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ENVIRONMENT & ENGINEERING

Modelling Uncertainty Analysis for Contaminant Risk Assessment

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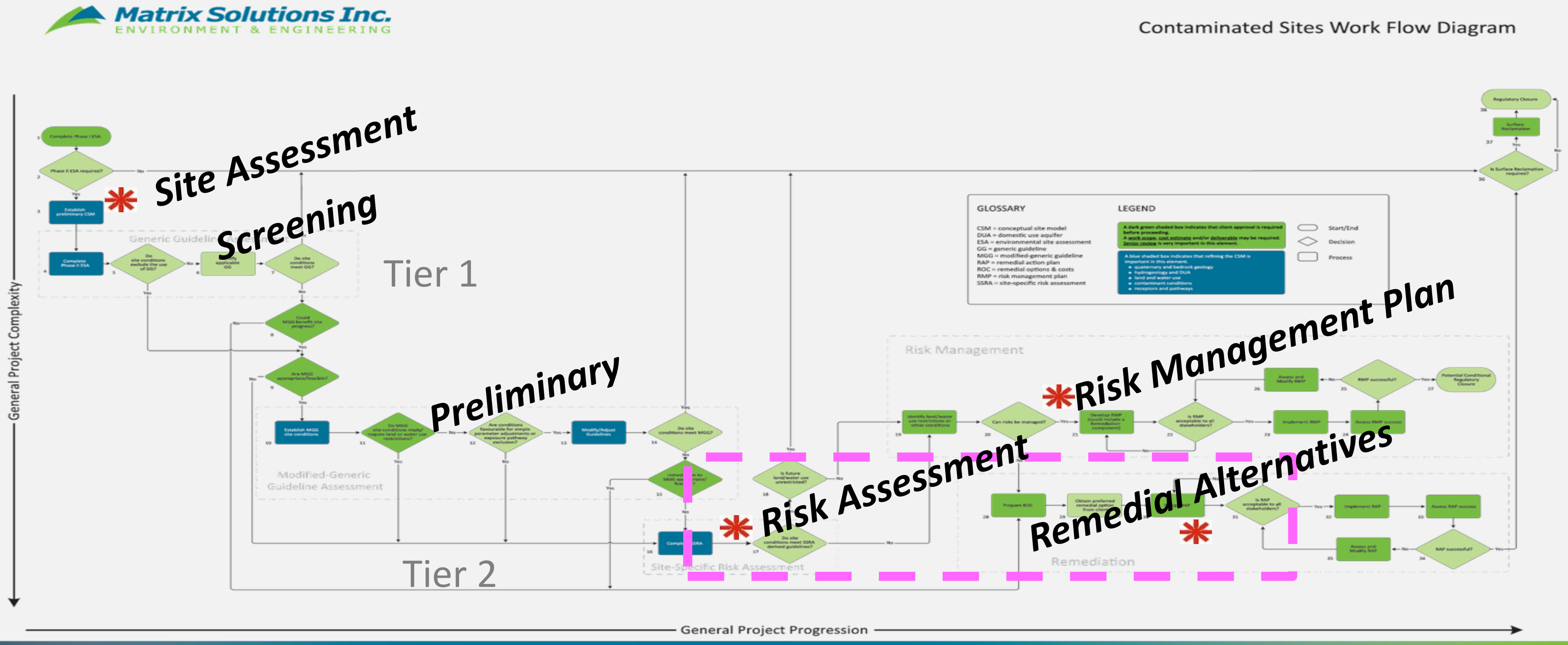
Presentation Outline

- Why modelling?
  - Key to site analysis (integrate data, physics)
  - Key to decision-making
- Why evaluate uncertainty?
  - Integrity & Transparency
  - Informed decision-making
- Case study

Model: Key Site Assessment Tool

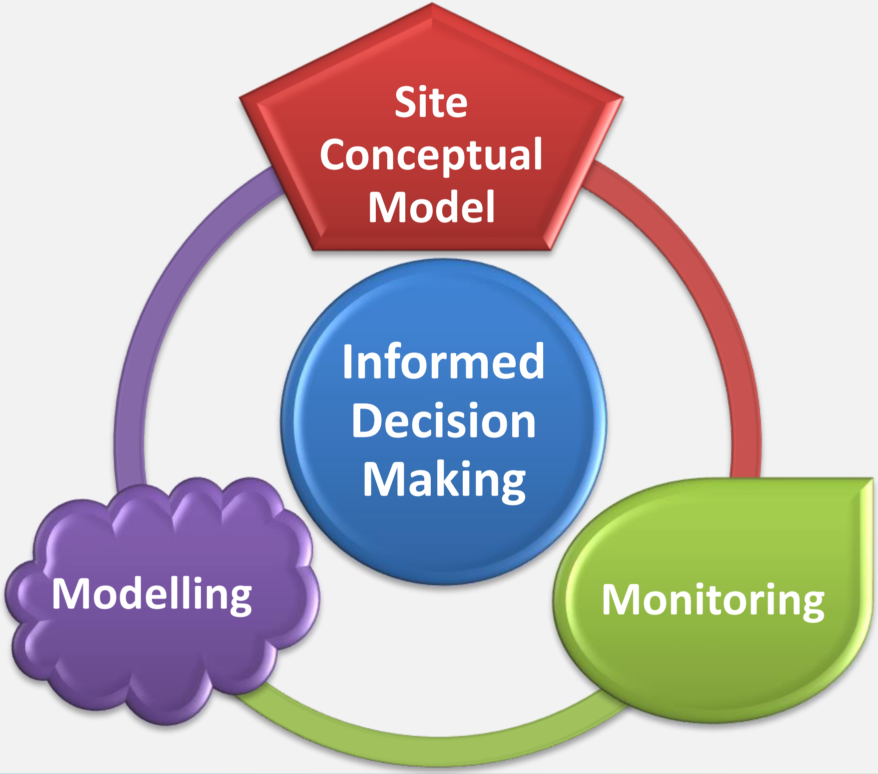


Beyond Standard Risk Assessment

Risk Assessment
- Quantify likelihood of harmful exposure

Typical Modelling Approach
- Simplified analytical models
- Designed to be conservative

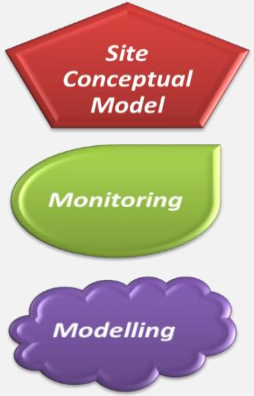
Our Modelling Approach
- Site specific
- More realistic, less conservative
- More cost effective remediation design



Elements Subject to Uncertainty

Sources of Uncertainty:

- Incomplete Hydrogeologic Knowledge
- Imperfect Measurements
- Model = Simplification

