Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Risk-Based Approach to Contaminated Site Remediation and Liability Reduction

Virtual RemTech 2020
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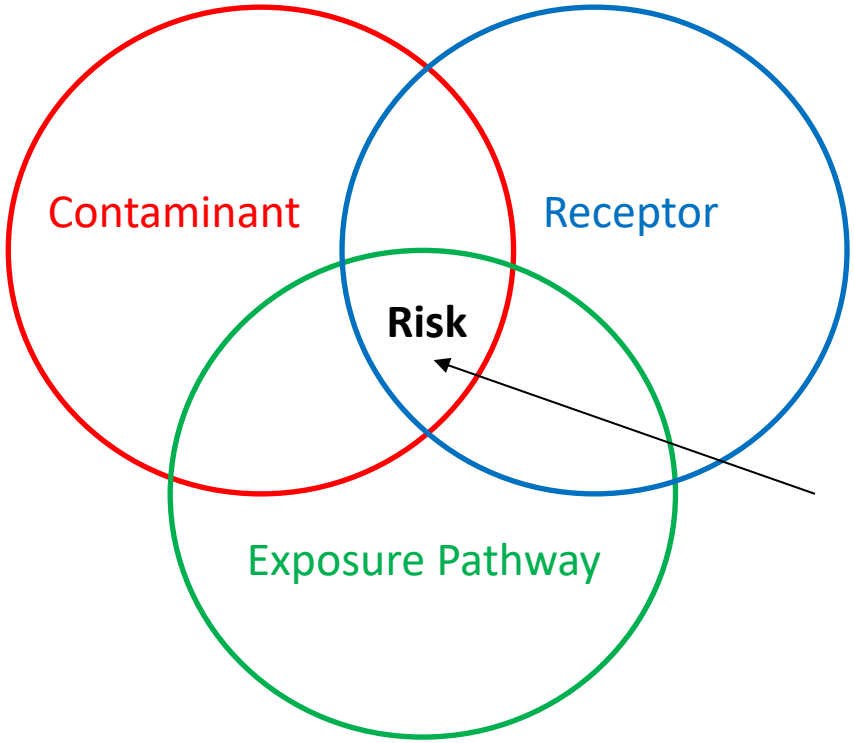
Overview

- Why use a risk-based approach?
- Regulatory Framework
- Case Studies
  - Site A: Remote Well Site
  - Site B: Pipeline Release
  - Site C: Abandoned Satellite

Why use a Risk-Based Approach?

- Oil and gas producers have identified reduction of environmental liability as a high priority
- On-going capital constraints has increased the need for cost savings
- Risk-based approaches to site management and remediation can result in substantial cost savings versus Tier 1

Why use a Risk-Based Approach?



Each of these 3 elements must be present for environmental risk to exist

Why use a Risk-Based Approach?

Site Data

- Site assessment data provides the foundation for the site conceptual model

Risk Assessment

- Use site data to develop CSM and assess the likelihood of harmful exposure to receptors
- Often less conservative than Tier 1

Risk-Based Site Management

- Spend money collecting data that will protect identified receptors
- Develop cost-effective remediation programs

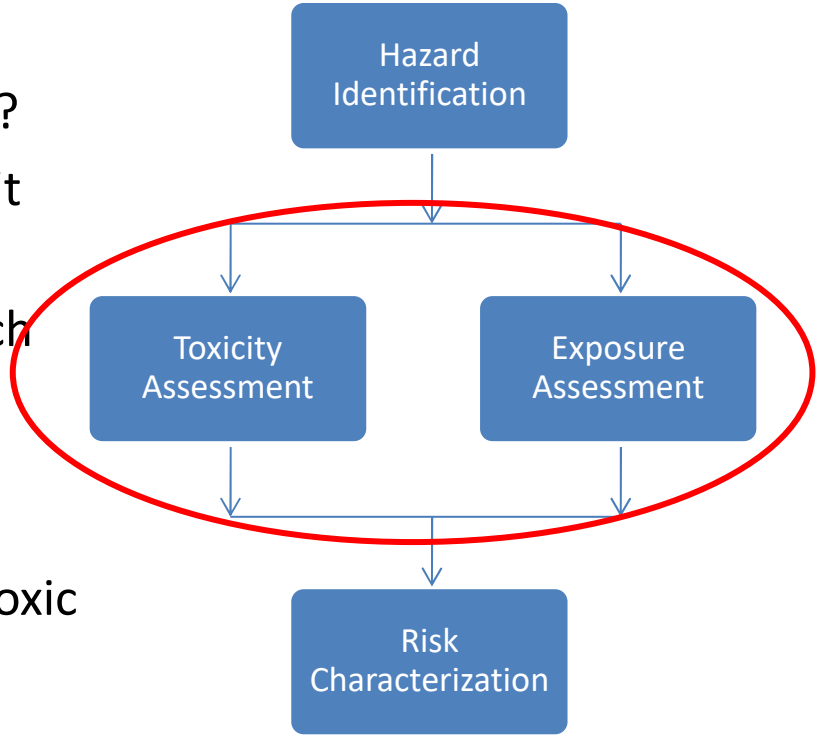
Why use a Risk-Based Approach?

HAZARD IDENTIFICATION—Can this chemical cause an adverse effect?

TOXICITY ASSESSMENT—How does it affect receptors? At what doses?

EXPOSURE ASSESSMENT—How much dose is the receptor likely to encounter?

RISK CHARACTERIZATION—Is the expected dose greater than the toxic dose?



