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Groundwater Modelling and Options Analysis for Long-Term Wetlands Remediation

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EcoNomics

Outline

- Background
- Problem Statement
- Flow and Transport Mechanism in Wetlands
- Case Study – Options Analysis

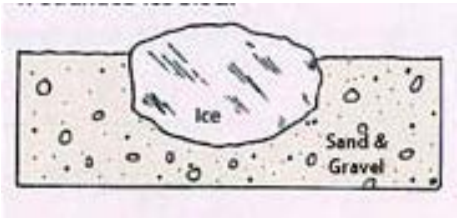
Northern Alberta

Source: Google Earth

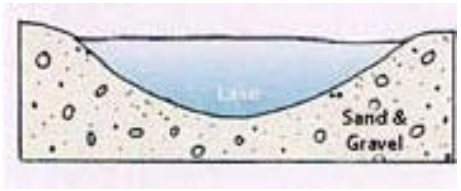
Challenges

- Key infrastructure crossing environmentally sensitive areas
- Remote settings, connected waters
- High sensitivity to water balance and salinity
- Complex flow and transport processes
- Minimal disturbance remedial approaches are preferred
- Long term management of sites may be required

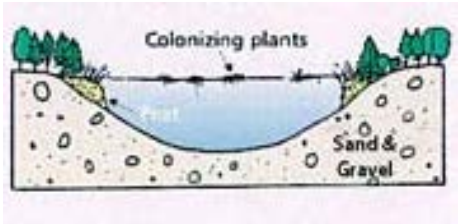
Wetlands Evolution



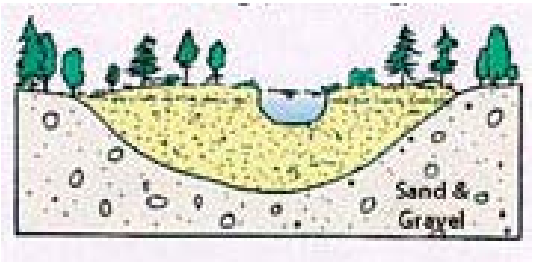
Stage 1: Receding glaciers



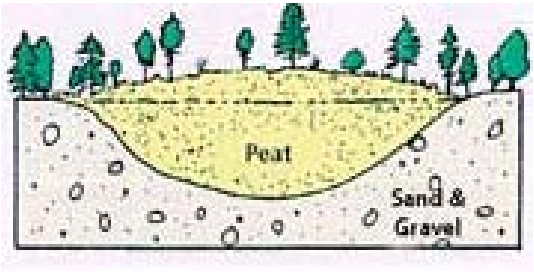
Stage 2: Shallow Glacial Lake



Stage 3: Colonization by vegetation



Stage 4: Cold and oxygen poor conditions, slow degradation, peat formation

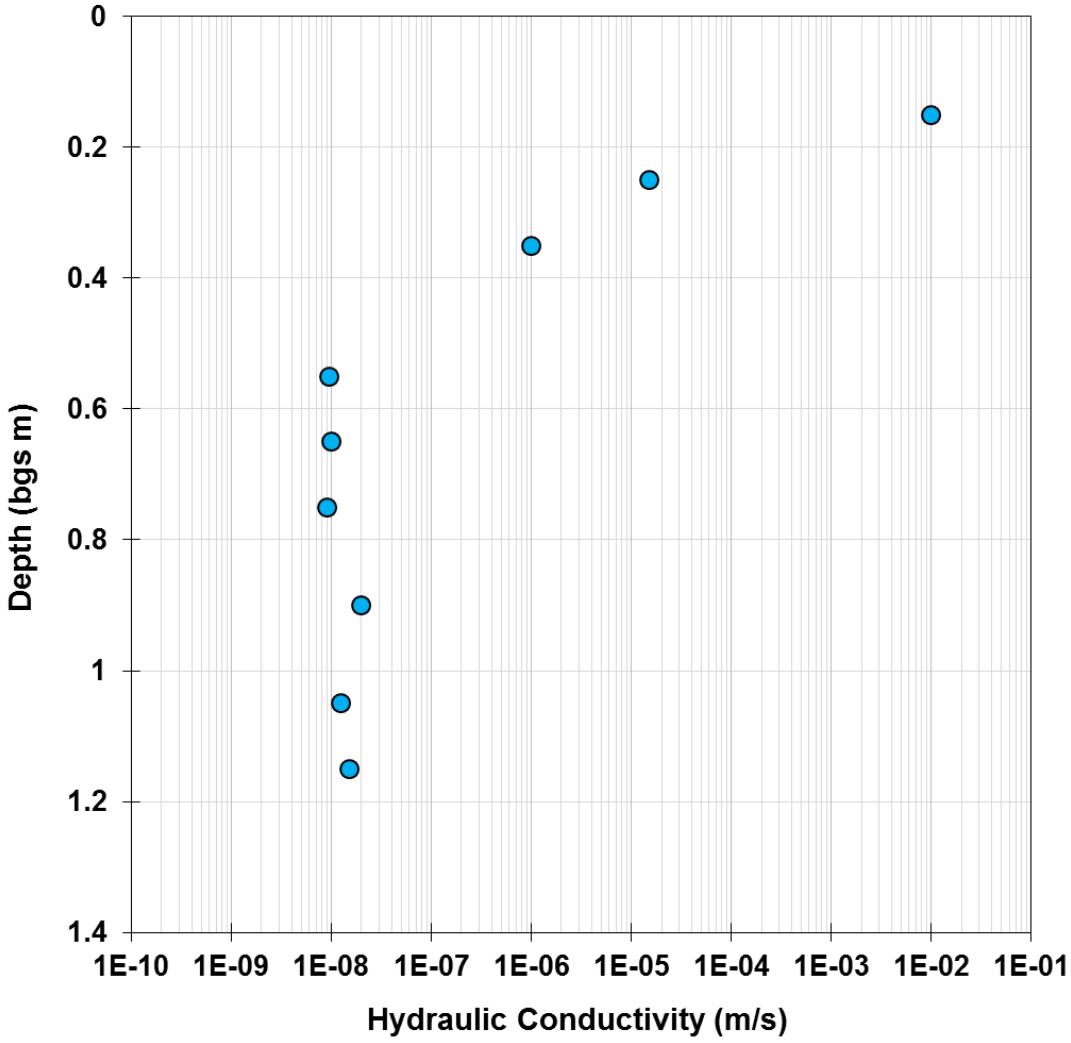


Stage 5: Nutrient poor conditions, slow growth and accumulation; layered structure