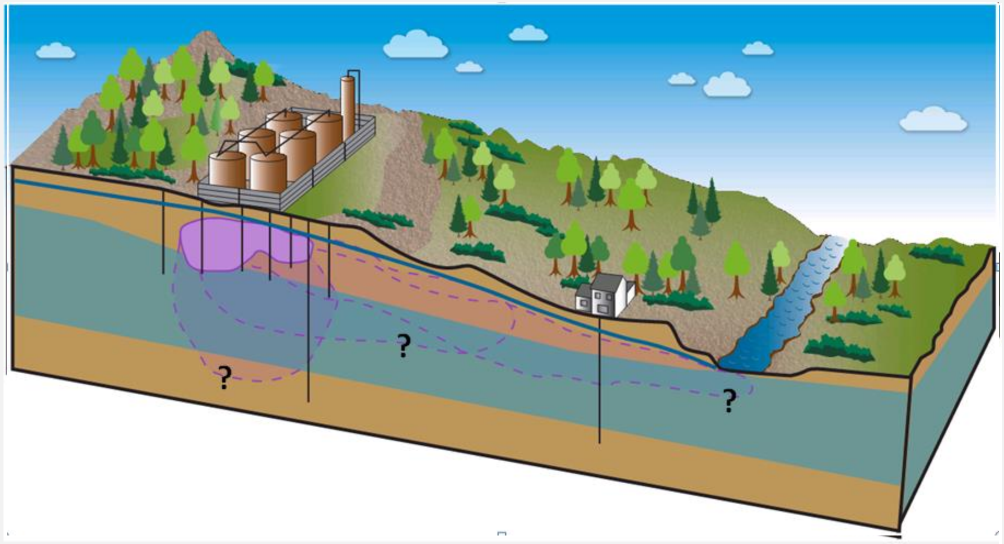


Uncertainty Analyses

→ Implication on Predicted Exposure

Implication of Uncertainty

- Uncertainty inherent
- Multiple potential interpretations
- Constrained by field data



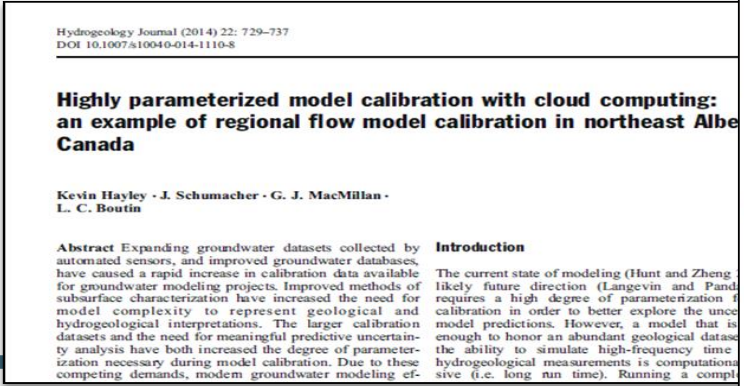
Null Space Monte Carlo Approach
Finds Suite of Feasible Scenarios

Uncertainty Analysis: NGWA White Paper

- Industry wide recognition of need to evaluate uncertainty
- Goals:
  - Provide guidance to practitioners
  - Illustrate benefits of practical approaches

What's New - Amazon Cloud Computing

- Cost Effective
- Access to 100's CPUs
- Scalable and Efficient
- Flexible Software



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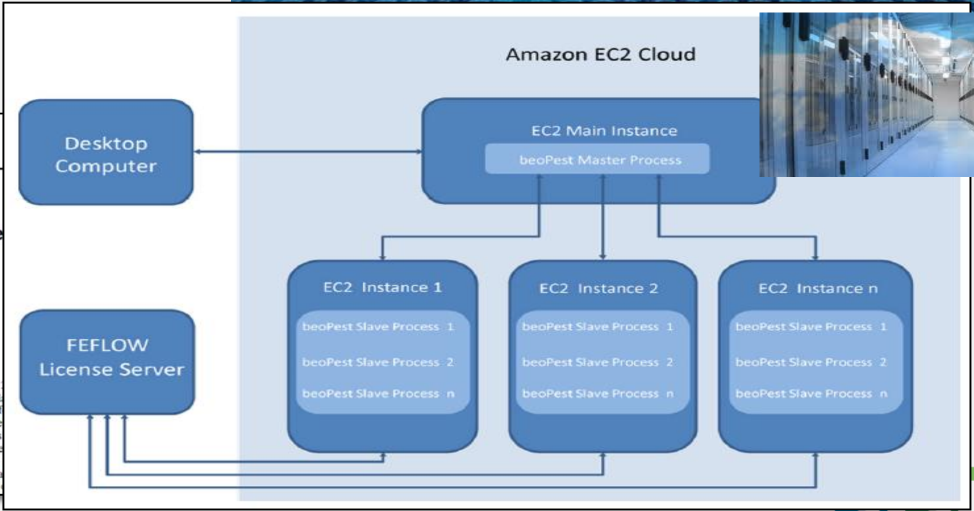
Highly parameterized model calibration with cloud computing: an example of regional flow model calibration in northeast Albe Canada