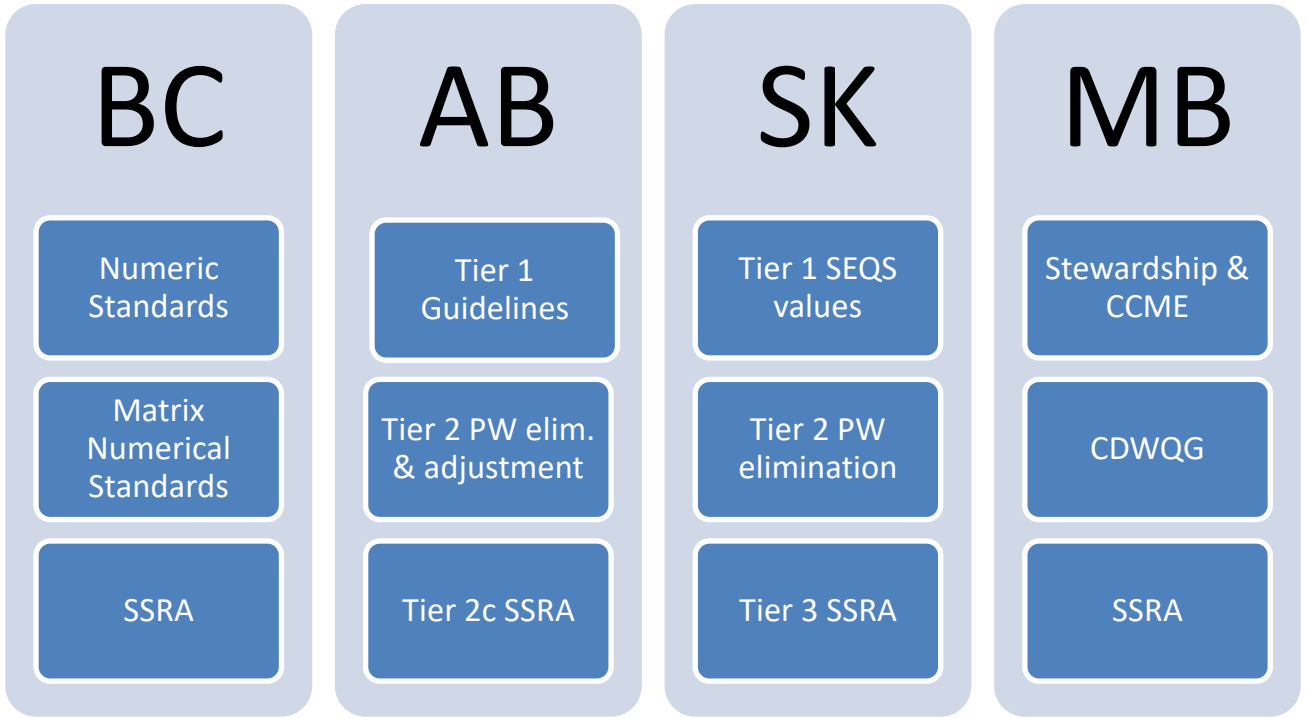
Regulatory Framework

Alberta Tier 1 and Tier 2 Management

Tier 1	Tier 2	Exposure Control
Meet generic criteria	Meet site-specific criteria	Control receptors and/or exposure pathways; monitor; have contingency plan(s)
	•Pathway exclusion	
	•Guideline modification	
	•Site-specific risk assessment	
←REGULATORY CLOSURE→		←NO REGULATORY CLOSURE→ (risk management)

The same degree of protection to receptors

Regulatory Framework



Case Study

Site A – Remote Well Site

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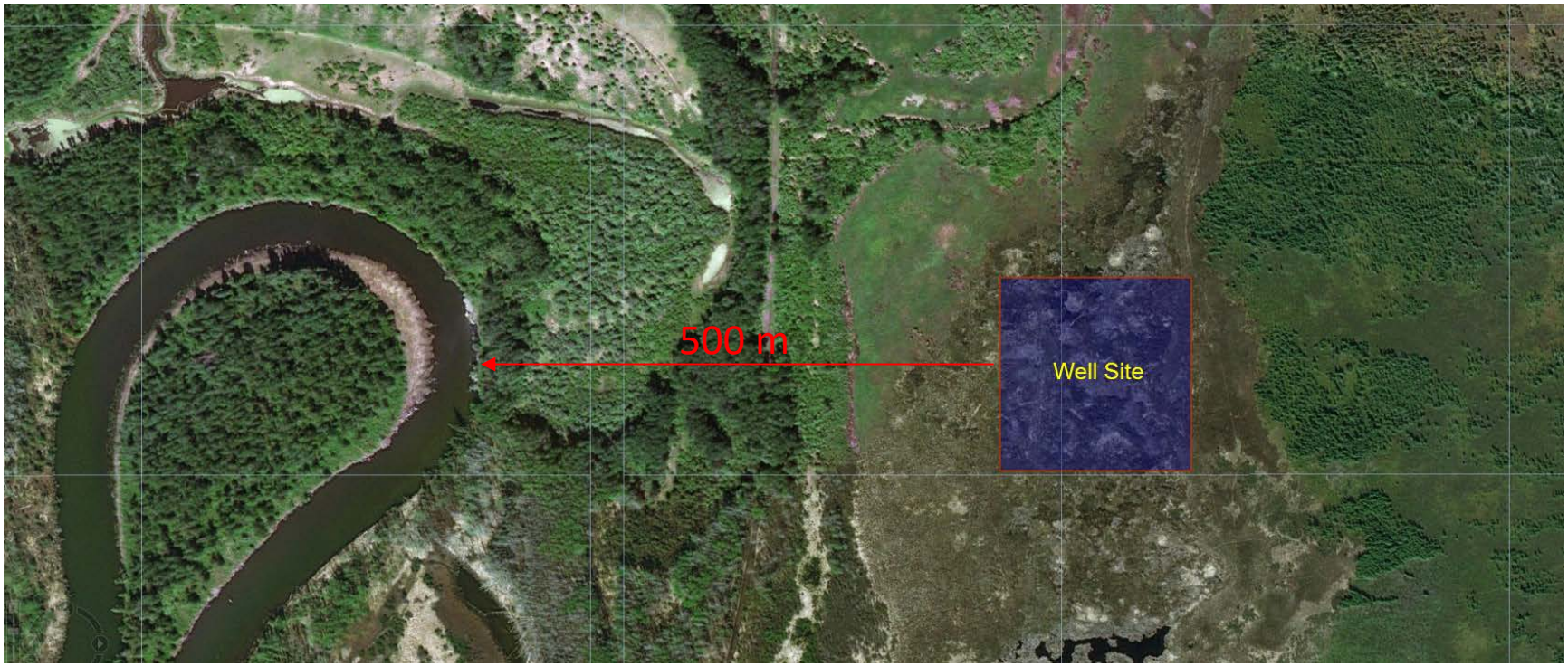

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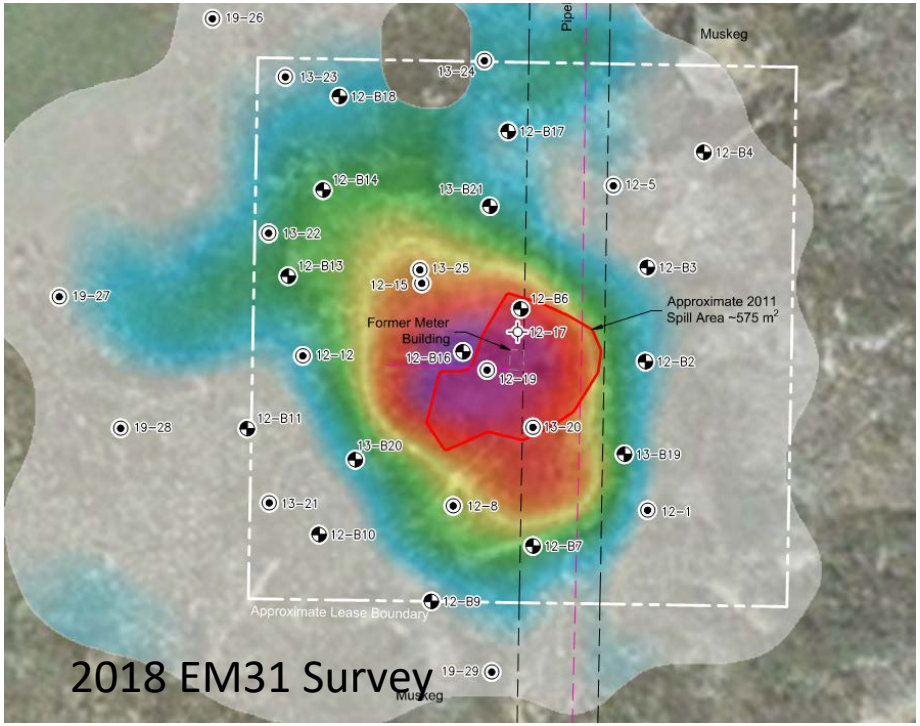
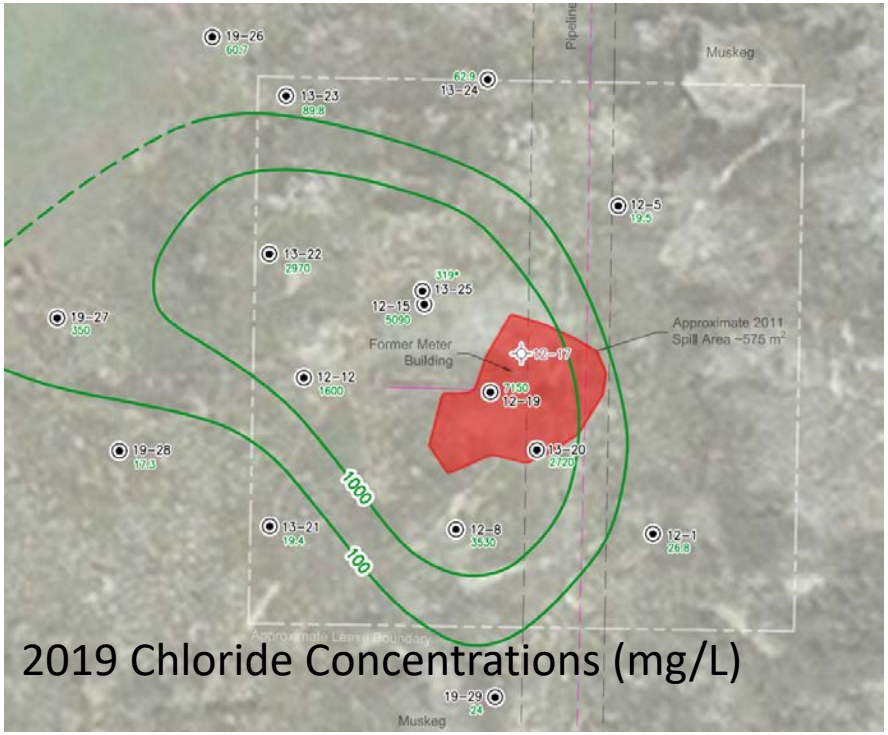


