Adaptive / Risk Management of Off-Site Contaminant Migration

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Engineering a better future for our planet and its people.

Our Vision

We create sustainable solutions that connect people, data and technology to design, deliver and operate the most complex projects.

Outline

- What are adaptive/risk management plans
- Components of a risk management plan
  - Identifying SOPC, receptors, applicable exposure pathways
  - Conceptual site models
  - Quantifying potential unacceptable risks
  - Management/mitigation strategies
- Components of adaptive management plan
  - Triggers, response actions, timelines
  - Mitigation options
  - Contingency plans
  - Communication plans

Adaptive / Risk Management Plans

- Provide an integrated plan to **manage/mitigate impacts** associated with off-site migration of contaminants for **operating sites** where potential environmental impacts are evolving
- Applies to large-scale sites in operation phase
- Formal, **systematic** approach
- Continuous **re-evaluation** of data
- **Adapt** for changing site conditions and new information

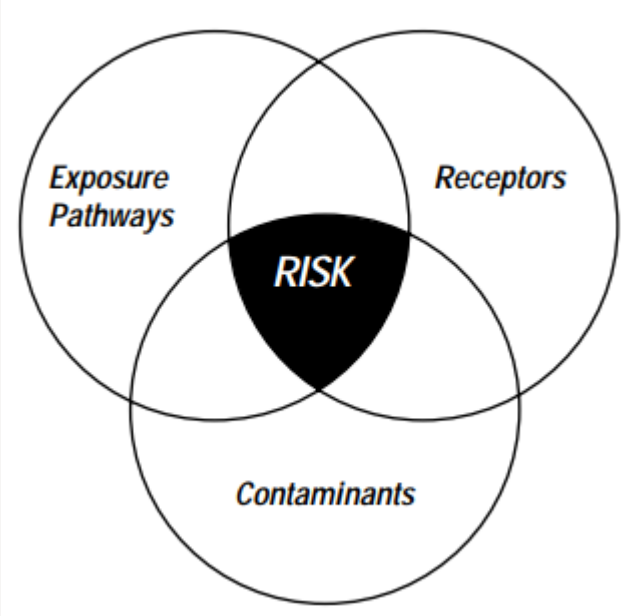
https://essa.com/what-role-does-adaptive-management-play-in-restoring-our-coast/

Adaptive / Risk Management Plans

- Involve multidisciplinary **team of environmental specialists**
- Incorporate environmental data into **conceptual site model**
- Require an understanding of hydrogeology controlling **contaminant migration**
- Require an understanding of the **human health and ecological risk** of environmental impacts
- Development of **triggers**, **potential response actions**, and **timelines**
- Provide a **communication plan** to affected stakeholders

Components of Risk Management Plan

- Identify substances of potential concern
- Develop conceptual site model
- Identify receptors of concern and applicable exposure pathways
- Determine the potential for unacceptable risk (human health and ecological)
- Develop strategies and recommendations to address potential unacceptable risks



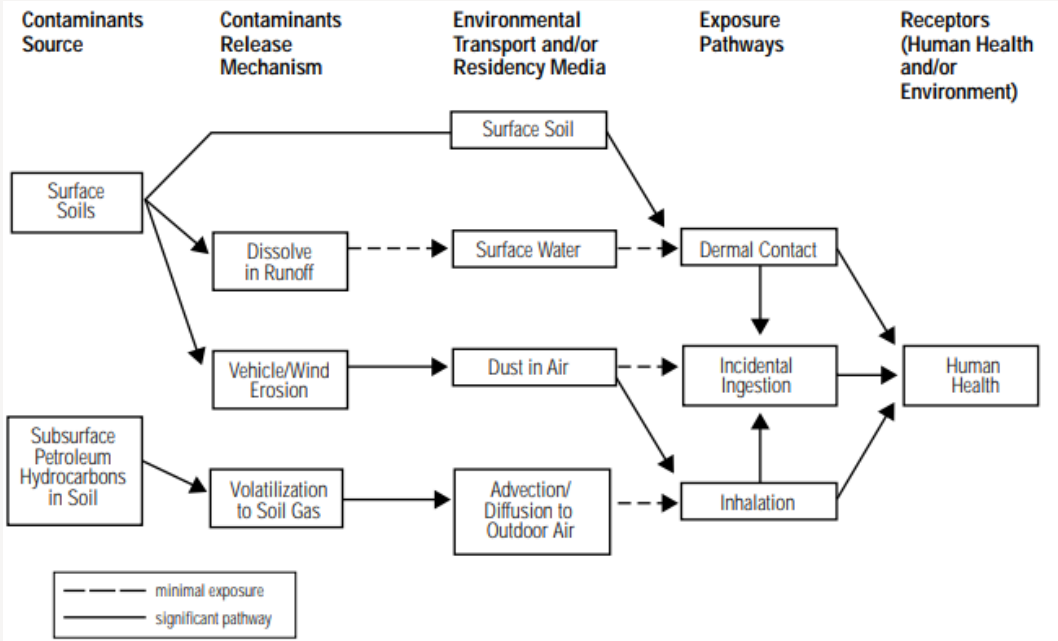
Risk Components Relationship
(from : A Federal Approach to Contaminated Sites)