Kevin Hayley · J. Schumacher · G. J. MacMillan · L. C. Boutin

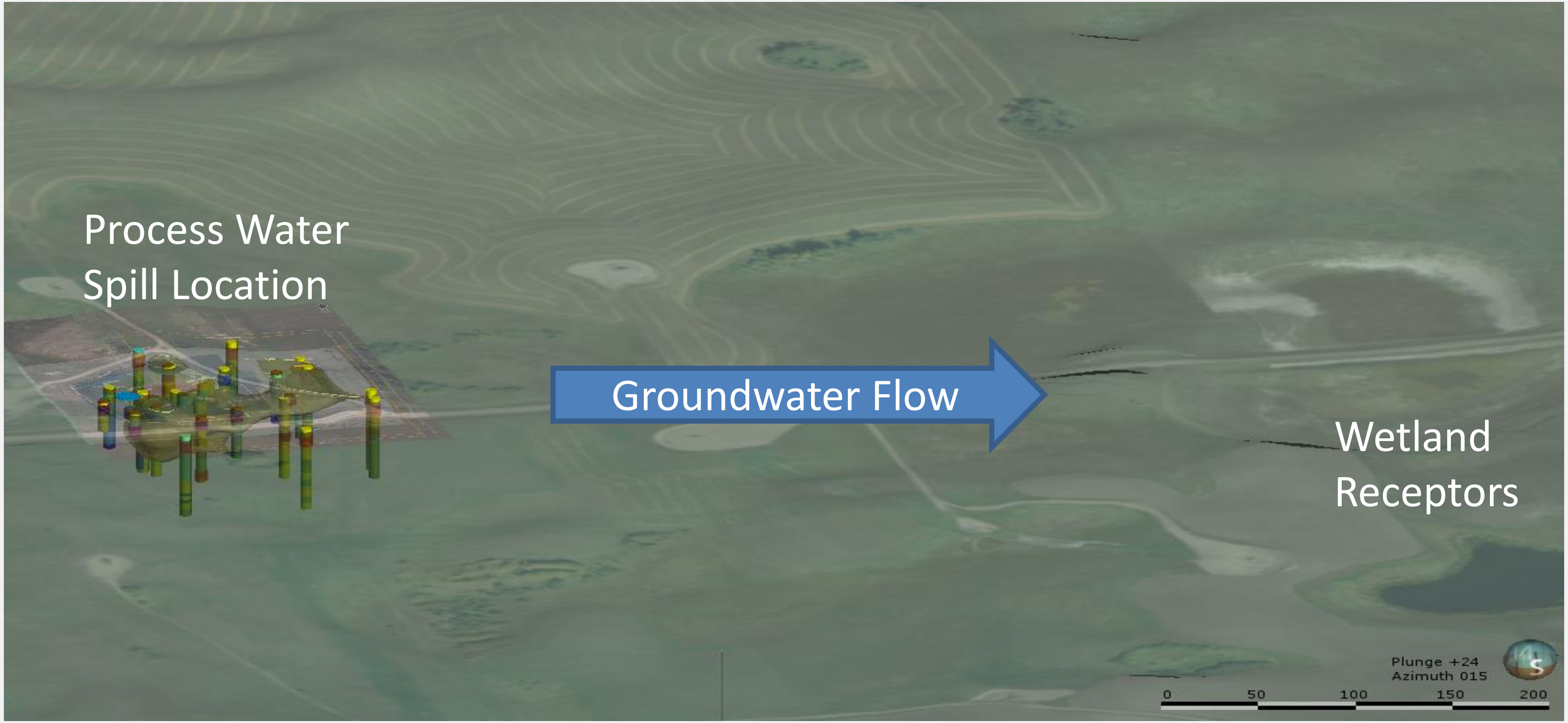
Abstract Expanding groundwater datasets collected by automated sensors, and improved groundwater databases, have caused a rapid increase in calibration data available for groundwater modeling projects. Improved methods of subsurface characterization have increased the need for model complexity to represent geological and hydrogeological interpretations. The larger calibration datasets and the need for meaningful predictive uncertainty analysis have both increased the degree of parameterization necessary during model calibration. Due to these competing demands, modern groundwater modeling ef-

Introduction

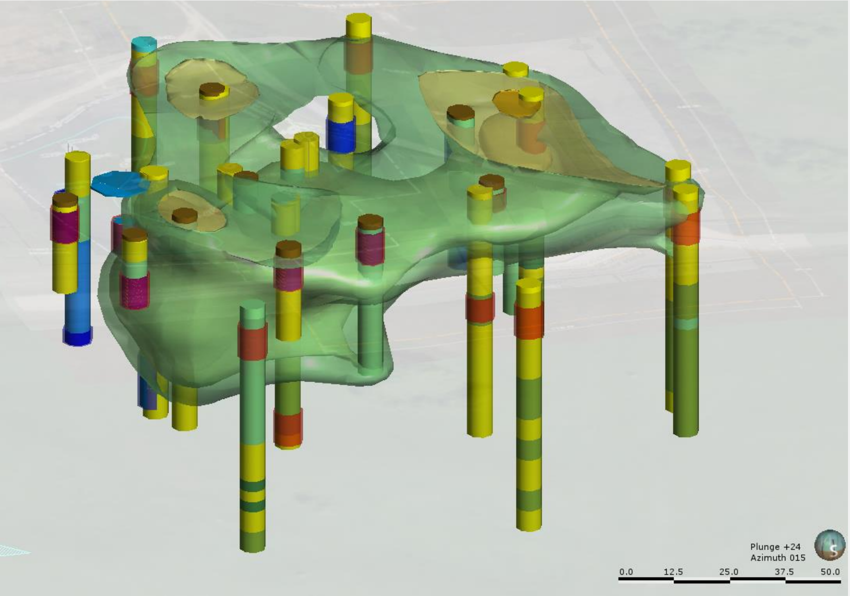
The current state of modeling (Hunt and Zheng likely future direction (Langevin and Pand requires a high degree of parameterization f calibration in order to better explore the unce model predictions. However, a model that is enough to honor an abundant geological datase the ability to simulate high-frequency time hydrogeological measurements is computationa sive (i.e. long run time). Running a compl



Case Study: Historic Pipeline Break



Sub-Surface Plume

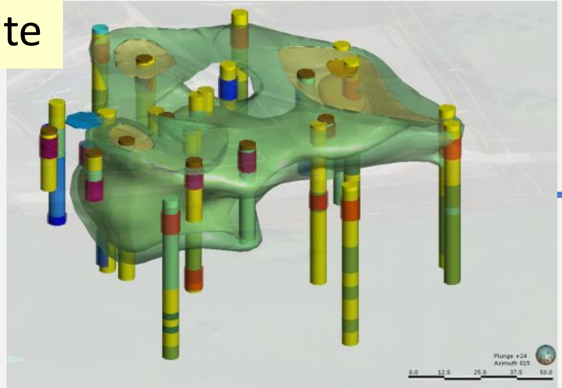


Plume characteristics:

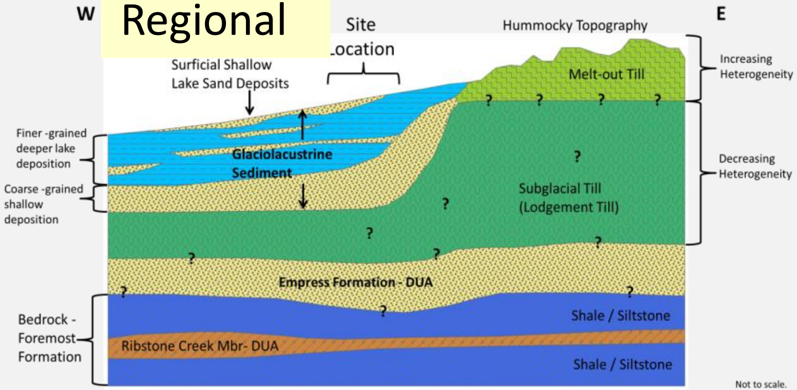
- Contaminant of concern = Chloride
- Longitudinal scale = 150 m
- Lateral scale = 130 m
- Vertical scale = 12 m
- Max [Cl] = 12,000 mg/L
- Mass In-Situ = 14,000 kg

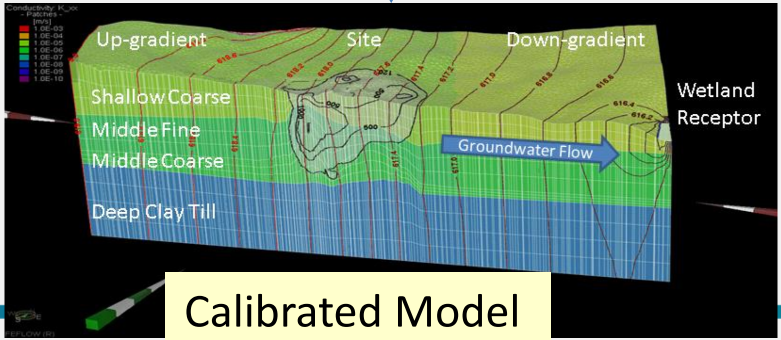
Model: Integration of Site and Regional Data