2018 EM31 Survey



2019 Chloride Concentrations (mg/L)

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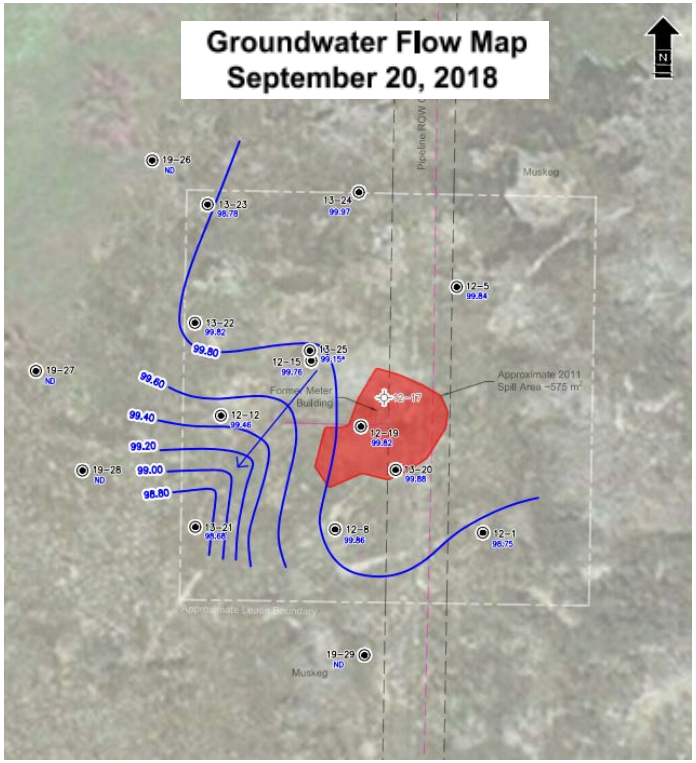