Peat Properties

- Exponential decrease in saturated hydraulic conductivity (K) with depth
- High degree of anisotropy and heterogeneity
- Pools of peat deposits – deposition history
- Integrated surface water – groundwater problem

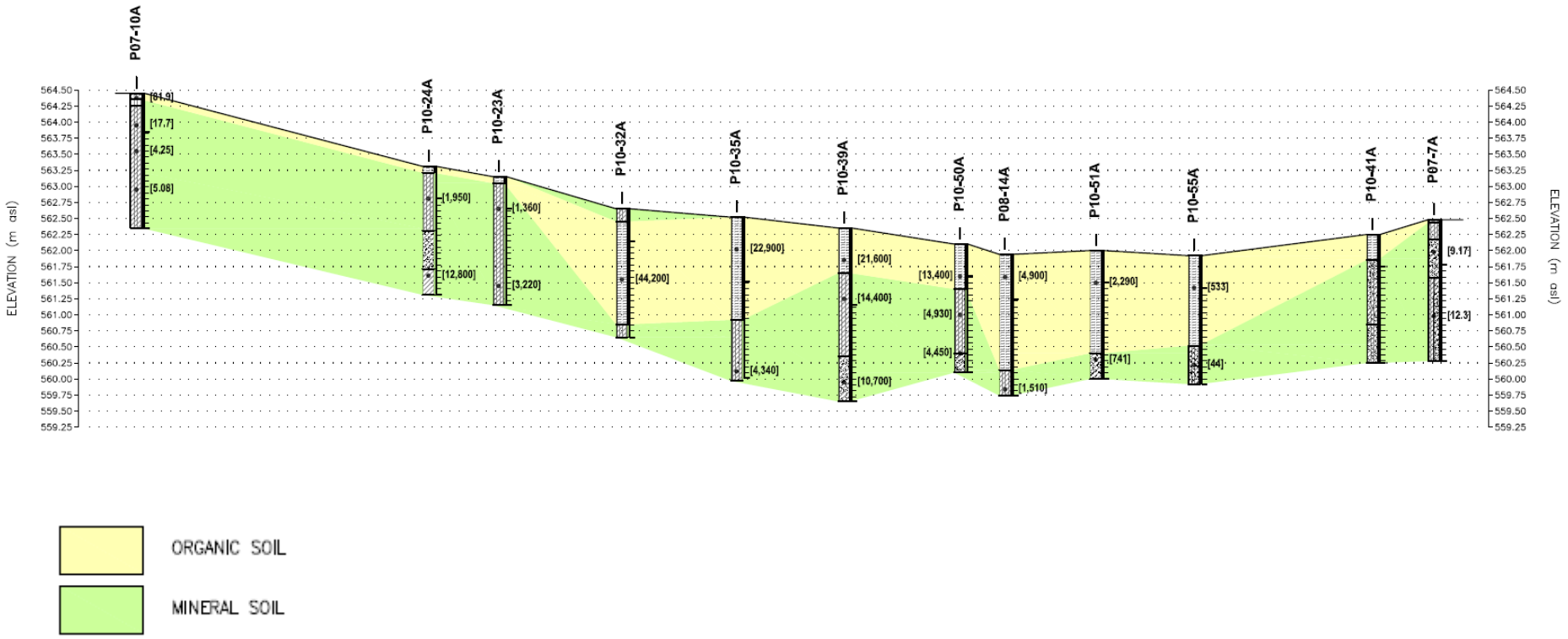
Peat Properties



Hoag, R.S., Price, J.S. (1995). J. of Hydrol.
Beckwith, C.W. et al. (2003a). Hydrol. Process.
Quinton, W.L. et al. (2008). Hydrol. Process.
Nagare, R.M. et al. (2013). Hydrogeology J.