Site



Regional



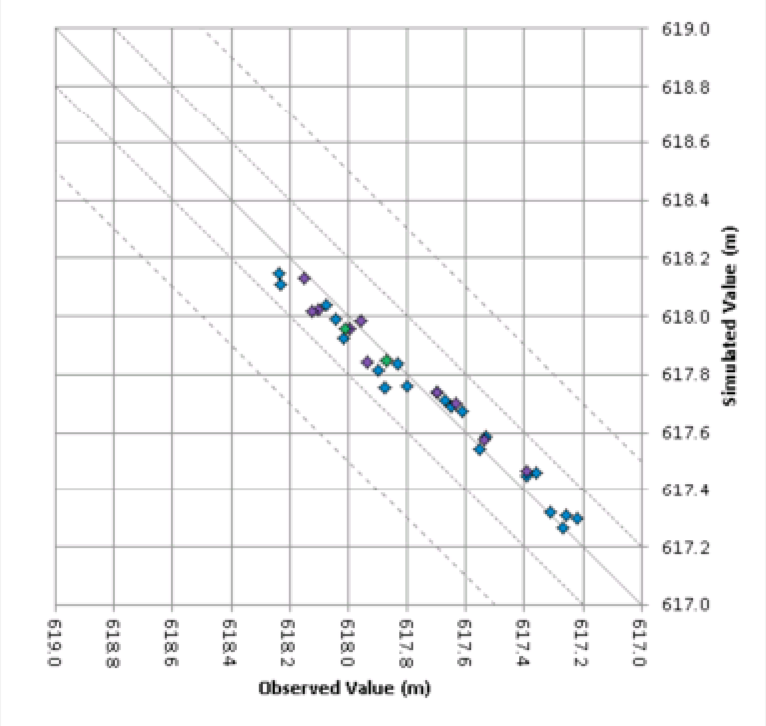


Calibrated Model

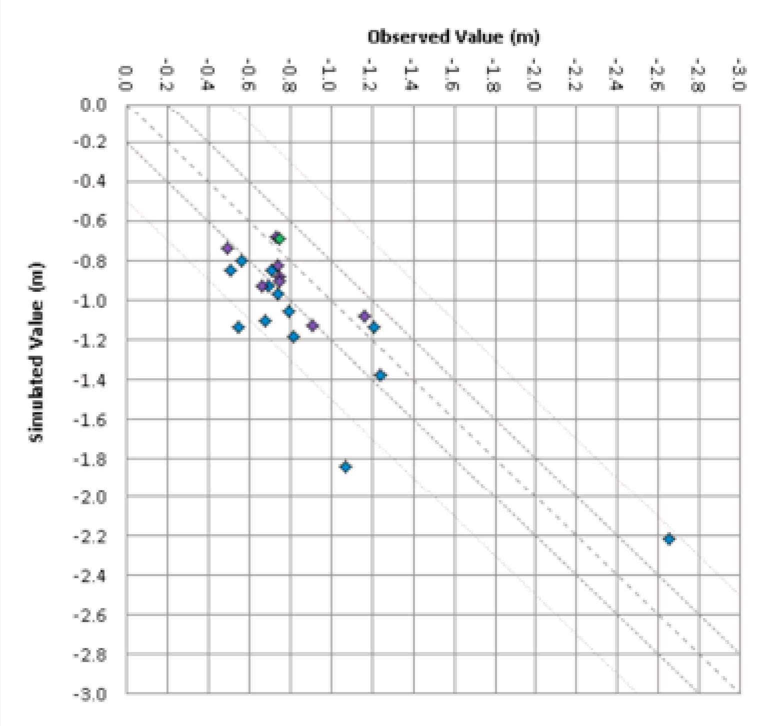
- Site data
- Regional understanding
- Integrated picture
- Calibrated to field data