Substances of Potential Concern

- Screening data against **applicable environmental quality guidelines** and **background** values
- Tiered risk-based approach to environmental protection under Saskatchewan Environmental Code
  - Tier 1 – generic values for land use, meant to be protective of all environments
  - Tier 2 – specific to exposure pathways, requires extensive knowledge of the site characteristics
  - Tier 3 – human health and ecological risk assessment

Receptors of Concern and Applicable Exposure Pathways

- Humans
  - Ingestion
  - Dermal Contact
  - Inhalation
- Ecological
  - Ecological direct contact (plants and soil invertebrates)
  - Wildlife – ingestion (direct and indirect, dermal contact
  - Aquatic Life
  - Irrigation
  - Livestock watering



Example of Human Health Conceptual Site Model (from : A Federal Approach to Contaminated Sites)

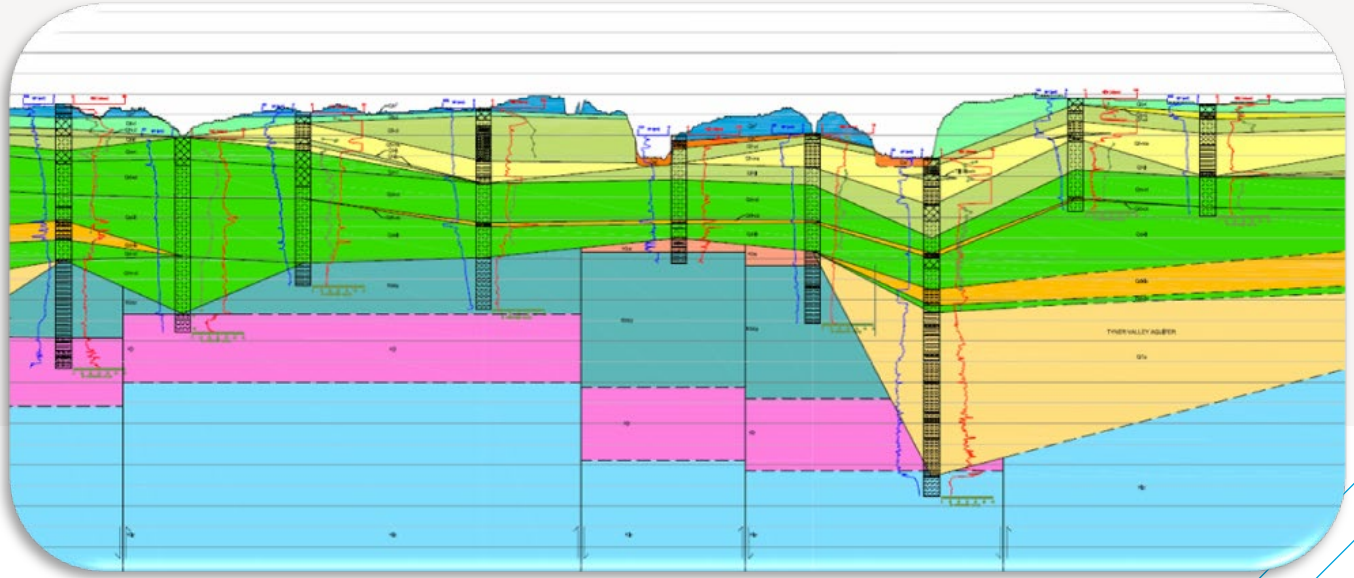
Determine Potential Unacceptable Risk

- Human Health / Ecological Risk Assessment
  - Exposure Assessment
  - Toxicity Assessment
  - Risk Characterization

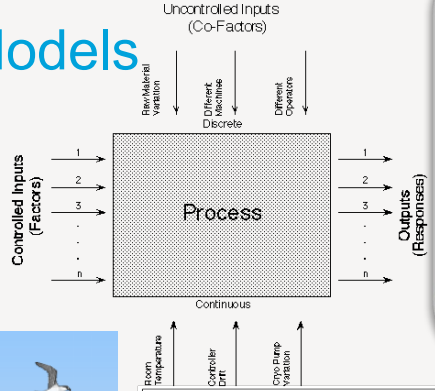
- HQ >1, potential unacceptable risk
  - Mitigate and/or manage with controls in the RMP (administrative, physical or engineered controls)
  - Used to establish benchmarks standards, triggering a response action in the AMP