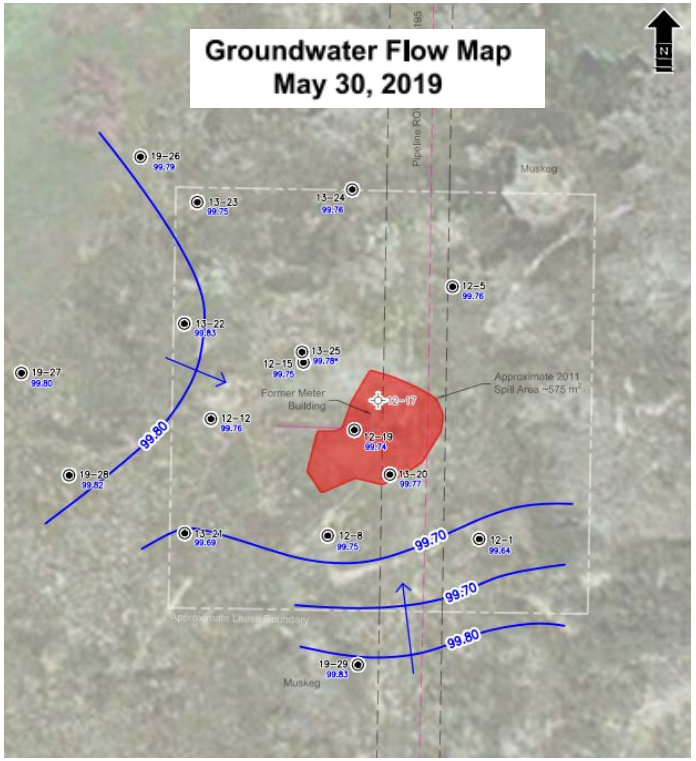

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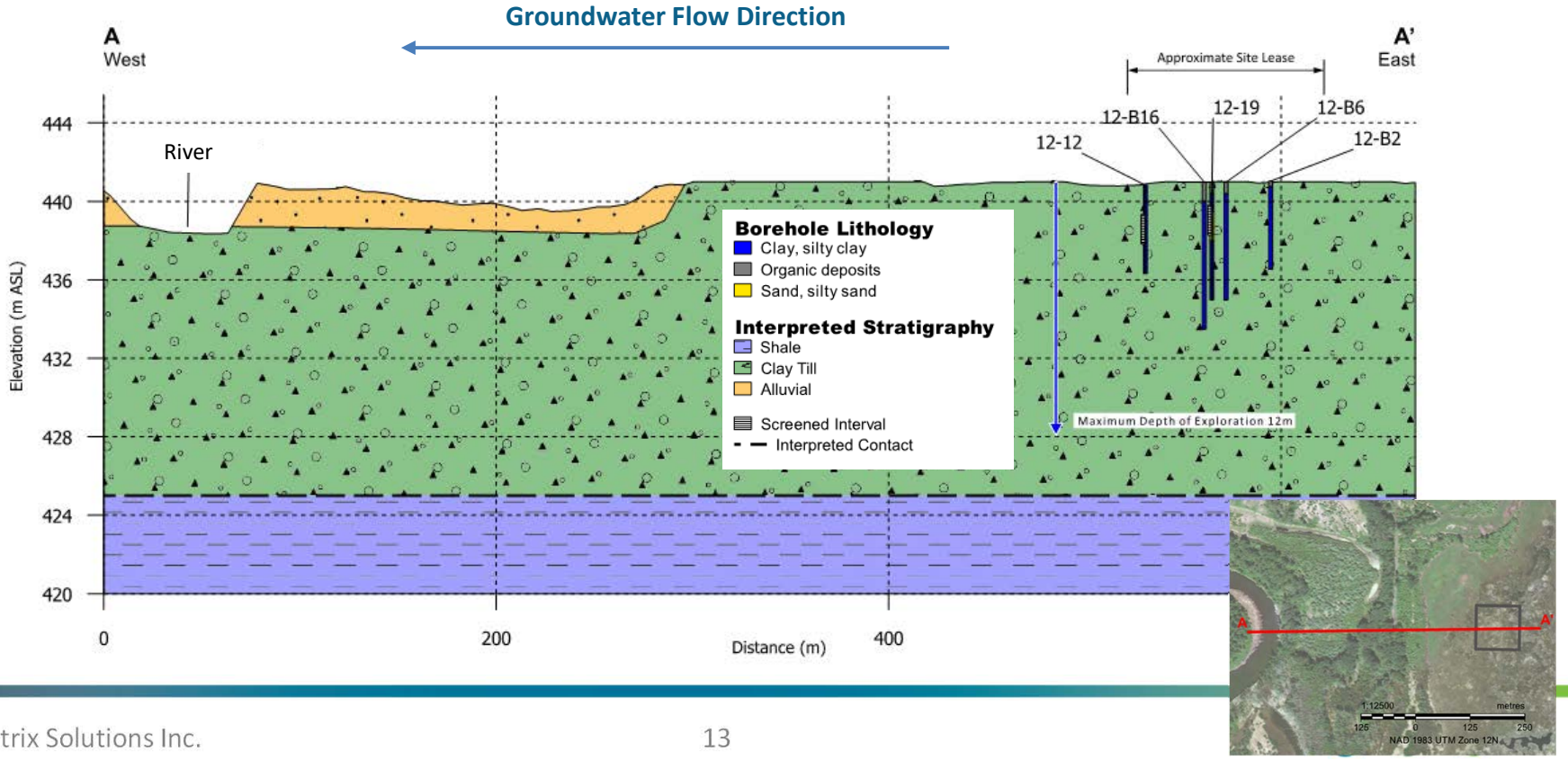

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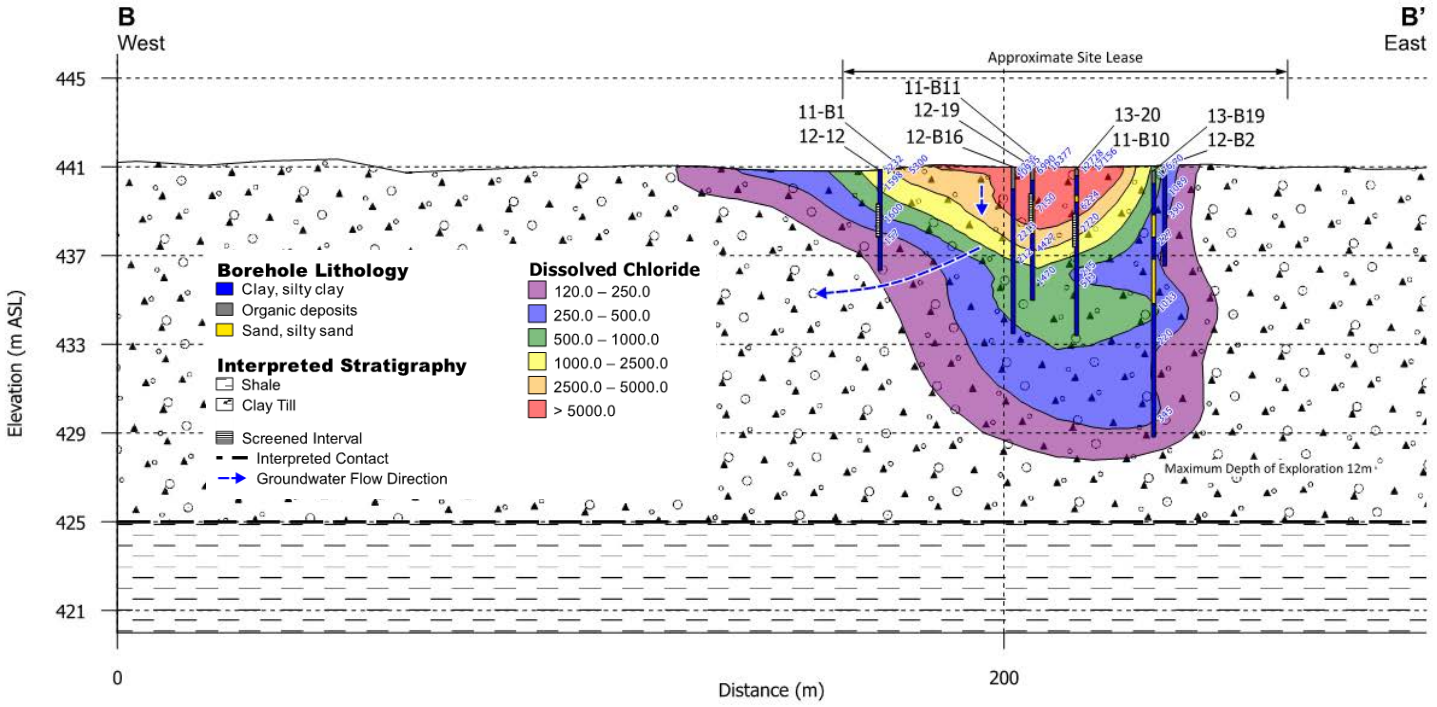
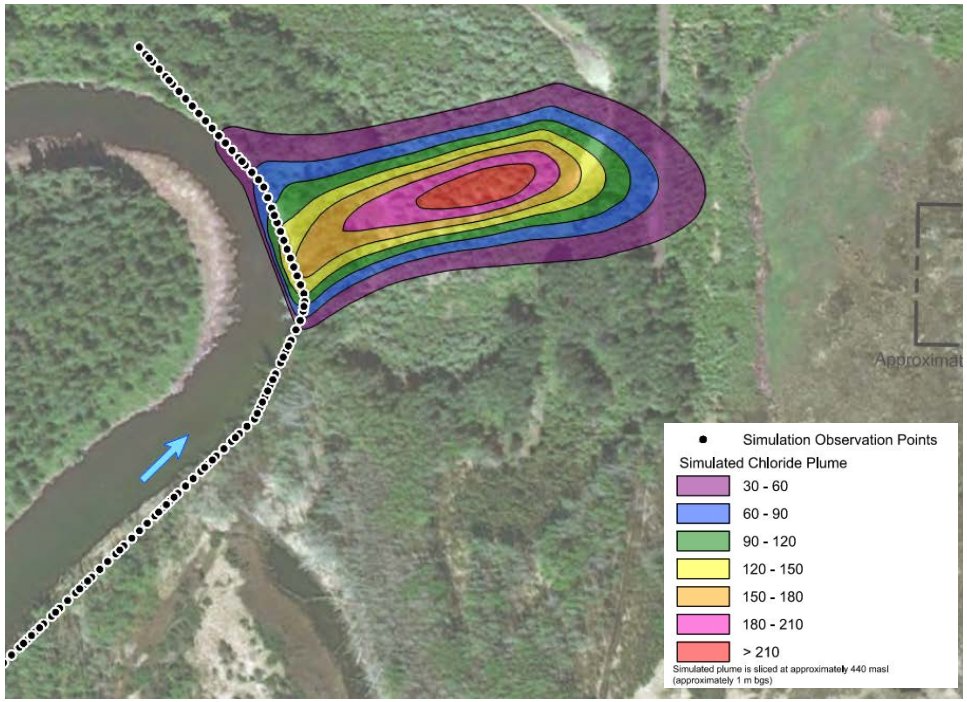
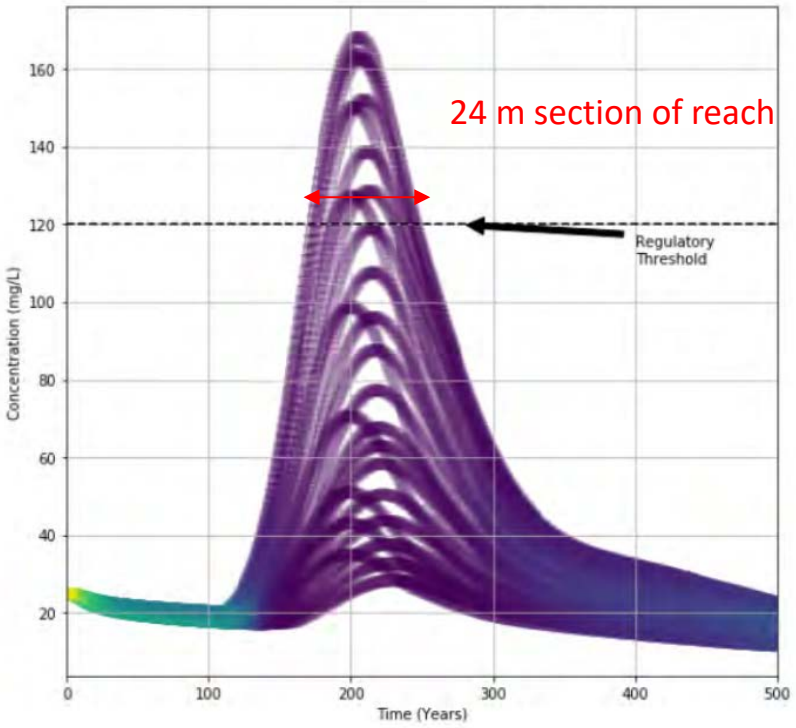