Typical Cross Section

TYPICAL CROSS SECTION

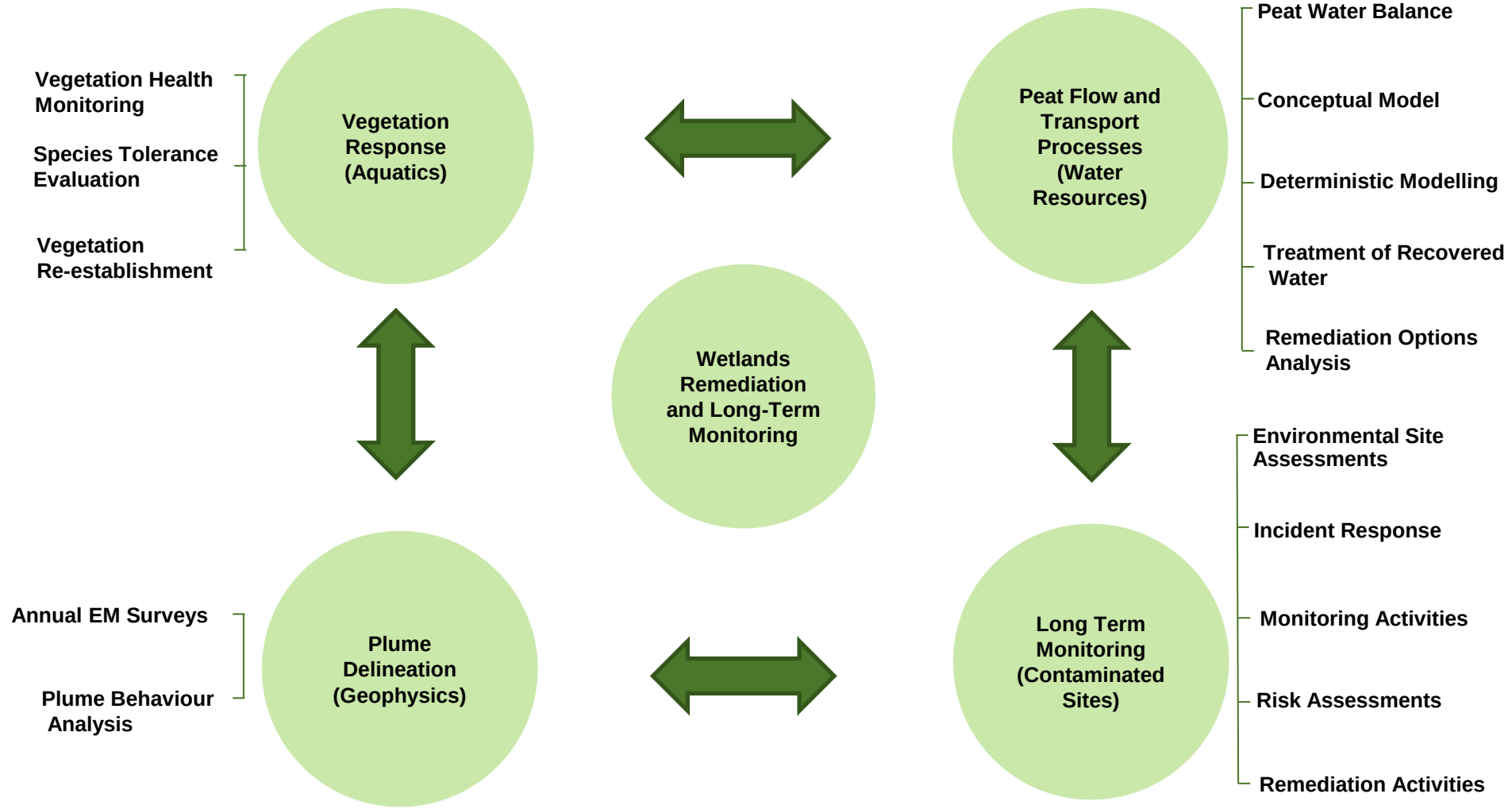


Source: WorleyParsons Canada Services Ltd.

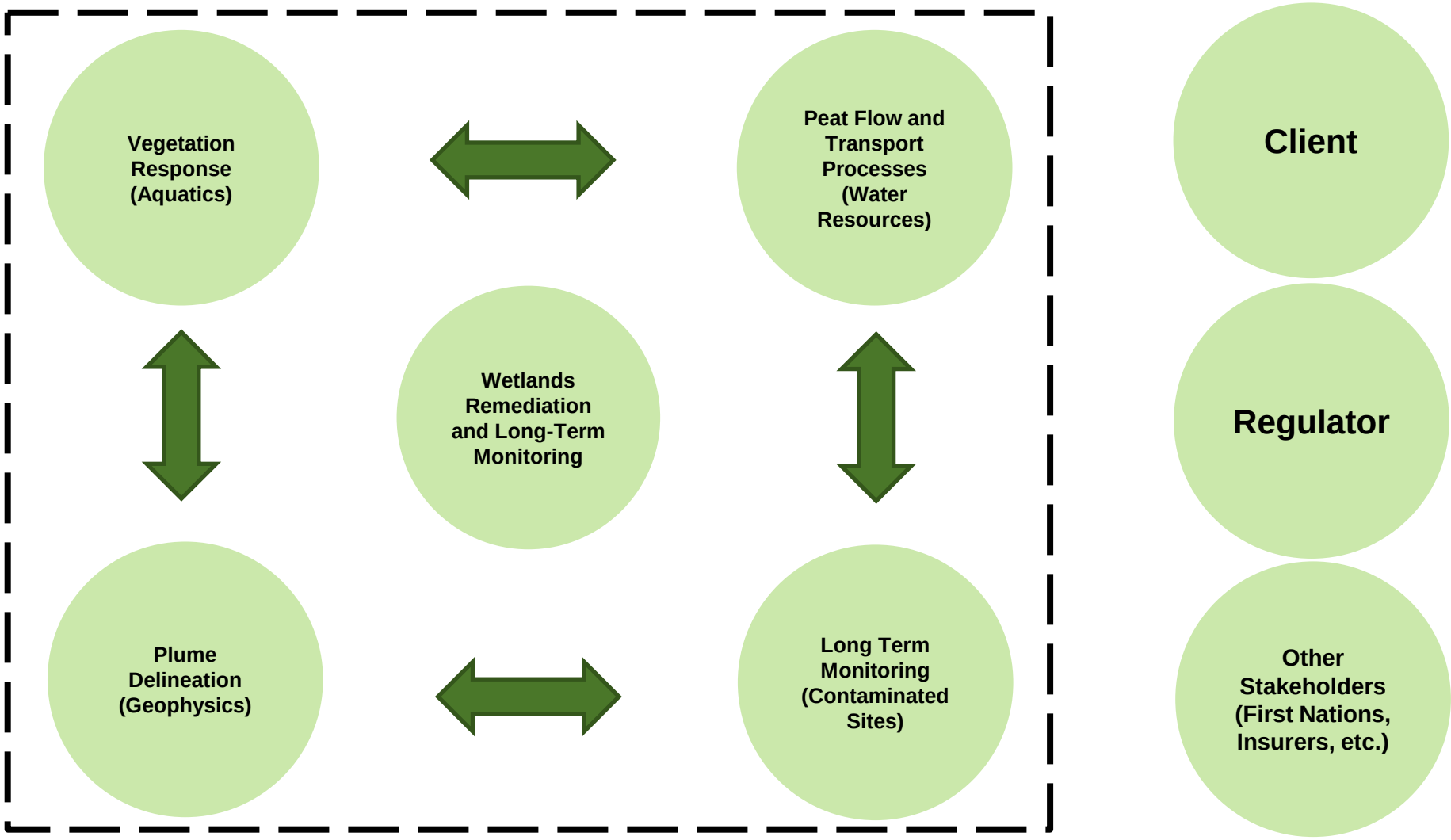
Contaminant Transport

- Mechanism dominated by K-Depth profile
- Advection vs. diffusion at different depths
- Closed pores, backward diffusion, fibre absorption, deep pools unique processes to peat