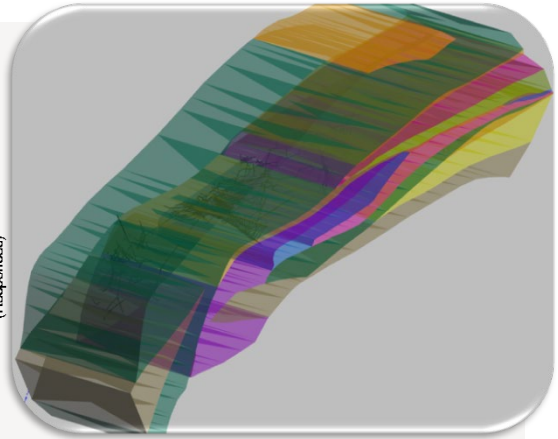
Fate and Transport – Hydrogeology and Hydrology

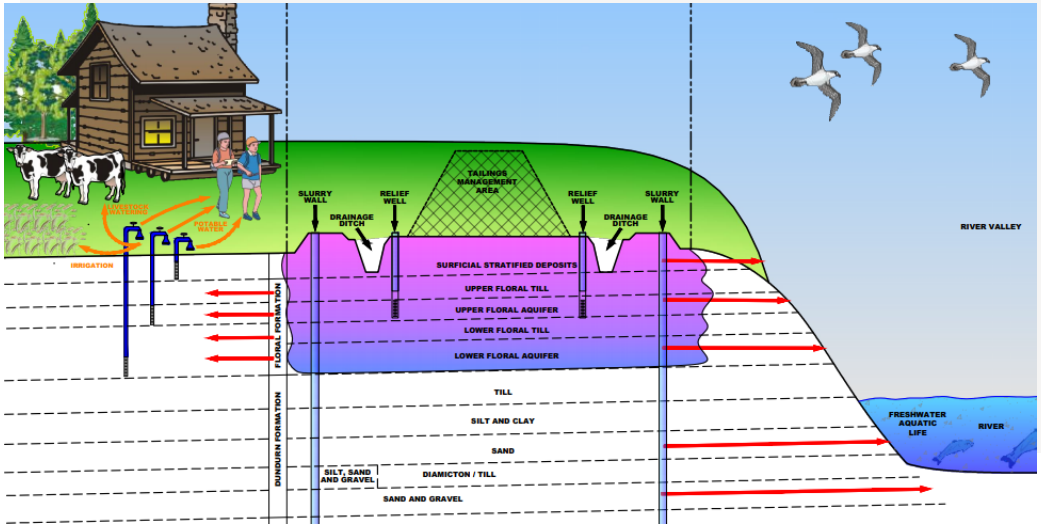
- Understanding the source and how it migrates / attenuates is critical
- Surface water and groundwater pathways need to be well understood
- Generally subsurface plume behavior is a function of the contaminant, geology and groundwater elevation gradient, and to a lesser extent other contaminant transport processes.
- Developing a CSM and considering these aspects are key when assessing a contaminated site

