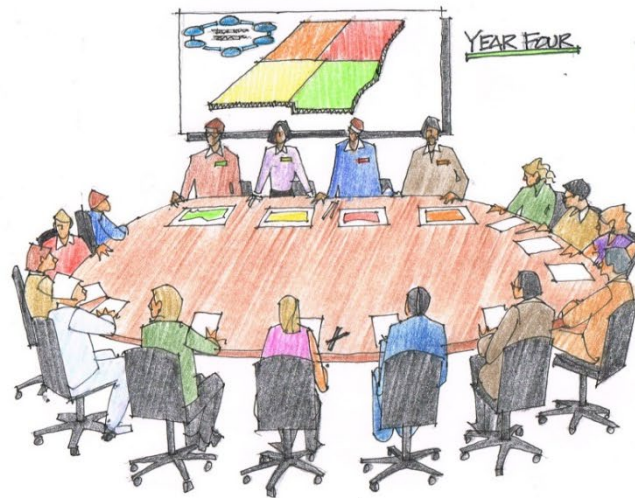
Gap Analysis



Consider Your Objectives

- ❑ Not a gap unless it represents a risk
- ❑ Applying our own implicit risk tolerance onto the problem
 - Implicit or Explicit
 - Bring your own experiences
 - Using the personal risk profile of the scientist or engineer
 - May not match the site's
- ❑ Is that risk profile is tied to the site's objectives?

What Is The Objective?



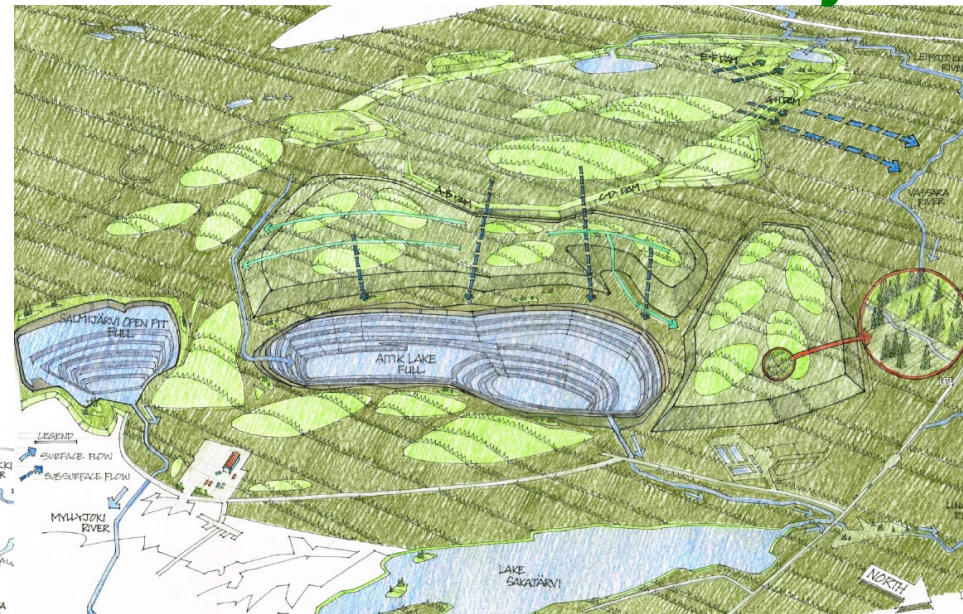
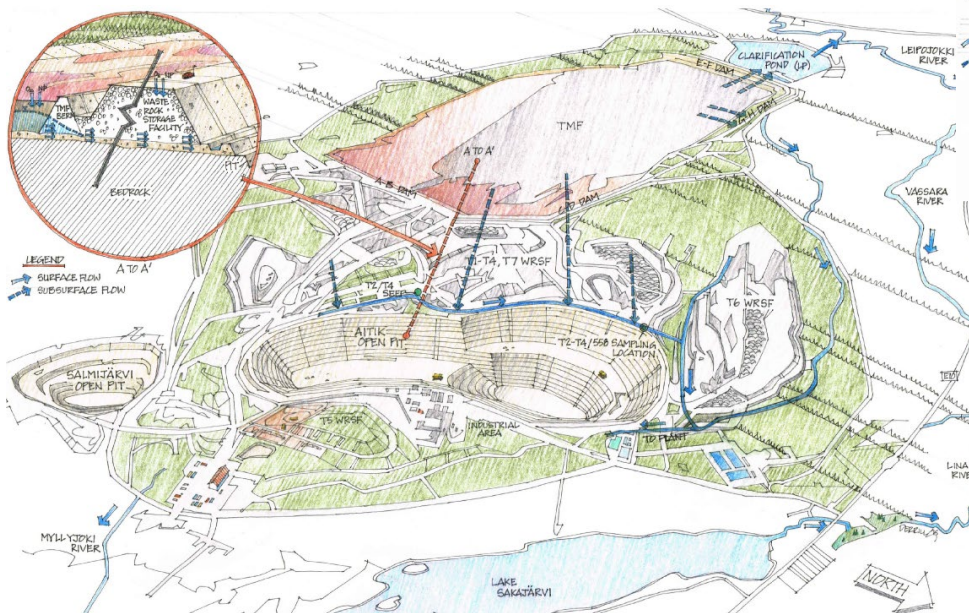
Risk to Opportunity