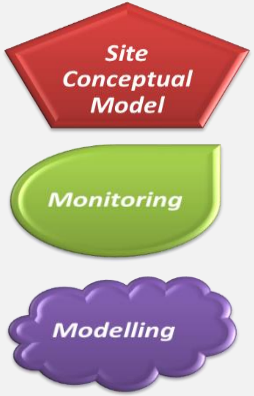
Calibration to Site Specific Data

Non-Pumping – Groundwater Elevation



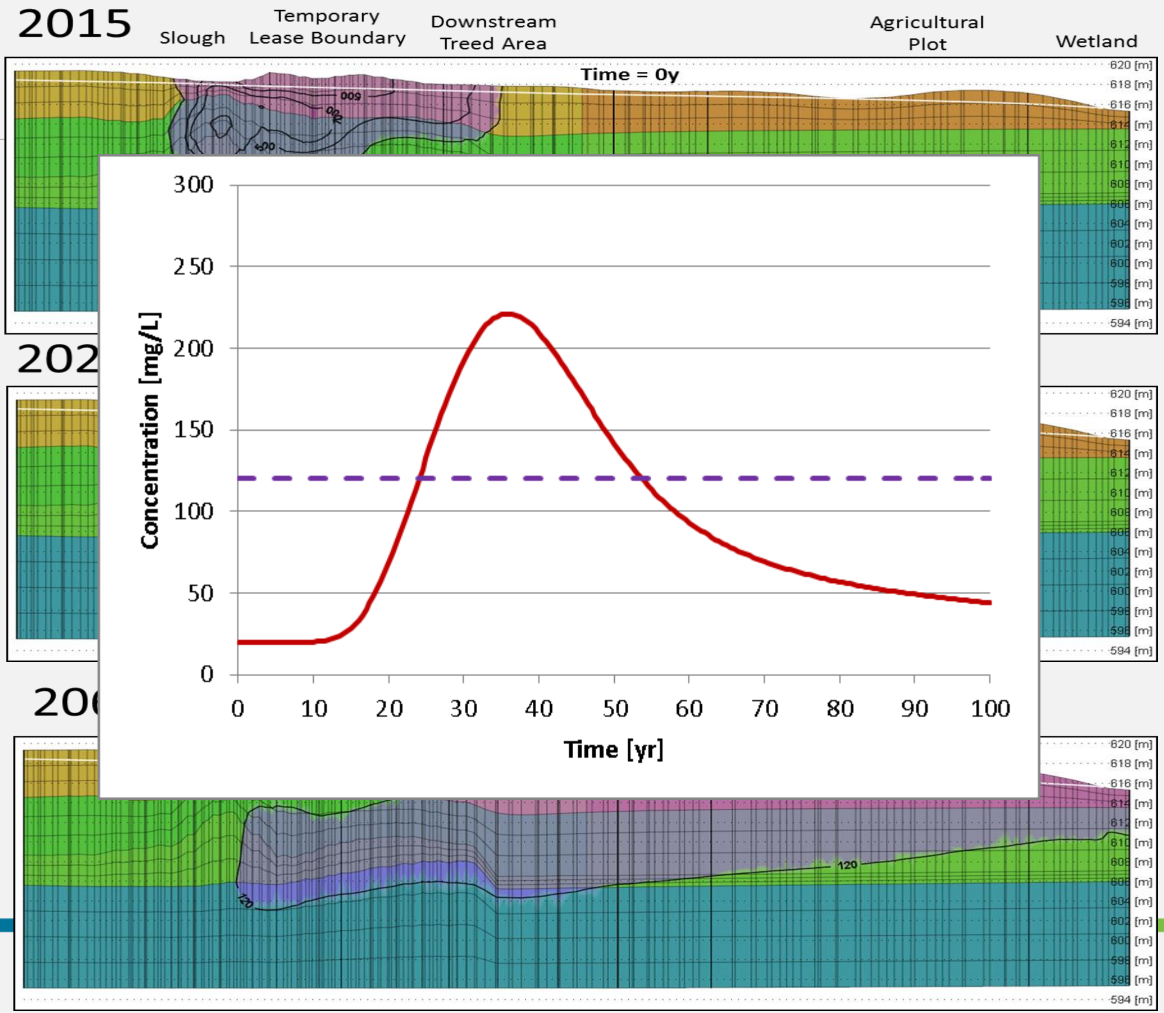
Pumping – Drawdown





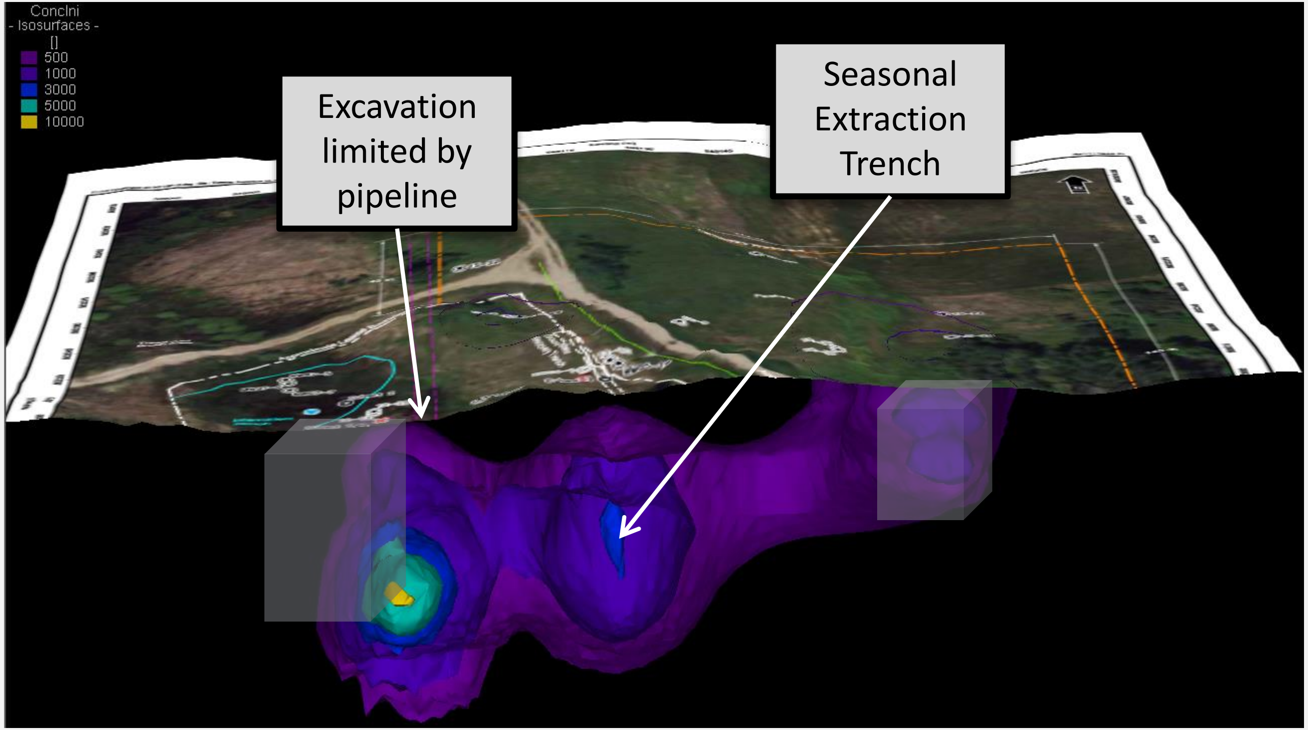
No Remediation

- Plume persists
- Impact at wetland > criteria
- Remediation required



Remediation Options and Obstacles

- Practical Excavation Limits
  - Depth
  - Infrastructure
- Collection System
  - How Long?