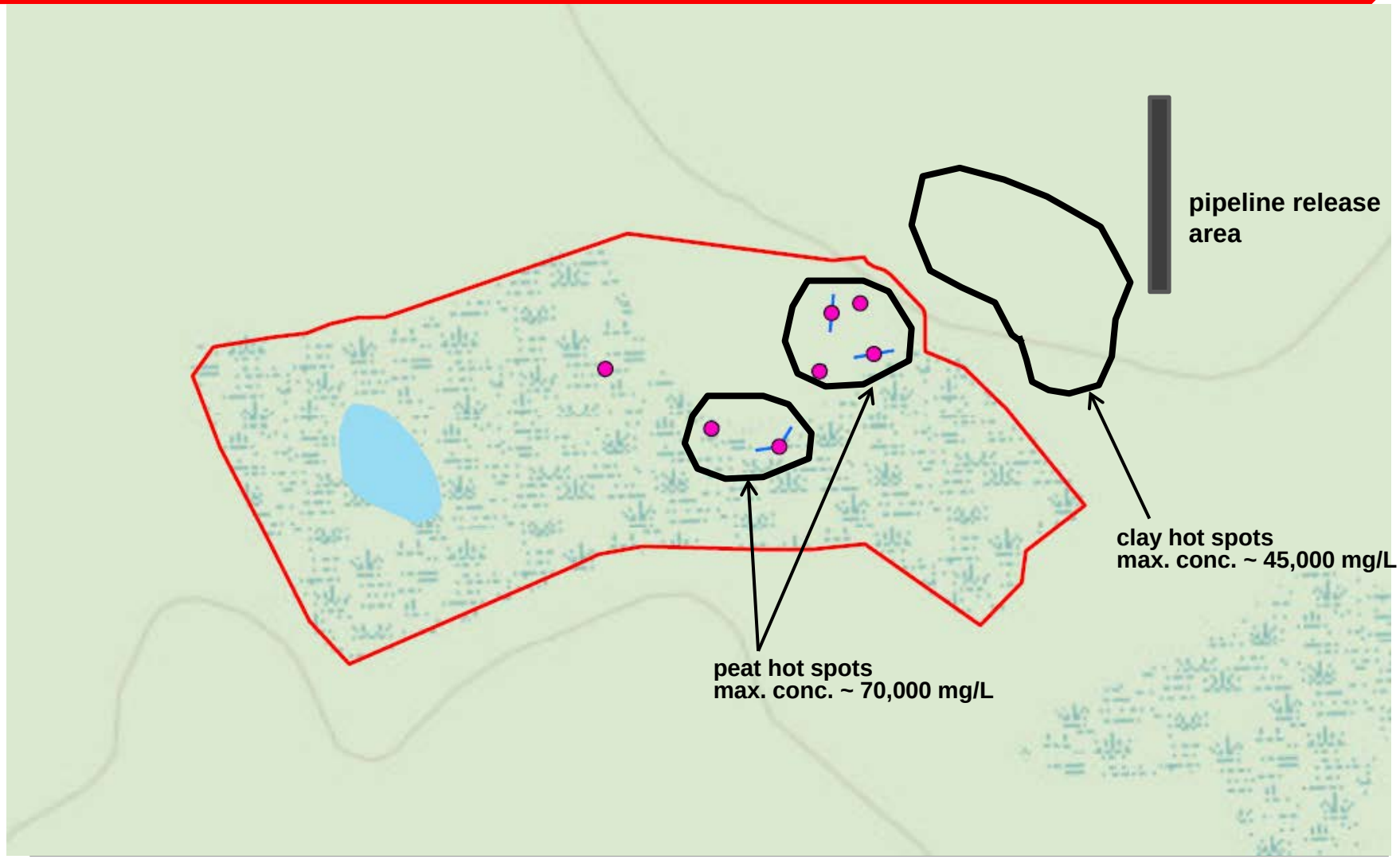
Multidisciplinary Problem



Multidisciplinary Problem



Case Study Background



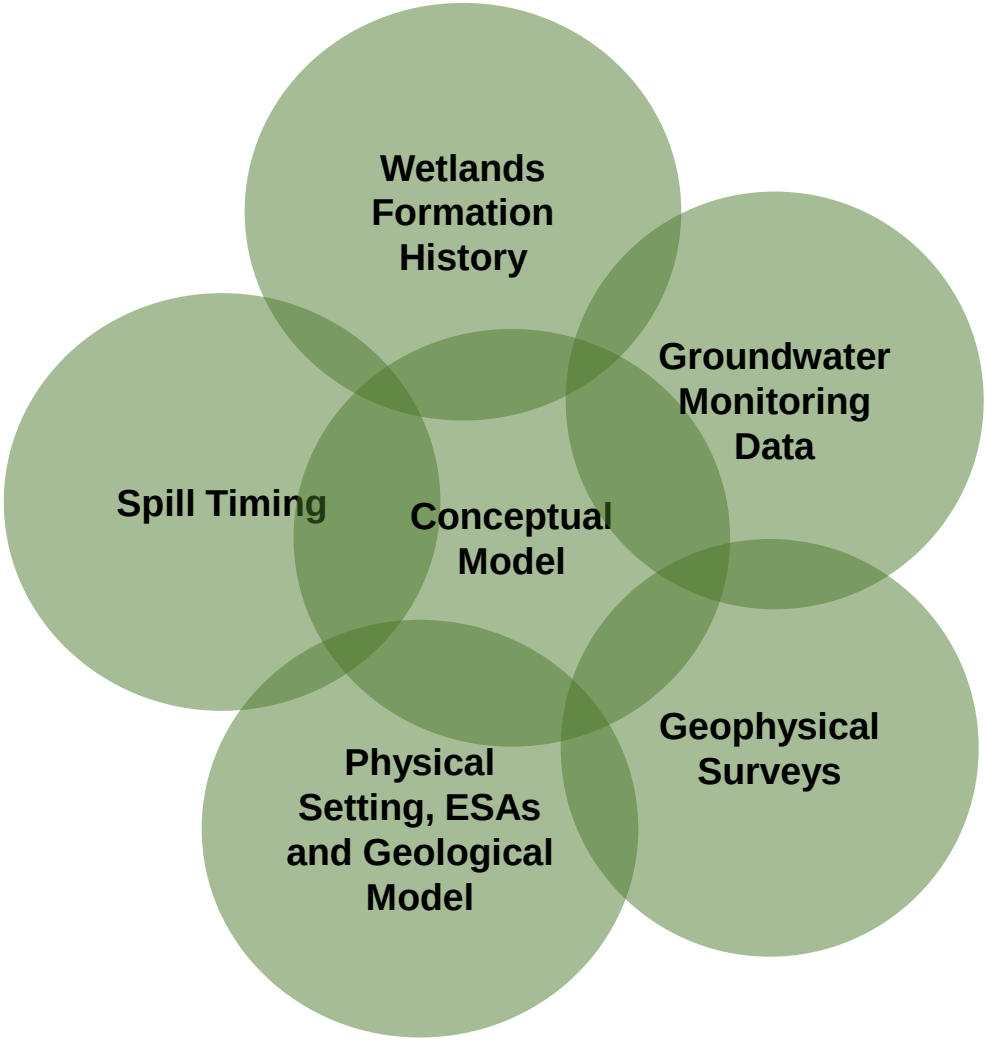
Objectives

Two broad objectives:

1) Spill conceptual model development

2) Remediation strategy development

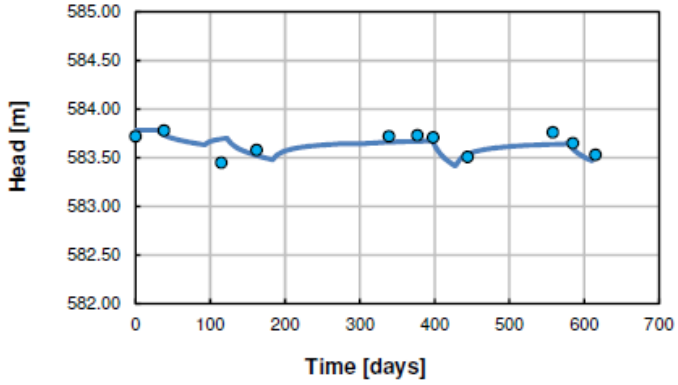
Conceptual Model Development

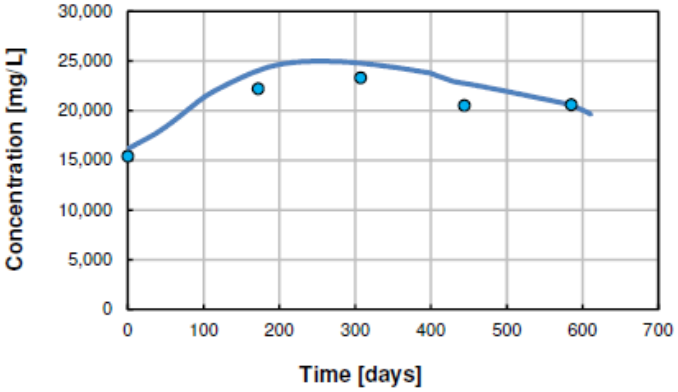


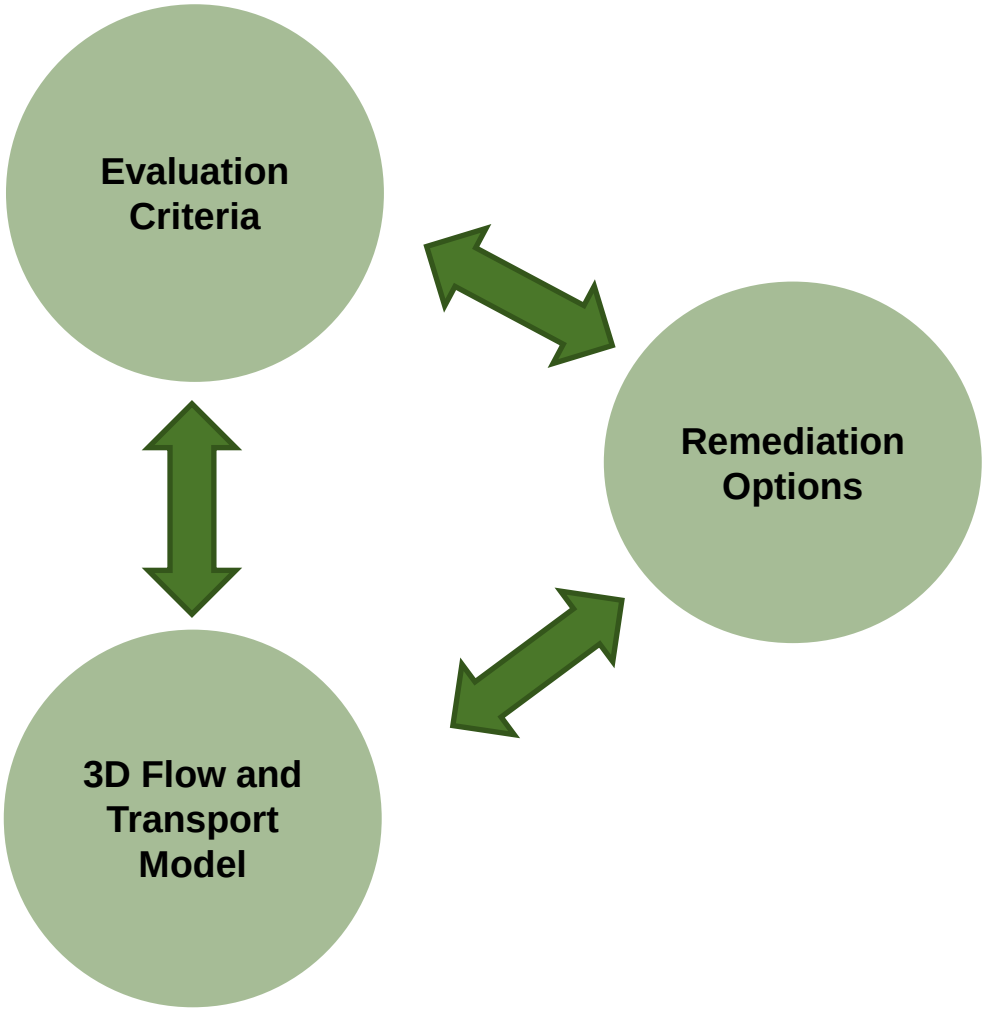
Conceptual Model

- Spill of produced water
- Initial mode of water transport dominantly overland
- Vertical movement into low K zone
- Accumulation into thicker peat zones
- Very little movement between 2007 and 2013