Recognize and Communicate:

...Different Temporal Scales

...Different Risk Profiles

Closure Planning:
Mine-Life-Cycle



Planning and Operations:
Life-of-Mine (LOM)
...next 3 to 6 mths

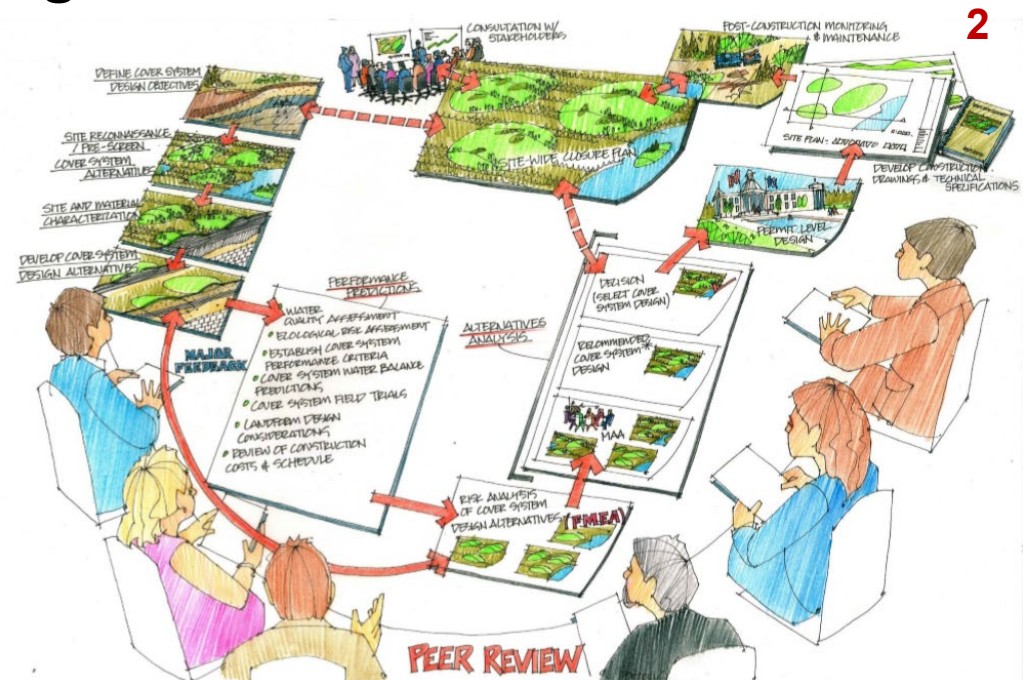
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Risk Communication

- Failure Modes and Effects Analysis (FMEA)
 - Distinct from a Risk Assessment
- Effective way to advance a project
 - Identify risks
 - Develop mitigation measures
 - Communicate that you've addressed them
- Technical aspects inform on the risk
 - Outcome of the process