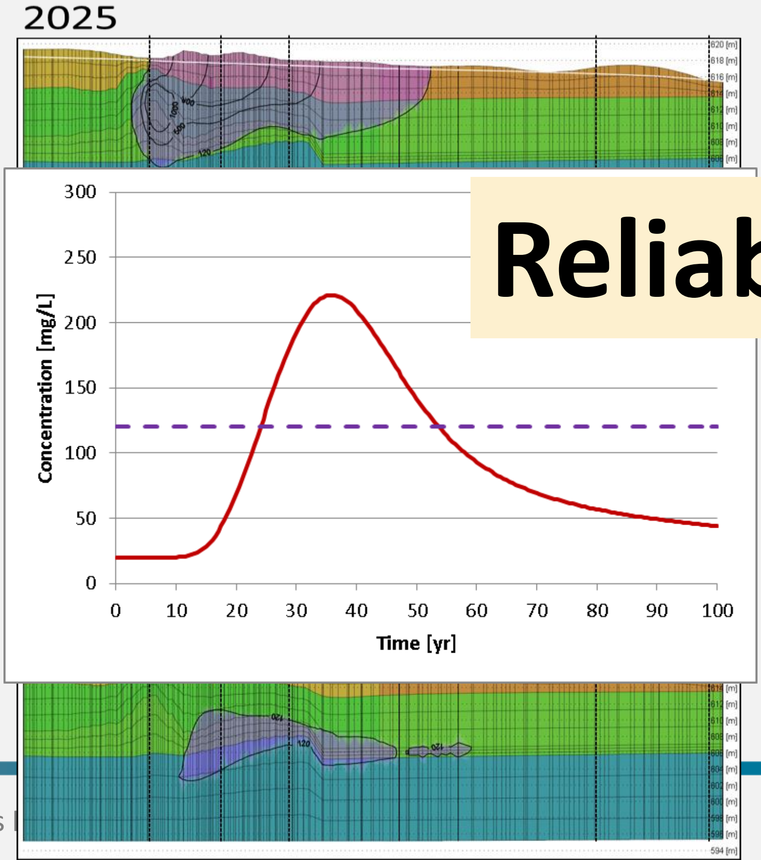
Remediation System - Prediction

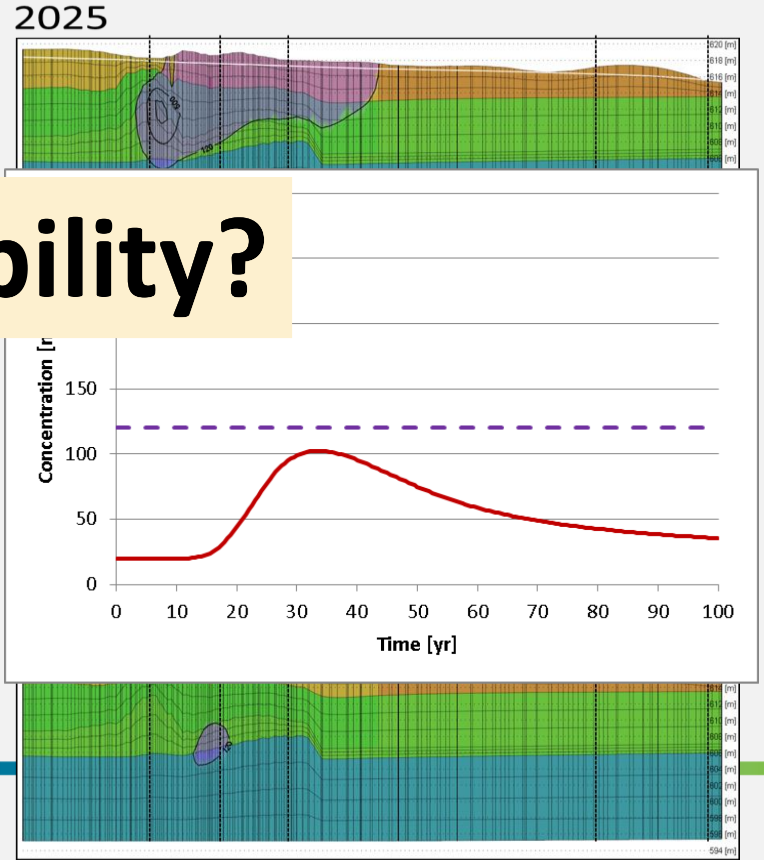
No Remediation | With Remediation

10-year horizon

50-year horizon

100-year horizon



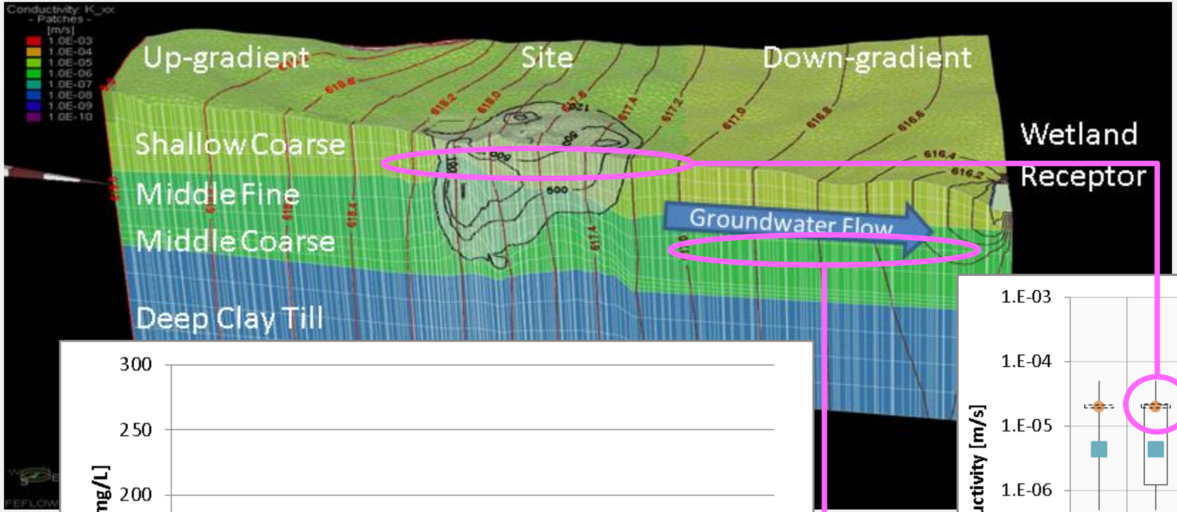


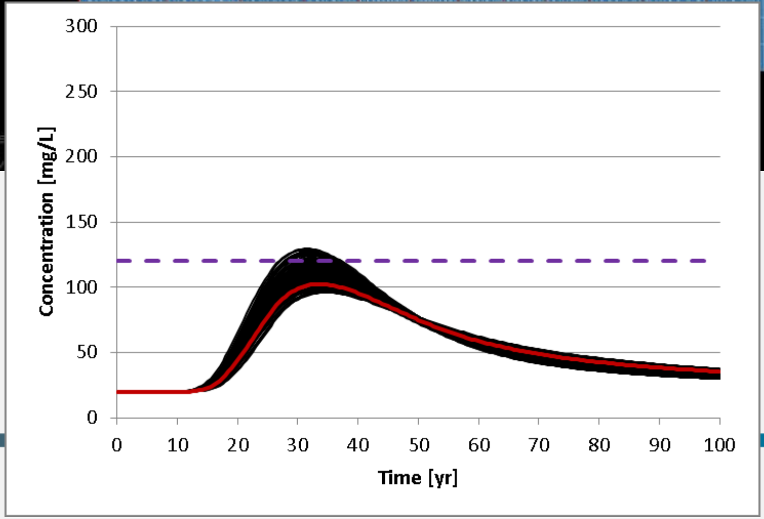
Reliability?

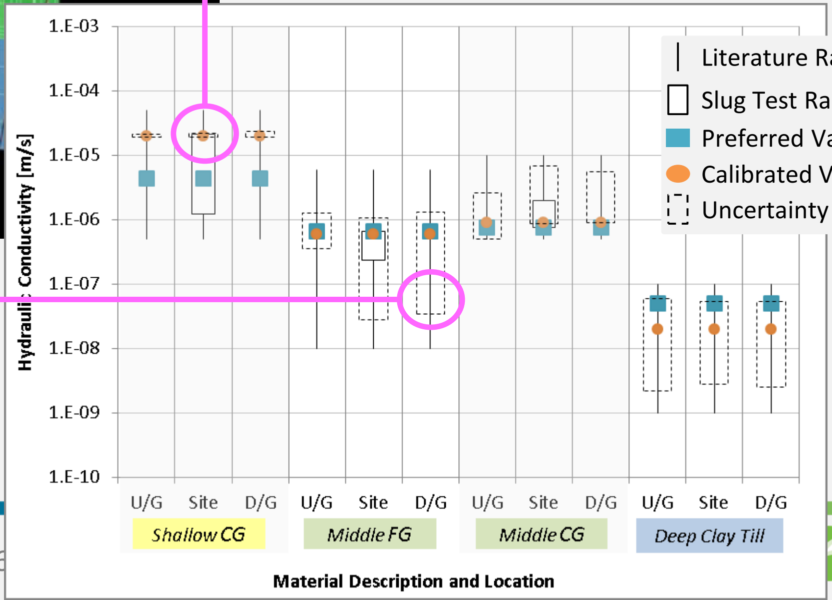
Calibration Constrained Uncertainty Analysis