Remediation Options Analysis







Remediation Options – Peat Area Criteria

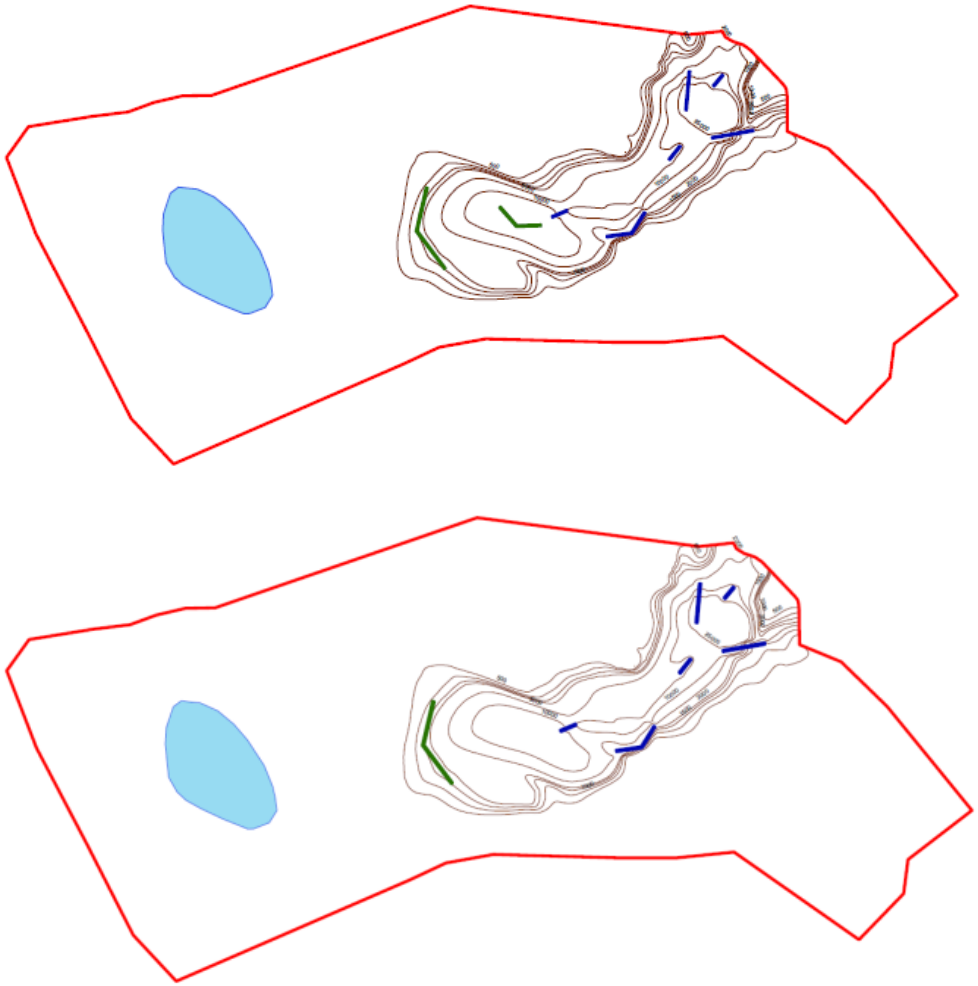
- Client
- Regulator
- Other Stakeholders (First Nations, Insurers, etc.)

Remediation Options – Clay Area Criteria

- Client
- Regulator
- Other Stakeholders (First Nations, Insurers, etc.)