Understanding / Communicating Risk

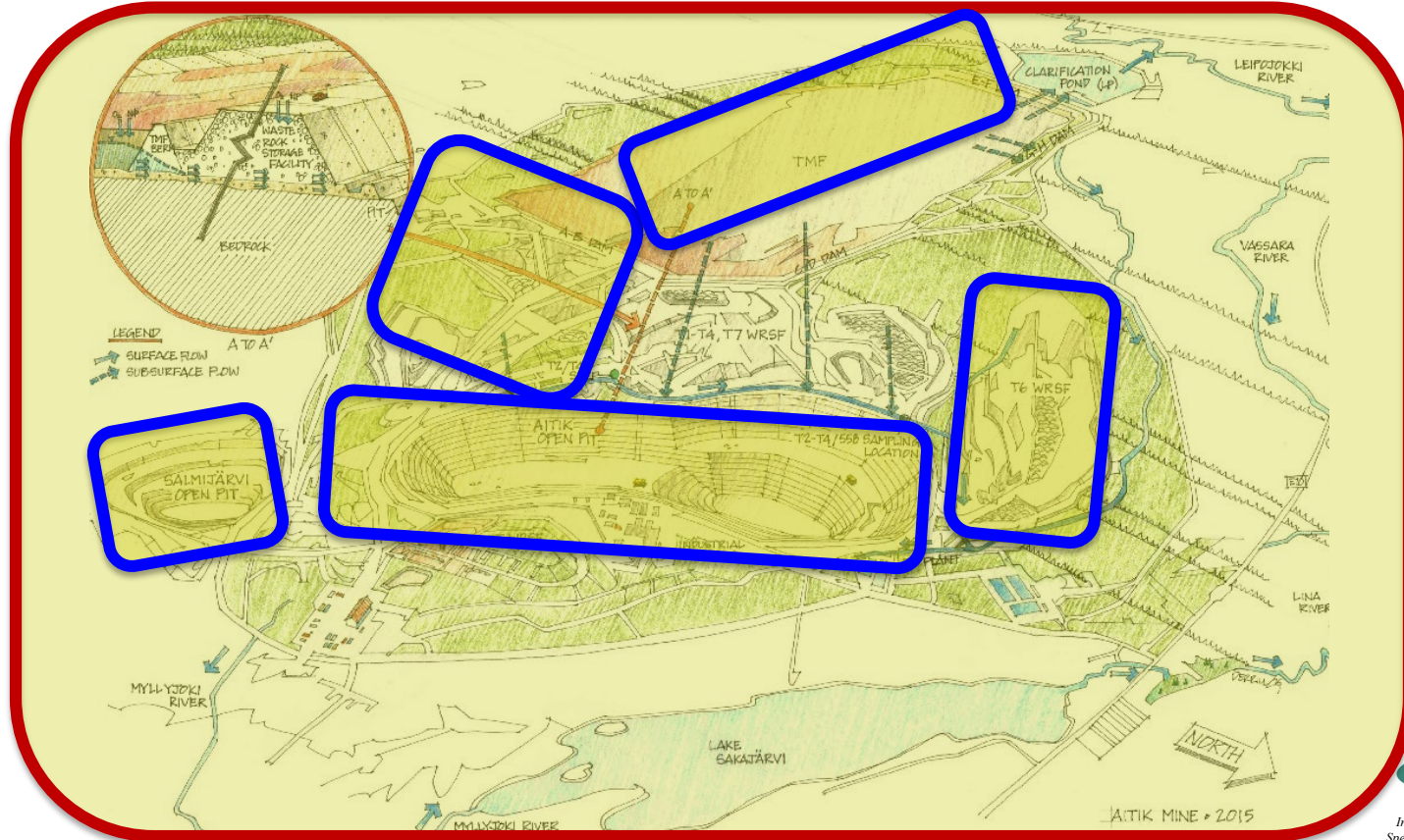
- **Failure Modes and Effects Analysis (FMEA) as a tool to inform on Engineering Design... Throughout the Project**
- **“A top down/ expert system approach to risk identification and quantification, and mitigation measure identification and prioritization”¹**
- **An FMEA Approach is the Appropriate Tool to move our design through time**



1. Robertson, A. and Shaw, S. 2006. Mine Closure. InfoMine E-Book, pp. 55
2. MEND 2012. Cold Regions Cover System Design Technical Guidance Document, MEND Report 1.61.5c

What is an FMEA?