Site A – Remote Well Site

Simulated Groundwater Chloride Concentrations (mg/L) t = 200 years





Spatial Frequency Distribution
Chloride Concentration Breakthrough Curves

Site A – Remote Well Site

- Based on the risk assessment:
  - low predicted risk to FAL in the river
  - impacts to root zone ~15,700 m^3
- Recommendation:
  - no excavation at this time
  - assess vegetation health onsite given salinity in the root zone
- Compare to ~76,000 m^3 soil for full excavation to meet Tier 1 FAL criteria

Case Study

Site B – Pipeline Release

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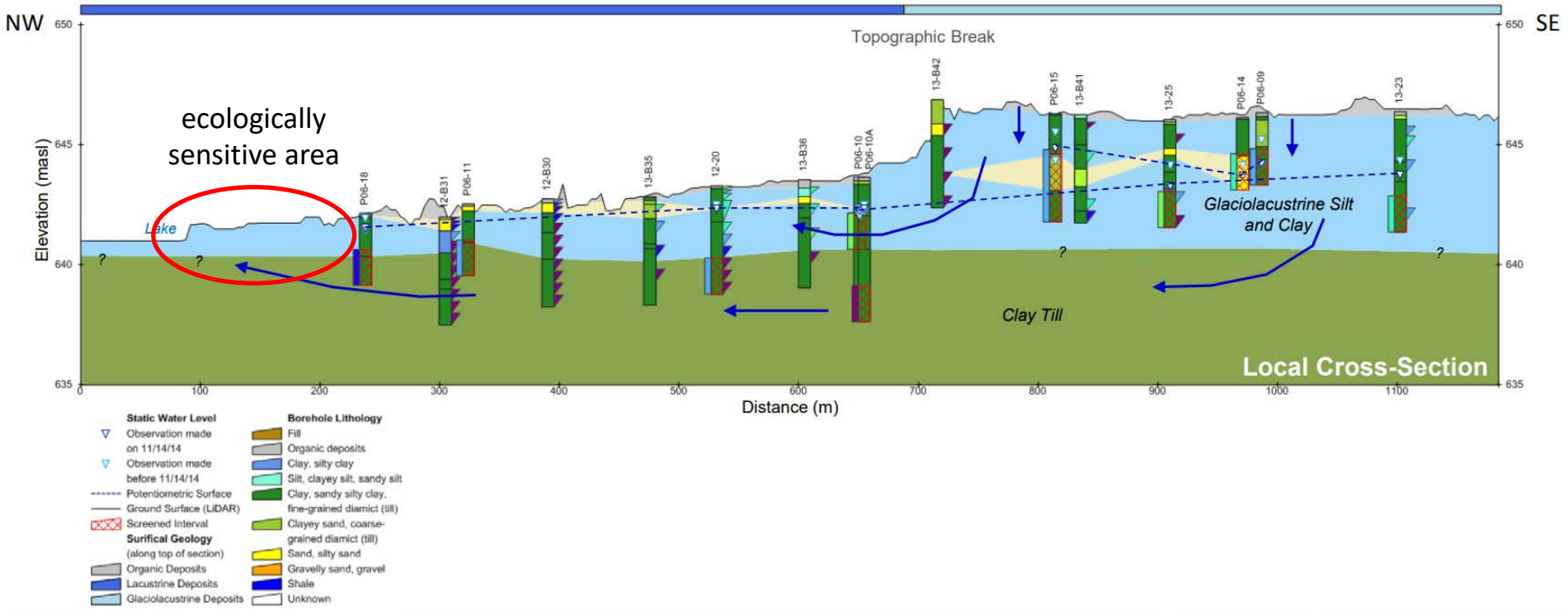