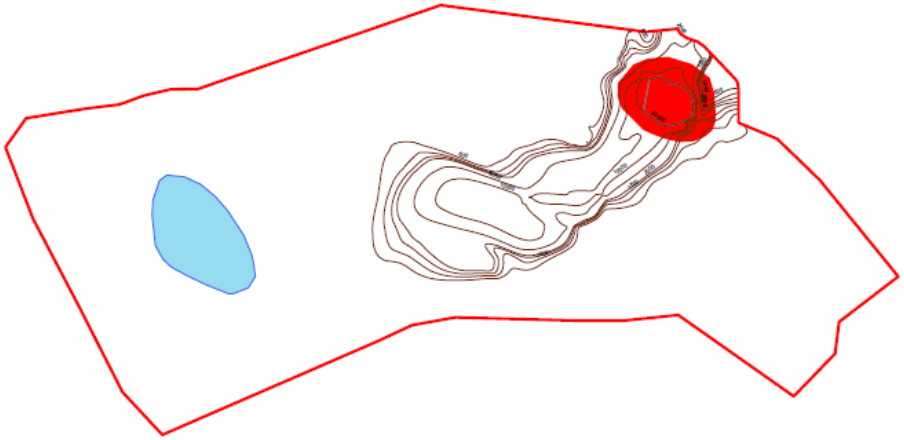
Remediation Options – Peat Area

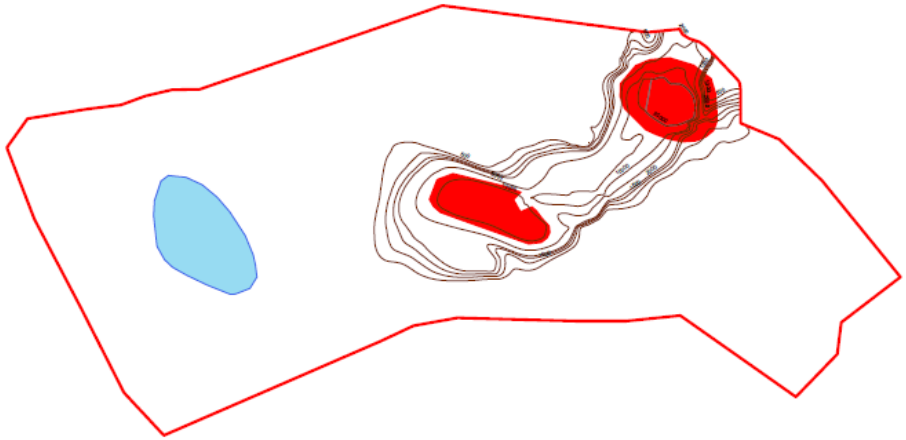
Peat Area Options – Dewatering Trenches

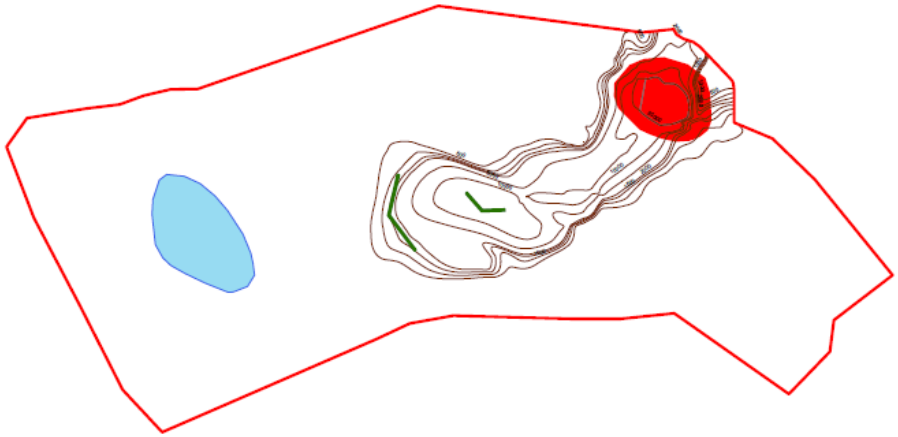


Peat Bog Extent
Slough
Chloride Concentration at 2013 end
Active Trenches
Additional Trenches

Peat Area Options – Excavation and Dewatering



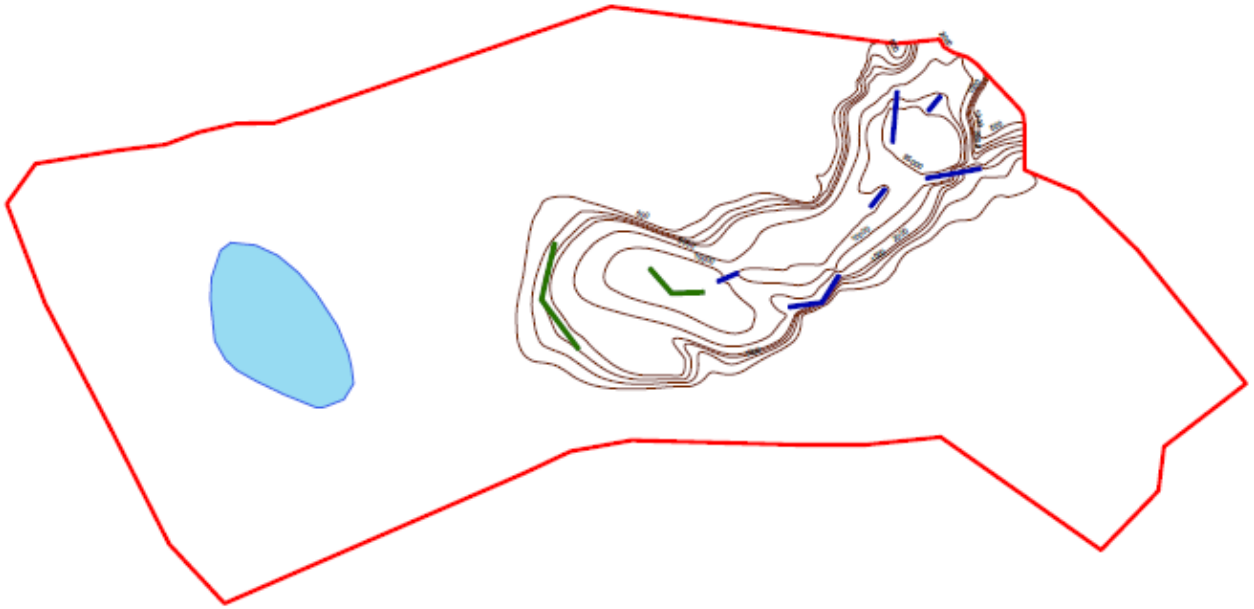




Peat Bog Extent
Slough
Chloride Concentration at 2013 end
Dewatering Trenches
Excavation