- An FMEA is fundamentally different than an ecological and human health risk assessment (for example)
 - **Ecological and Human Health RA:** Consider System as a **WHOLE**
 - **FMEA:** Failure of Individual **COMPONENTS OF THE SYSTEM**, and Effect on the System's Functionality



FMEA – As a Communication Tool

Failure Mode	Effects and Pathways	Likelihood	Env. Impact	Cost	Human Health & Safety	Regulatory Compliance	Highest Risk Rank
Differential settlement greater than predicted for landform design and disruption of surface water drainage	Discharge routed through tailings entering lake causing exceedance of arsenic trigger value	High 10-50%	Moderate	Moderate \$1- 5 million	Low	Major	High

		Consequence Severity				
		Low (L)	Minor (Mi)	Moderate (Mo)	Major (M)	Critical (C)
Likelihood	Expected (E)	Moderate	Moderately High	High	Critical	Critical
	High (H)	Moderate	Moderate	Moderately High	High	Critical
	Moderate (M)	Low	Moderate	Moderately High	High	High
	Low (L)	Low	Low	Moderate	Moderately High	Moderately High
	Not Likely (NL)	Low	Low	Low	Moderate	Moderately High

Permafrost melting already observed

Consequence costs reflect potential replacement of cover system sections, importing cover system materials, and/or higher unit costs

Risk of becoming out of compliance

FMEA – As a Communication Tool

Failure Mode	Effects and Pathways	Likelihood	Env. Impact	Cost	Human Health & Safety	Regulatory Compliance	Highest Risk Rank
Differential settlement greater than predicted for landform design and disruption of surface water drainage	Discharge routed through tailings entering lake causing exceedance of arsenic trigger value	Low 1-10%	Minor	Moderate \$1- 5 million	Low	Moderate	Moderately High

Likelihood – Low: More sophisticated thermal modelling

Env. Impact – Minor: A comprehensive QA/QC assurance plan will be developed for full-scale construction

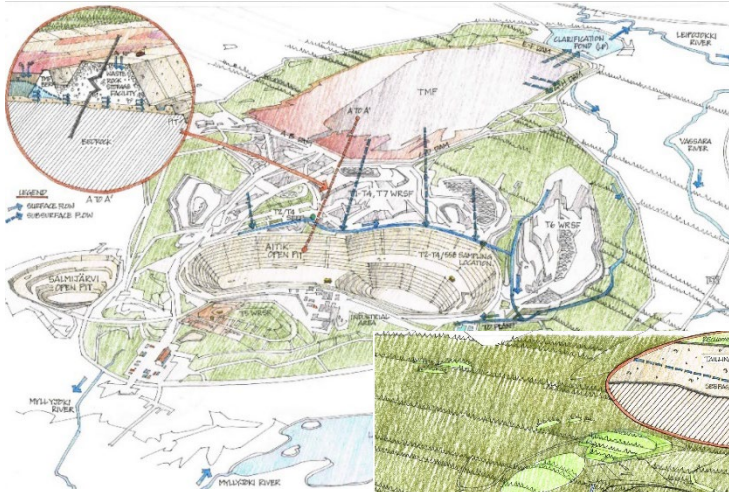
Consequence Costs – Moderate: Unchanged

Regulatory Compliance – Moderate: Adaptive management plan developed well in advance of closure

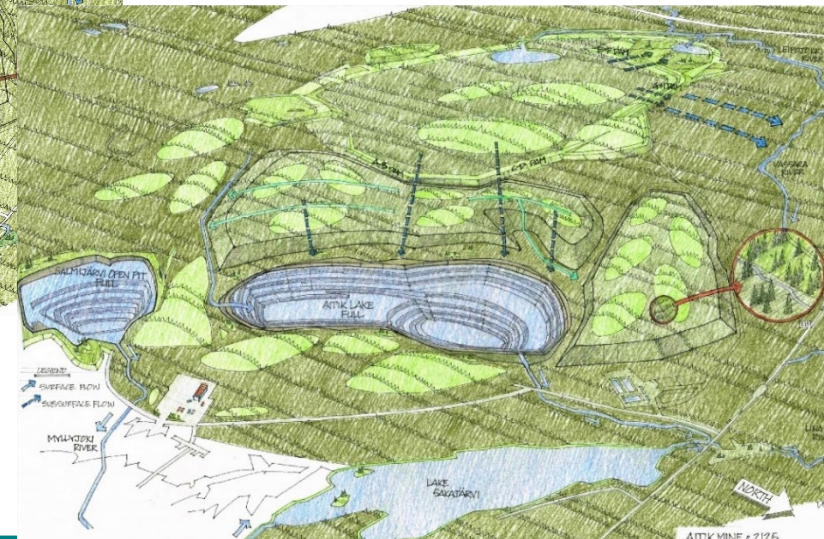
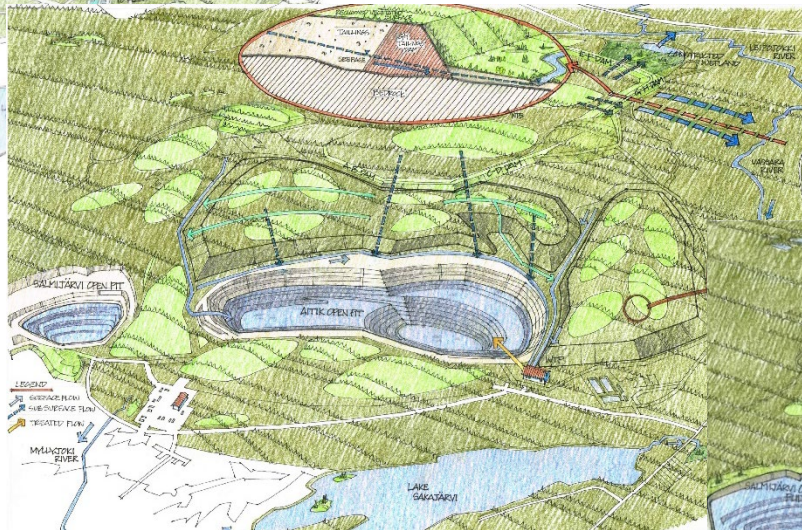
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FMEA – As a Communication Tool