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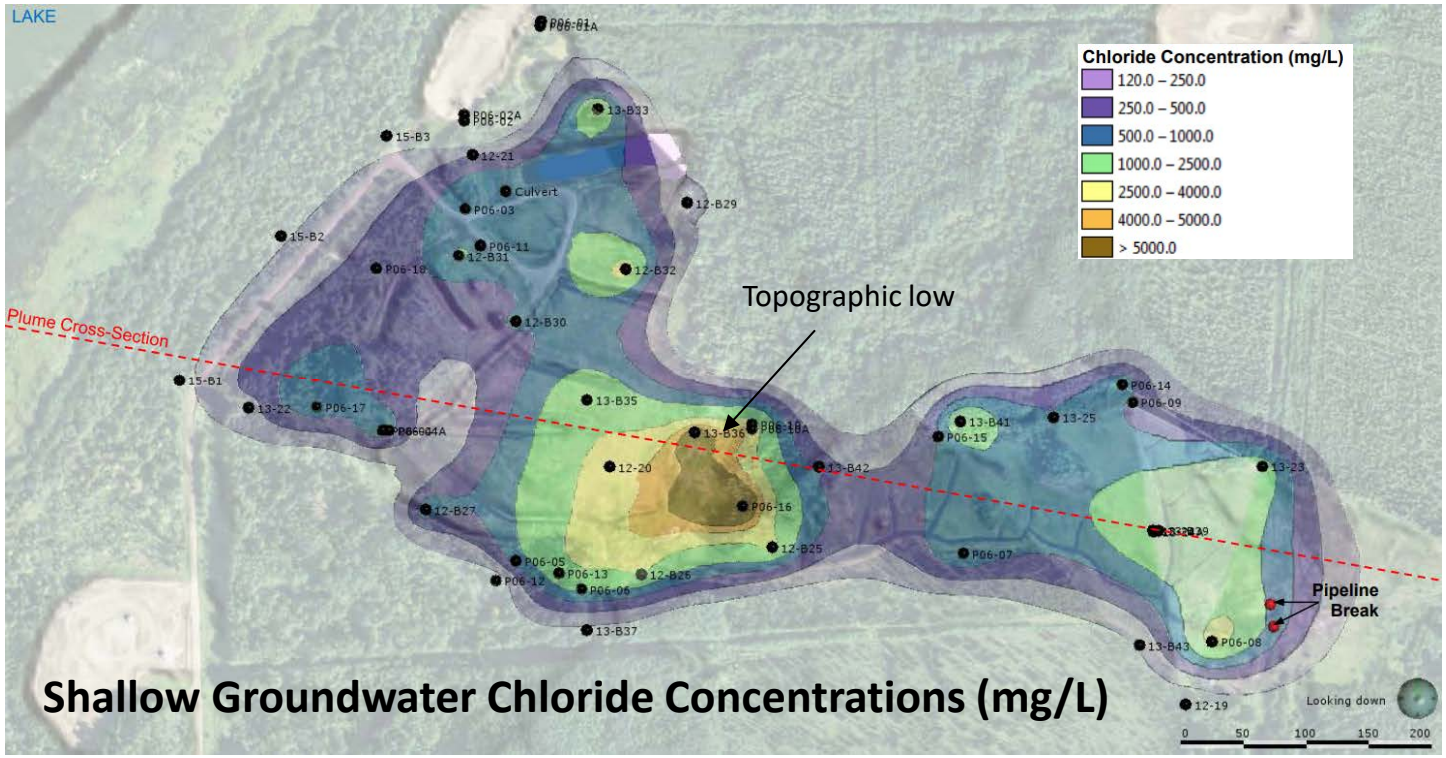

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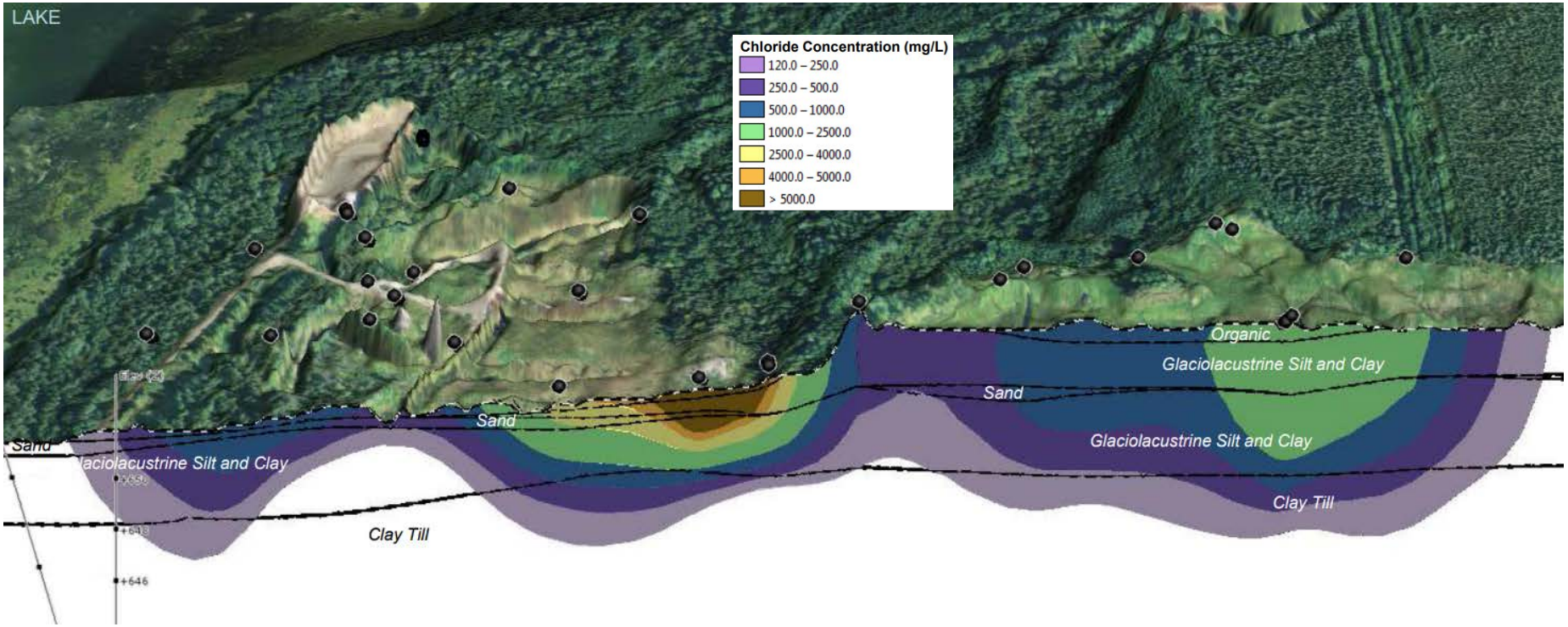
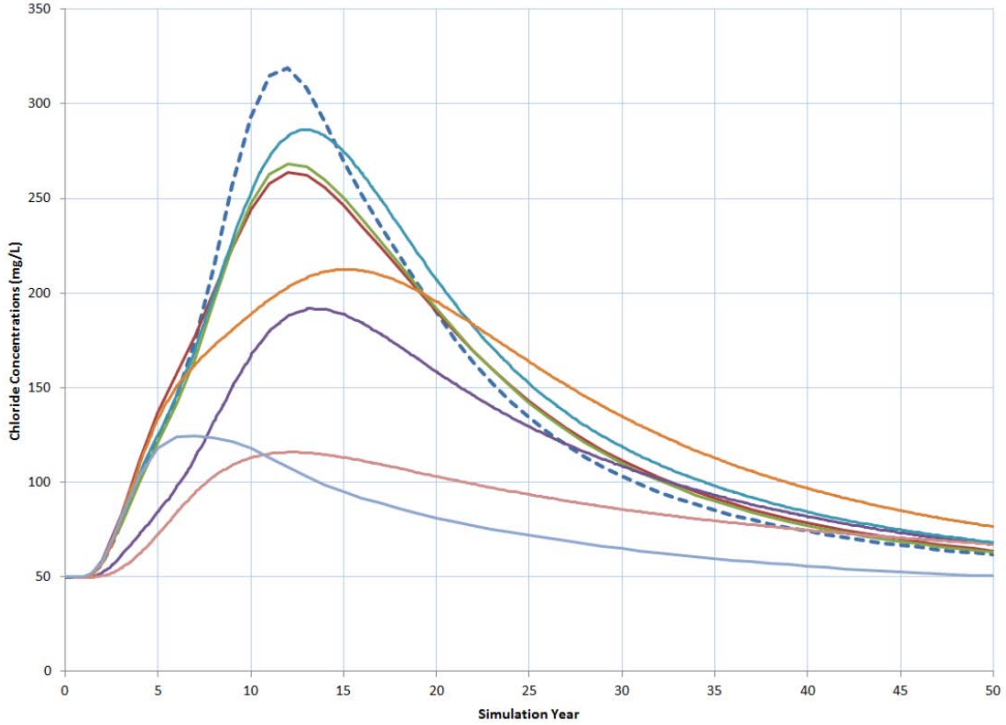