Peat Area Options – Treatment and Dilution

Chosen Option – Peat Area

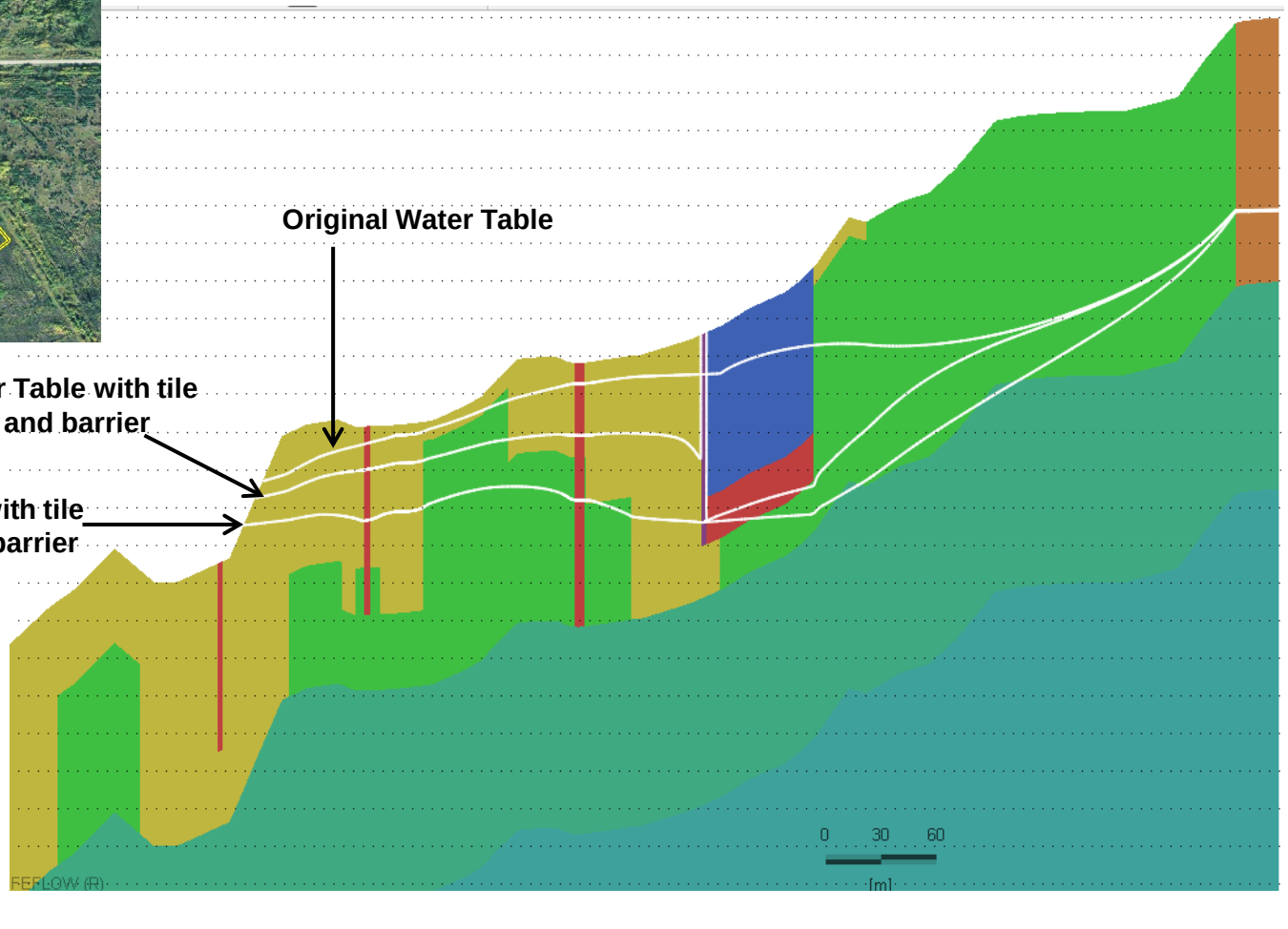


Peat Bog Extent
Slough
Chloride Concentration at 2013 end
Active Trenches
Additional Trenches

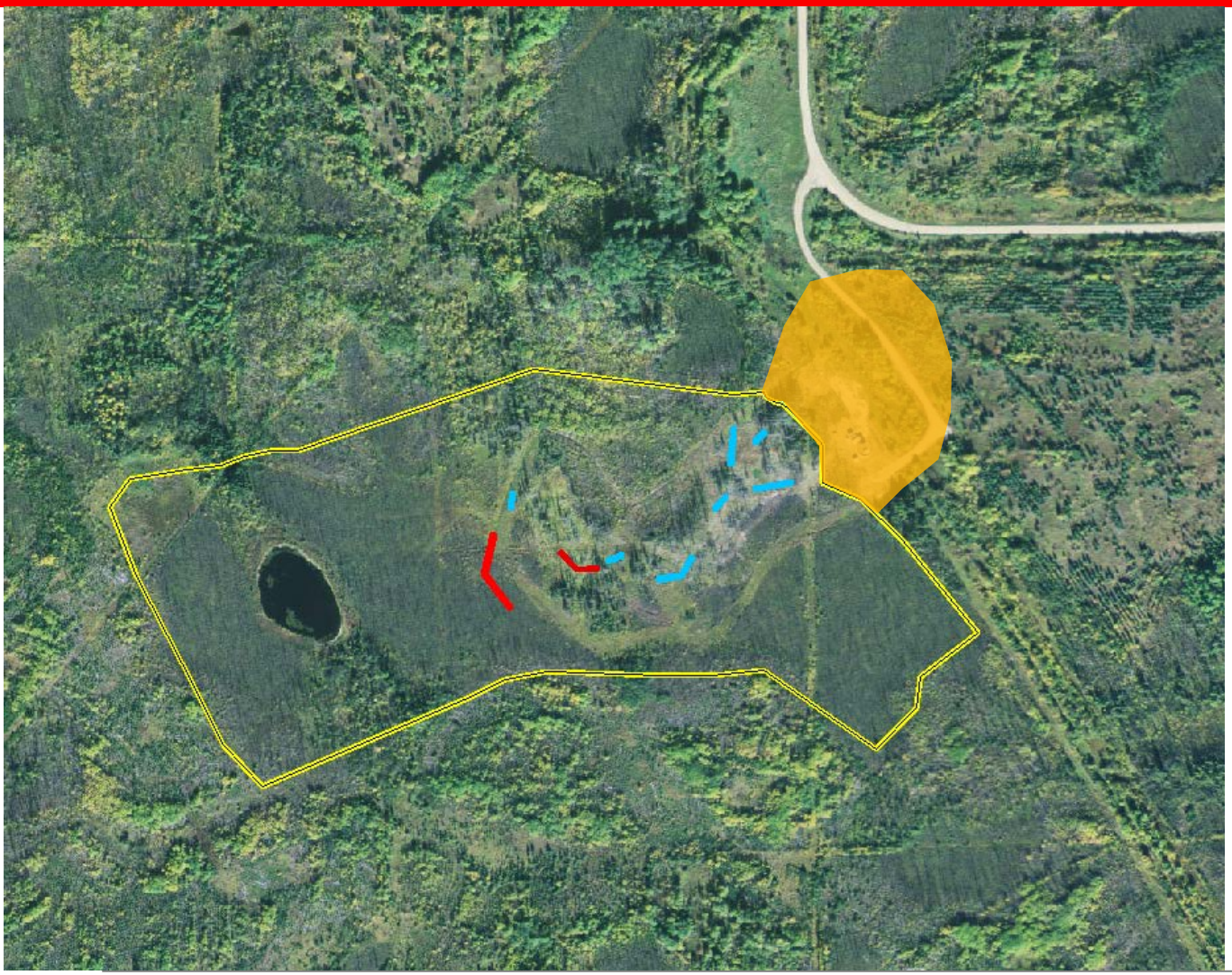
Remediation Options – Clay Area

- 3 m excavation with backfill
- 1.5 m excavation with backfill
- 2 m excavation, backfill and tile drains
- 2 m excavation with backfill, clay barrier and tile drains

Tile Drains and Peat Dewatering Impacts



Remediation System Design



Conclusions

- Multidisciplinary problem needs multidisciplinary approach
- Conceptual model must adhere to wetlands evolution history
- Deterministic model an informative tool
- Integrated management approach
- Long term monitoring and optimization key to success

Questions

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