- **Differential settlement greater than predicted for landform design and disruption of surface water drainage**

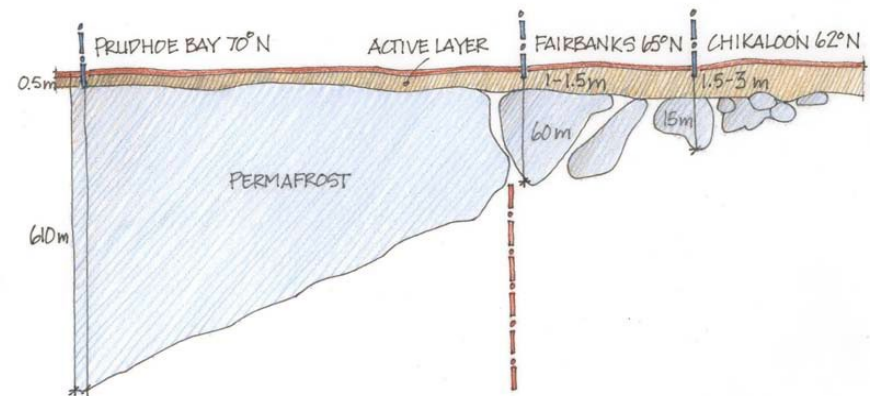
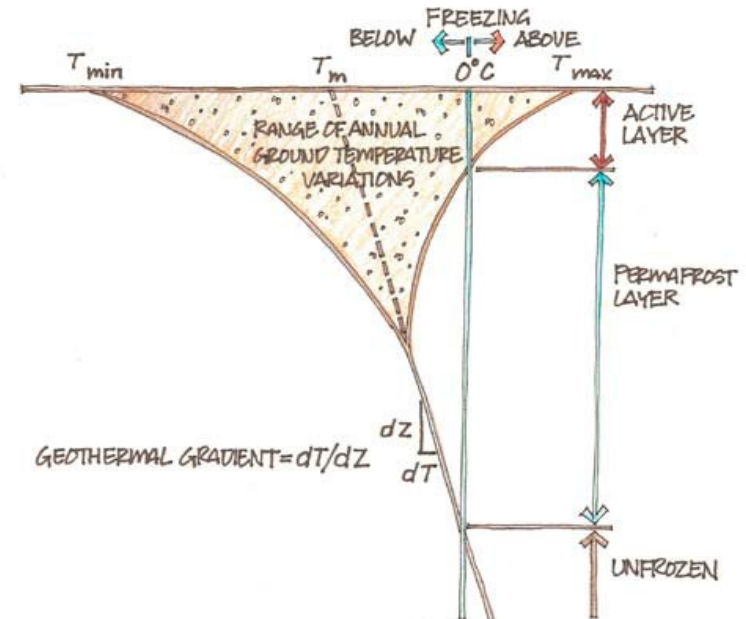