2 options:

1) Fill Data Gap
2) Optimize Remediation

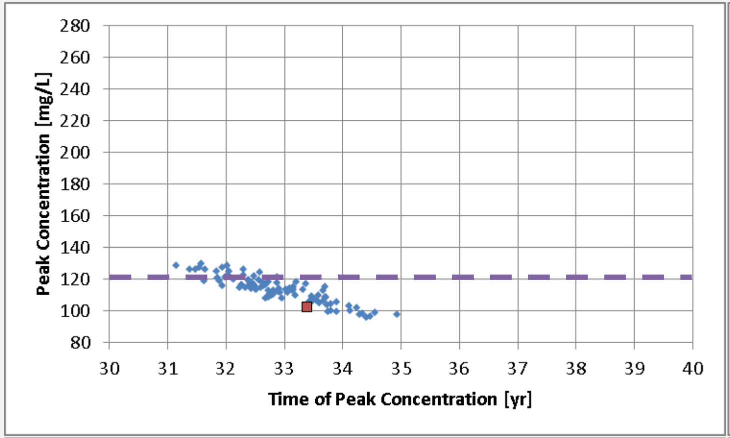


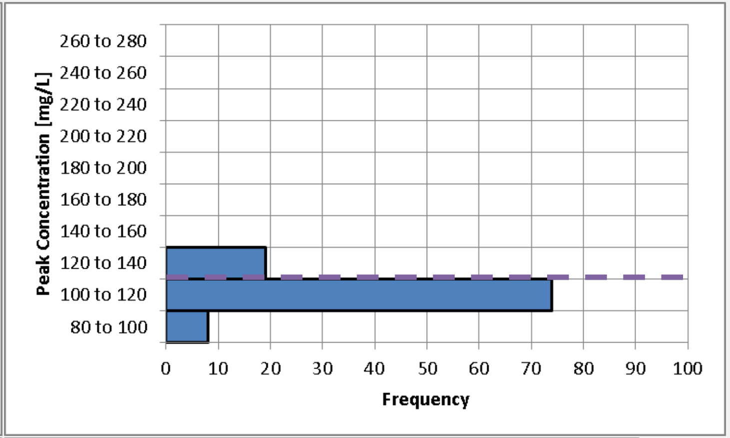


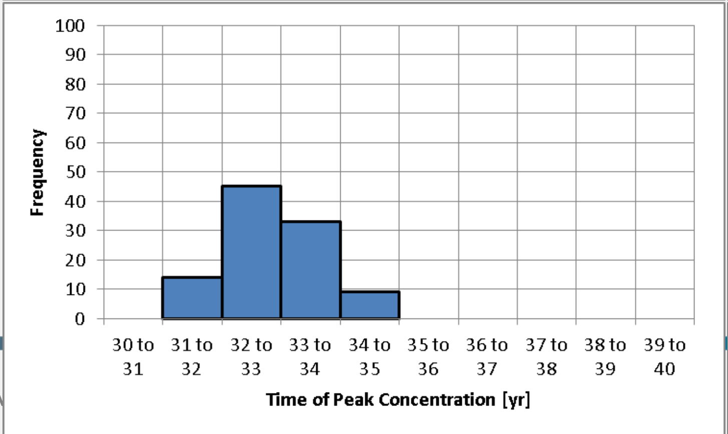


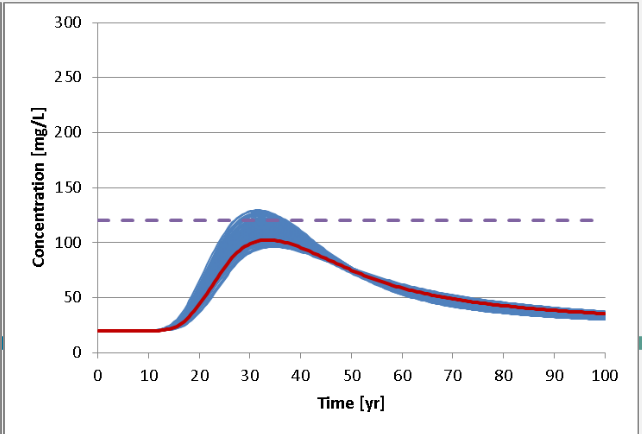
Informed Decision Making

Informed Decision Making







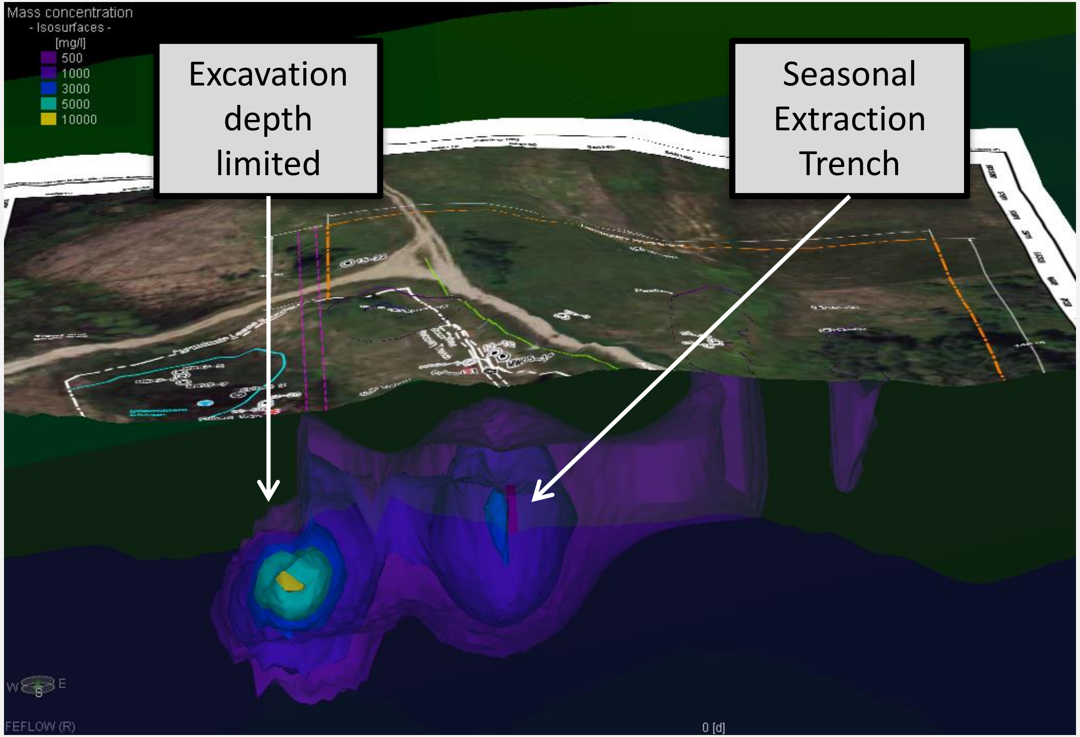


Optimized Remediation – Design

Optimized Extraction & Excavation

Excavation
- 1T Cl removed (5,600 m^3)
- 13T Cl remain
  - C > 10,000 mg/L

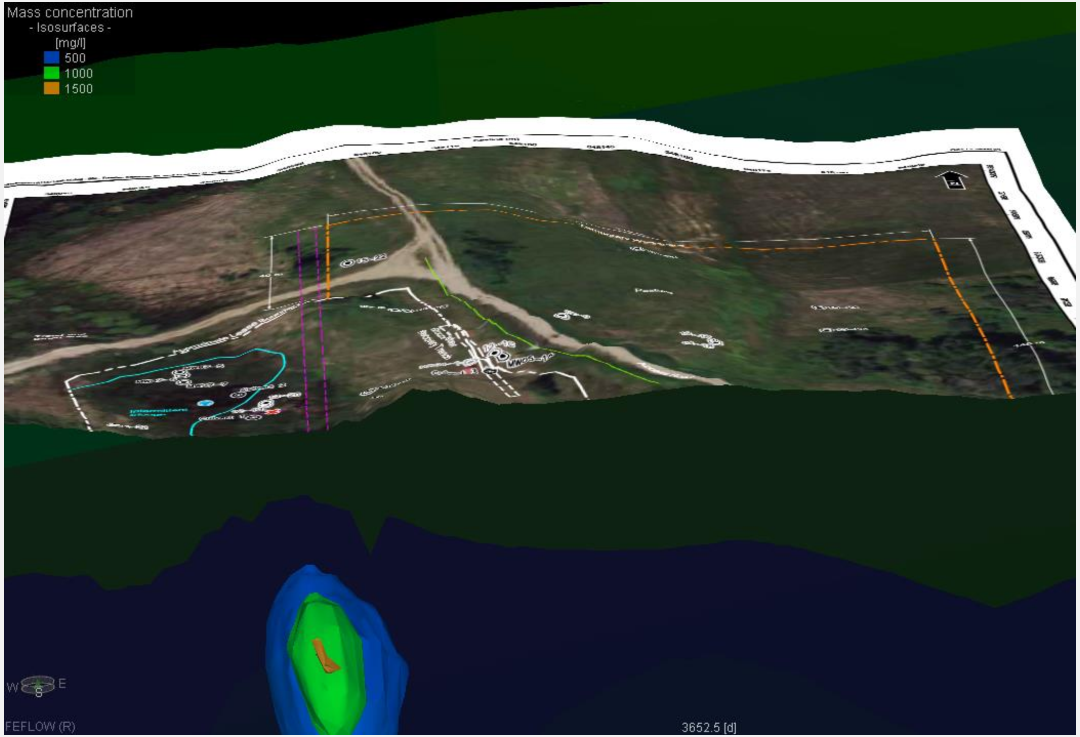
Trench
- 10-yr operation



Optimized Remediation – Performance

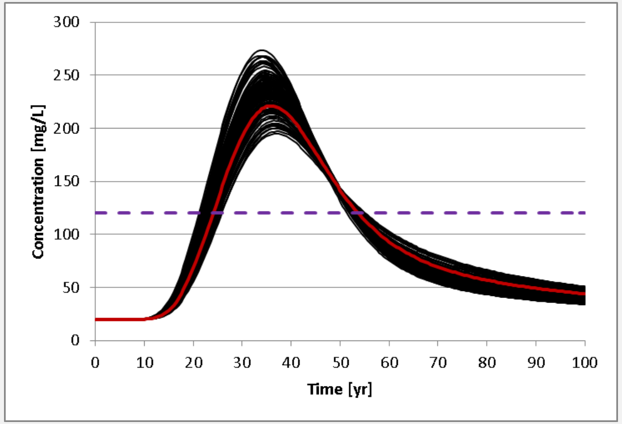
After 10 years
- Extraction system effective