Site B – Pipeline Release

- Groundwater flow and mass transport numerical model was constructed and calibrated:
  - goal was to evaluate risk to FAL in lake and deep DUA due to the remaining chloride impacts
  - Simulate the base case – no further remediation
- Several remediation scenarios were also evaluated:
  - soil excavation of hot spots
  - groundwater recovery in hot spots at various rates

Site B – Pipeline Release

Breakthrough curves for chloride concentrations within shallow groundwater at lake shore



Base Case **No further remediation**

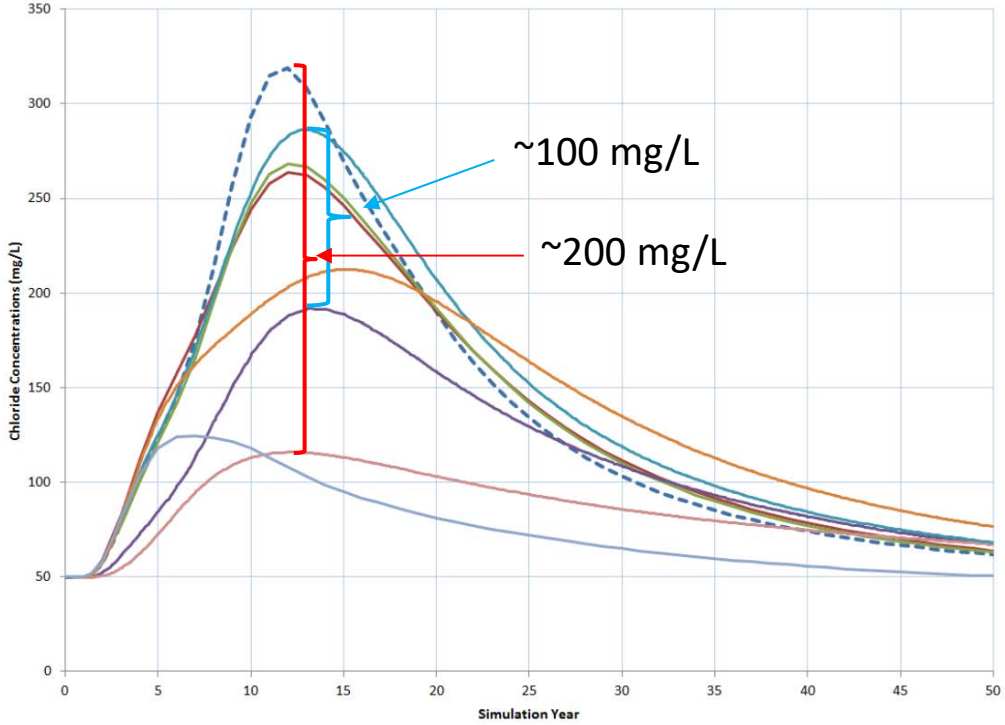
Scenario B1
Scenario B2
B = Hot spot soil excavation

Scenario C1B
Scenario C2B
Scenario C1A
Scenario C2A
C = Groundwater Recovery (1= low rate; 2 = high rate)

Scenario B - **Removal of all soil Cl >1,000 mg/L**

Site B – Pipeline Release

Breakthrough curves for chloride concentrations within shallow groundwater at lake shore



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Site B – Pipeline Release

- Vegetation and aquatic life assessments indicate biological receptors are not impacted and that future risk is negligible
- Active remediation not recommended given low risk to receptors
- New RMP based on the SSRA – natural attenuation with reduced monitoring schedule
- Original SSLA was $3.5M but will be updated and reduced based on RMP

Case Study

Site C – Abandoned Satellite

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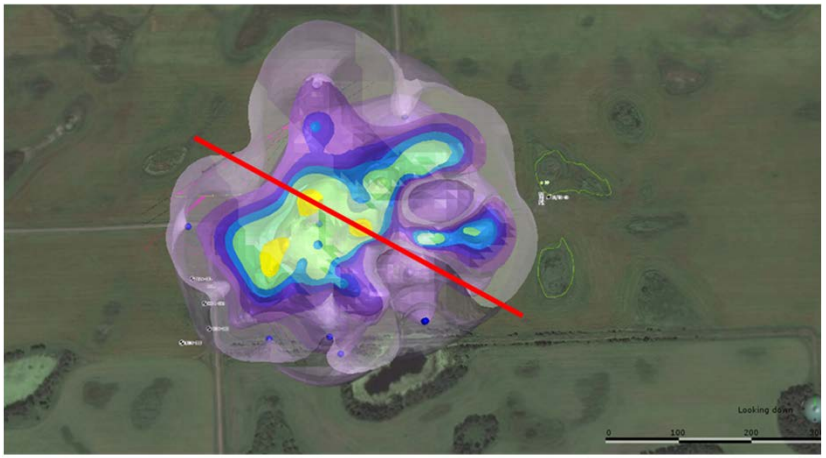
- Multiple Phase II ESAs to characterise soil and groundwater quality 2015-2017
- Salinity impacted soil:
  - 58,000 m^3 above Tier 1 guidelines and site-specific background values
  - upward shallow groundwater gradients are present at the site
  - tile drain recovery system (installed in 1990)
  - maximum groundwater chloride concentration was still ~65,000 mg/L in 2017
- 2015 Saskatchewan MER assigned liability was $9.8M
- 2015 Matrix SSLA was $1.5M (or $6M for full Tier 1 excavation)

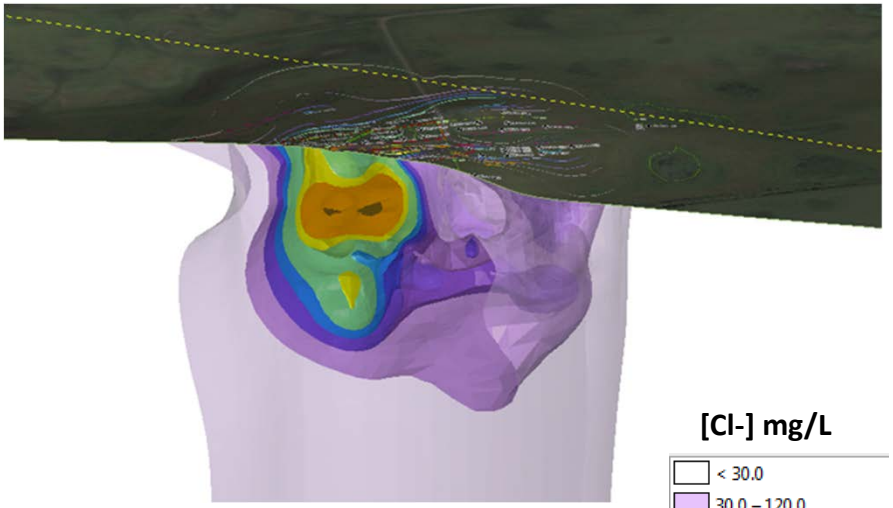
Site C – Abandoned Satellite

Site C – Abandoned Satellite

- Detailed site assessment and characterisation
  - conceptual site model development including chloride plume interpolation
  - detailed numerical modelling was done to evaluate the risk to receptors including deep PWA, FAL in nearby wetlands and root zone (Hydrus)
  - vegetation assessment
- The landowner was involved and updated throughout each phase of the assessment
  - communication and understanding his concerns/objectives for the site was important