- *Progressive rehabilitation will allow consistent evaluation of QA/QC plan,*
- *Cover material characterization program*
- *Develop materials balance*
- *Undertake cover system field trials*



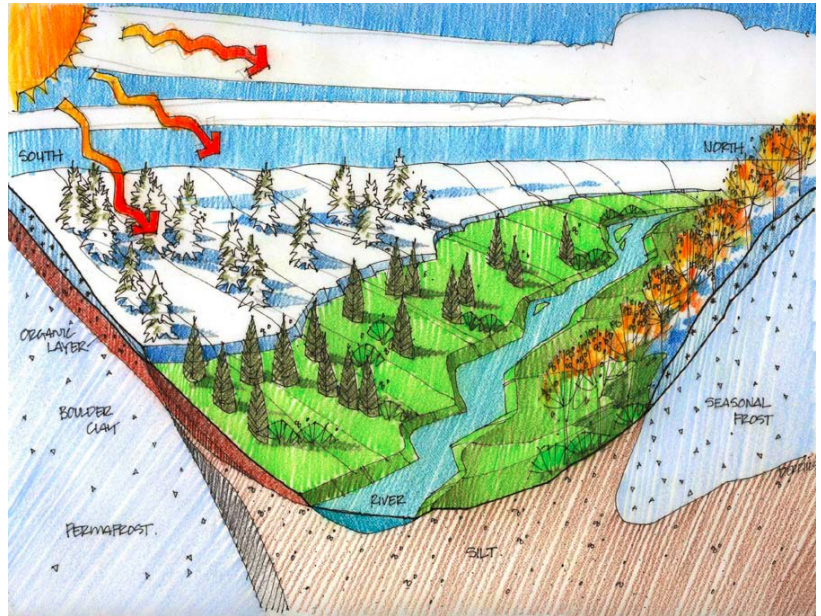
Technical Work

- Risks become driver for technical work
 - Guided by objectives
 - Technical work supports risk assessment
- Risk Assessment supports design
 - Avoid implicit risk aversion
 - “Keeping it simple”



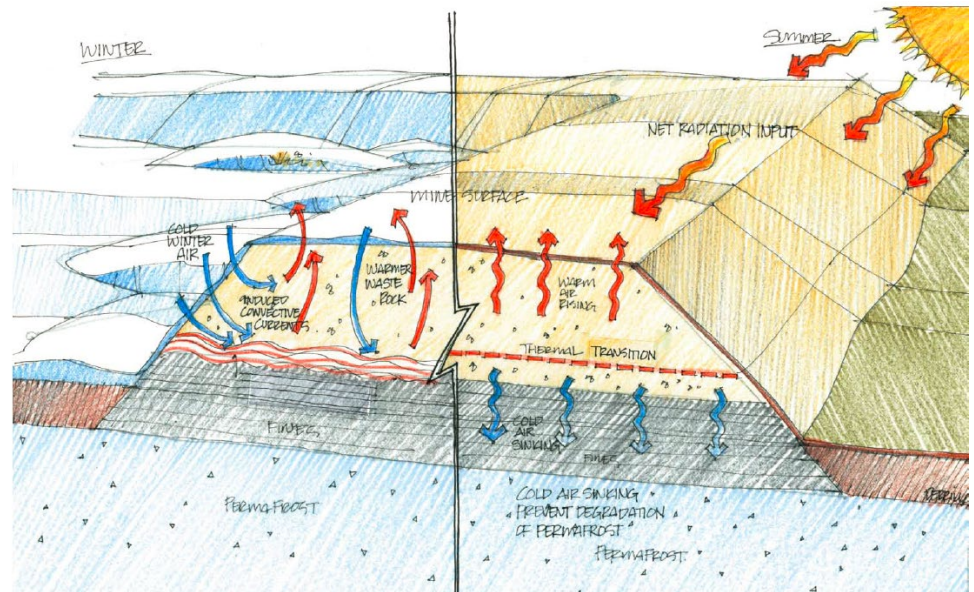
Conceptual Framework

- Design as risk management tool
- Future unknowns - today's design
- Rooted in risk management
 - Technical support
- Eliminate vs Mitigate
 - Suboptimal designs
- Complexity as required
 - Simple, but no simpler