- Source plume >1,500 mg/L

½ of contaminant mass left in subsurface to disperse



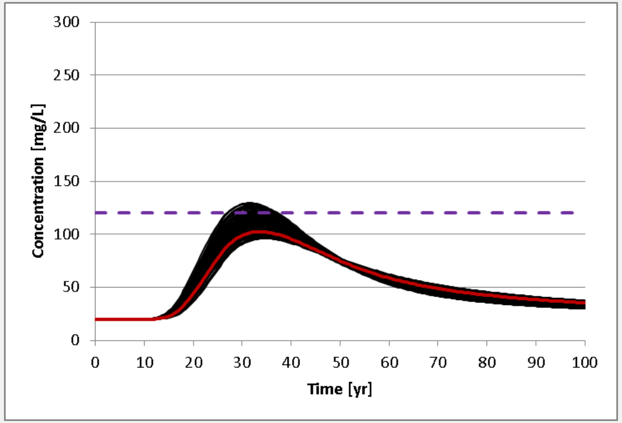
Review and Summary

No Remediation



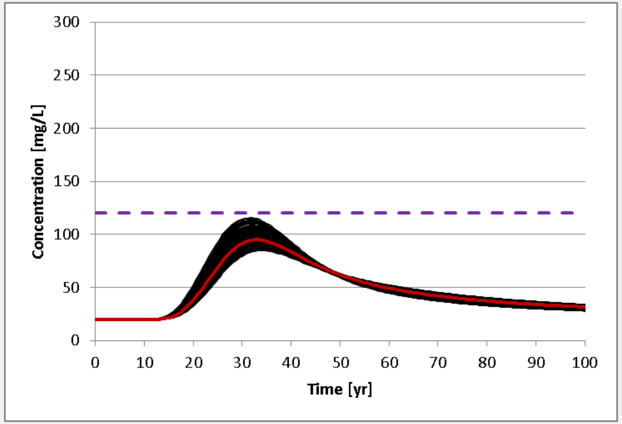
Meet Criteria 0 %

Remediation



Meet Criteria 81 %

Optimized Remediation



Meet Criteria 100 %

Comparison with SST:

- 5,600 m^3 vs. 75,000 m^3
- 1,500 mg/L vs. 260 mg/L

Benefits of Detailed Approach

Site data & knowledge fully utilized

Thorough evaluation of:

- Exposure at receptors
- Remedial design effectiveness
- Importance of data gaps

Enhances confidence regarding:

- Reliable Design
- Cost-Effective Investment
- Robust Remediation Plan
- Transparent Solutions