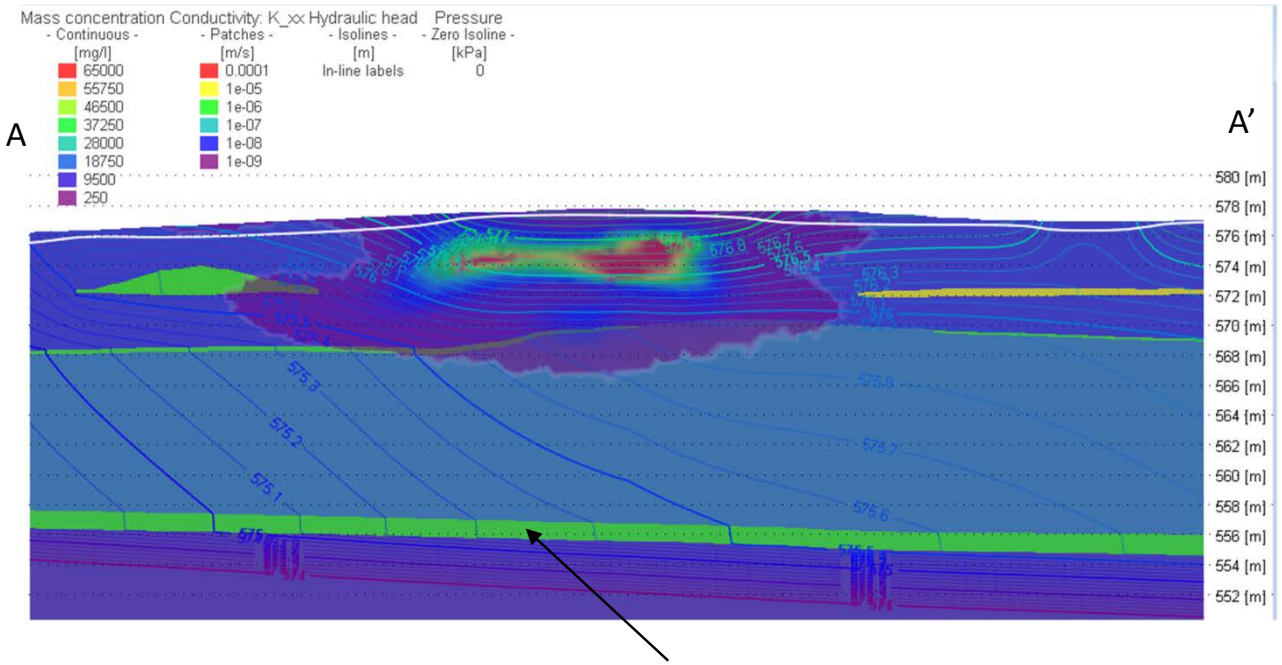
Site C – Abandoned Satellite

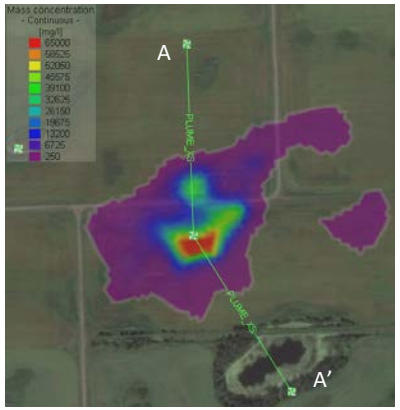




Leapfrog 3D Chloride Plume Interpolation

Site C – Abandoned Satellite





Sand Lens (20 m bgs)

Site C – Abandoned Satellite

- Landowner's preference:
  - didn't see value in excavation and landfilling of root zone soil
  - focus shifted to economic compensation:
    - reduced crop yield in impacted areas and/or reduced land value at sale
    - administrative controls are currently approved for the site and will be put in place

Site C – Abandoned Satellite

- Acknowledgment of Reclamation Requirements (Directive PNG016) Amendment:
  - sites are divided into Routine (low risk) and Non-Routine (higher risk)
  - for Non-Routine Sites:
    - Risk-Based Site Closure – for salinity-impacted sites where levels are > Tier 1 but within site-specific guidelines
    - Administrative Controls – for salinity-impacted sites where levels are > Tier 1 and site-specific guidelines but where additional remediation is shown to be unwarranted

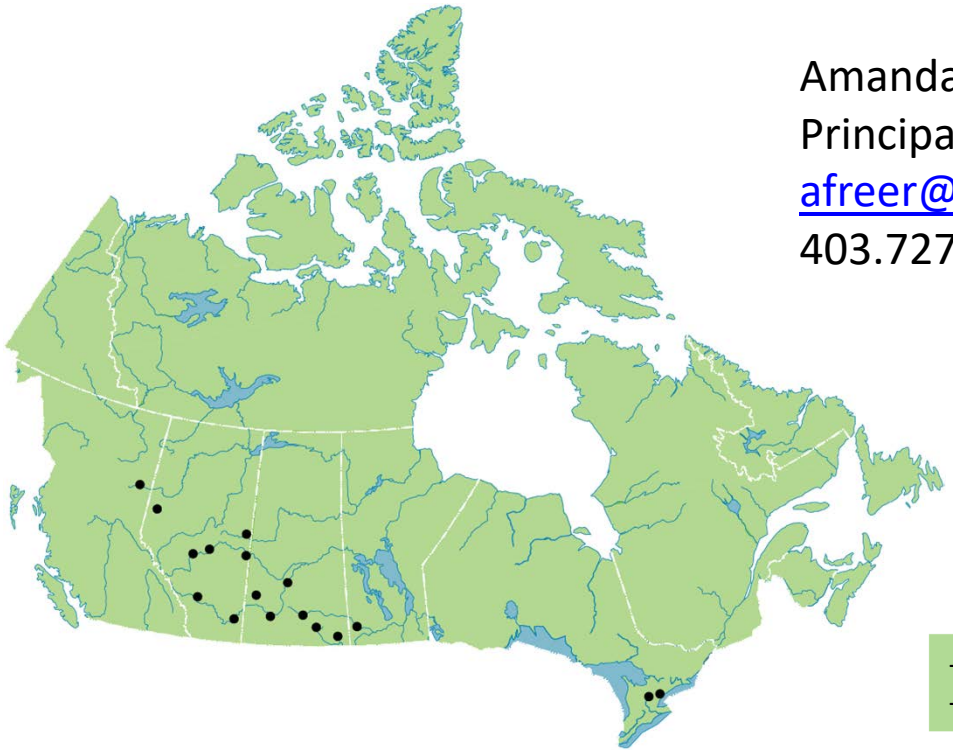
Summary

- Case studies were used to illustrate risk-based approaches to evaluate and reduce the environmental liability associated with a given site.
- Each approach was site-specific and based on the unique combination of contaminants, pathways and receptors.

Summary

- There are often safety, technical and financial limitations to contaminated site remediation
  - risk-based approaches can be used to focus resources on sites that carry the greatest risk
  - identify the remedial strategy that manages or eliminates risk but also maximise the overall environmental, social and economic benefits
  - continuing dialogue with regulators and stakeholders is important

Matrix Office Locations



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