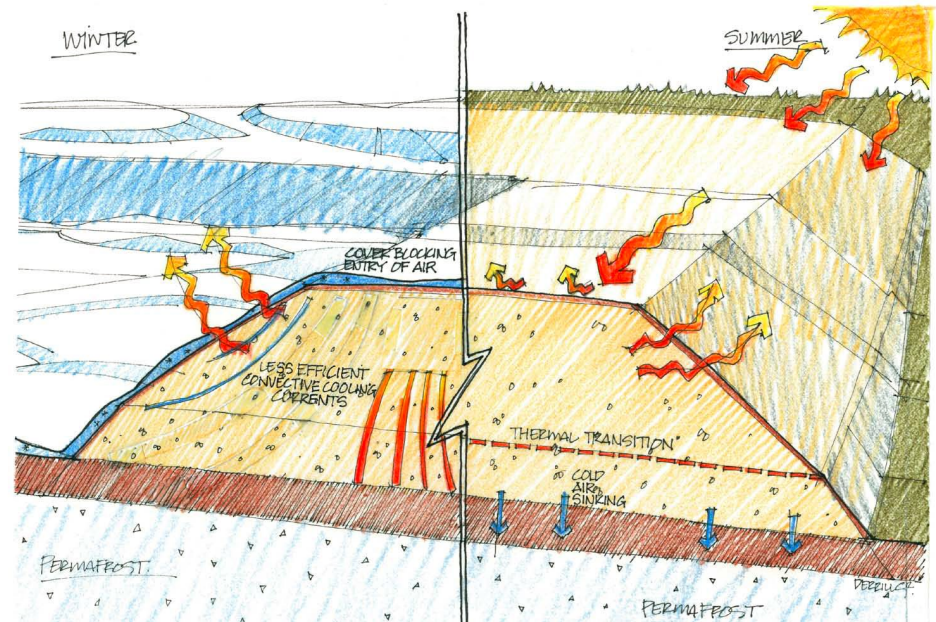
Conceptual Framework

- Allows progress
 - All have been heard
 - Risks have been identified
 - Mitigation communicated
- Get into the detail without letting it overwhelm
 - Prioritize
 - Apply correct profile



Conceptual Framework

- Our job as scientists and engineers
- Catalogue risks
- Revisit over time
- Take advantage of opportunities
- Focused studies
 - Serve risk mitigation



Summary

□ FMEA

- Communication
- Risks catalogued
- Prioritized
- Each one addressed

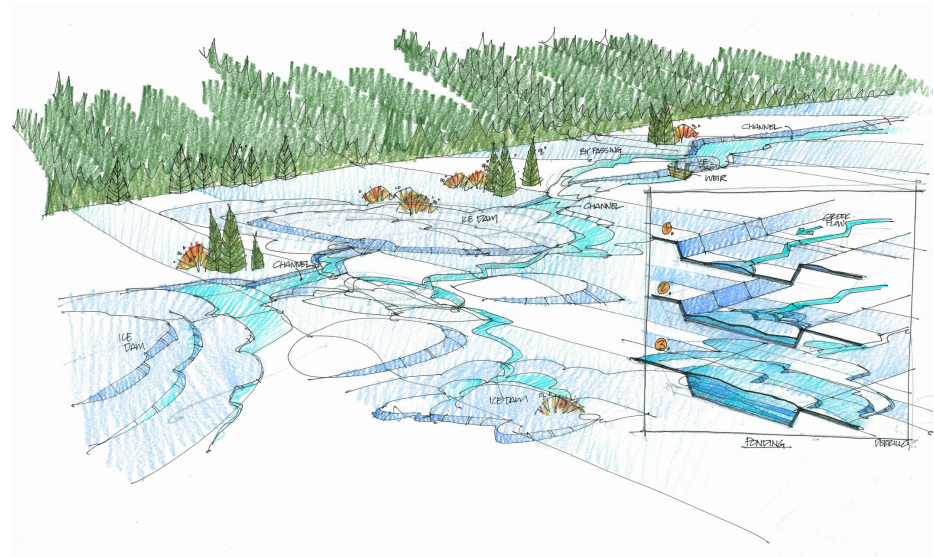
□ Technical studies

- ## — Outcome of FMEA

❑ Failure Modes

- Prompt a reaction
- Revisit often

- ❑ Not designing in green box



Conclusion

- Whose risks are you mitigating?
 - Can you demonstrate that?
- What and when are your objectives?
- Technical detail is a risk mitigation tool
 - Simple, but no simpler



Thank You!



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