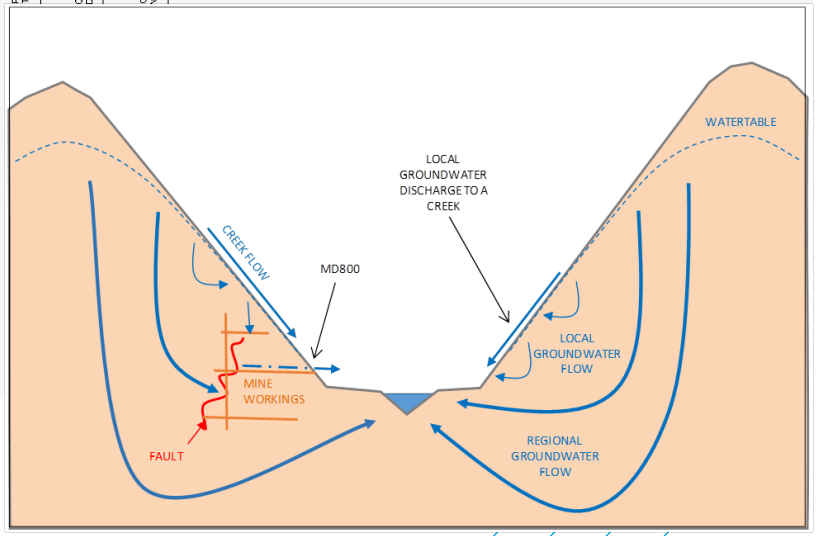


Example of a Conceptual Site Models









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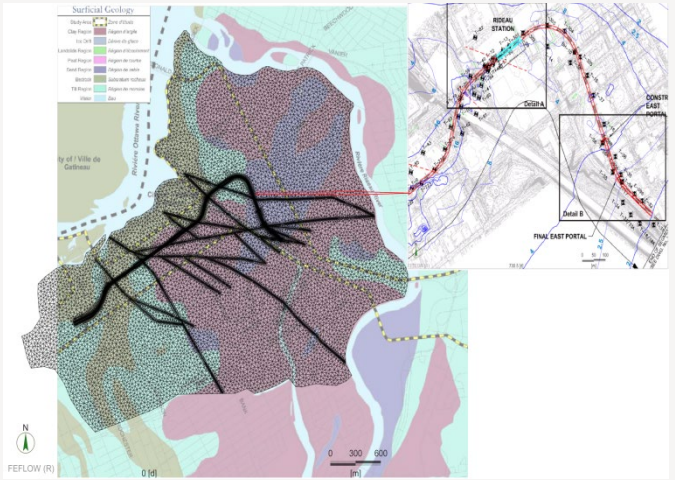
Predicting Future Concentrations

- Fate and transport modelling to estimate migration and loading to potential receptors
  - Analytical calculations to complex 3-dimensional numerical modelling
  - Useful for the comparative evaluation of mitigation measures (i.e. relief wells, pumpback wells, excavation, barrier wall, passive reactive barriers, drain systems, cover systems, etc.)
  - Useful for the timing and budgeting for design and implementation of mitigative measures
  - Useful for establishing trigger levels
  - Never reality no matter how simple or complex
  - Adapative management uses the assessment of monitoring data, not modelling results, for management of risk and mitigation measures at a site



	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	370	380	390	400
200	3.7	3.8	3.9	4.1	4.2	4.3	4.5	4.6	4.8	4.9	5.1	5.2	5.3	5.5	5.6	5.7	5.7	5.8	5.8	5.9	5.9	5.9	5.8	5.8	5.7	5.6	5.6	5.5	5.3	5.2	5.1	4.9	4.8	4.6	4.5	4.3	4.2	4.0	3.9	3.8	3.6
180	3.8	3.9	4.1	4.2	4.4	4.6	4.7	4.9	5.1	5.3	5.4	5.6	5.8	5.9	6.1	6.2	6.3	6.3	6.4	6.4	6.4	6.4	6.4	6.3	6.3	6.2	6.1	5.9	5.8	5.6	5.4	5.3	5.1	4.9	4.7	4.6	4.4	4.2	4.1	3.9	3.8
160	3.9	4.1	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.9	6.1	6.3	6.5	6.7	6.8	6.9	7.0	7.1	7.1	7.1	7.1	7.1	7.0	6.9	6.8	6.7	6.5	6.3	6.1	5.8	5.6	5.4	5.2	5.0	4.8	4.6	4.4	4.2	4.1	3.9
140	4.0	4.2	4.3	4.5	4.7	4.9	5.2	5.4	5.7	6.0	6.3	6.6	6.9	7.2	7.4	7.6	7.7	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.7	7.6	7.4	7.2	6.9	6.6	6.3	6.0	5.7	5.4	5.2	4.9	4.7	4.5	4.3	4.2	4.0
120	4.1	4.2	4.4	4.6	4.8	5.1	5.3	5.6	5.9	6.2	6.6	7.1	7.5	8.1	8.4	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.4	8.0	7.5	7.0	6.6	6.2	5.9	5.6	5.3	5.1	4.8	4.6	4.4	4.2	4.0
100	4.1	4.3	4.4	4.6	4.9	5.1	5.4	5.7	6.0	6.4	6.8	7.3	8.0	8.9	9.8	9.3	9.2	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.2	9.3	9.8	8.9	8.0	7.3	6.8	6.3	6.0	5.7	5.4	5.1	4.9	4.6	4.4	4.2	4.1
80	4.1	4.2	4.4	4.6	4.8	5.1	5.3	5.6	5.9	6.2	6.6	7.1	7.6	8.1	8.5	8.6	8.6	8.6	8.6	8.7	8.7	8.7	8.6	8.6	8.6	8.6	8.5	8.1	7.6	7.1	6.6	6.2	5.9	5.6	5.3	5.1	4.8	4.6	4.4	4.2	4.0
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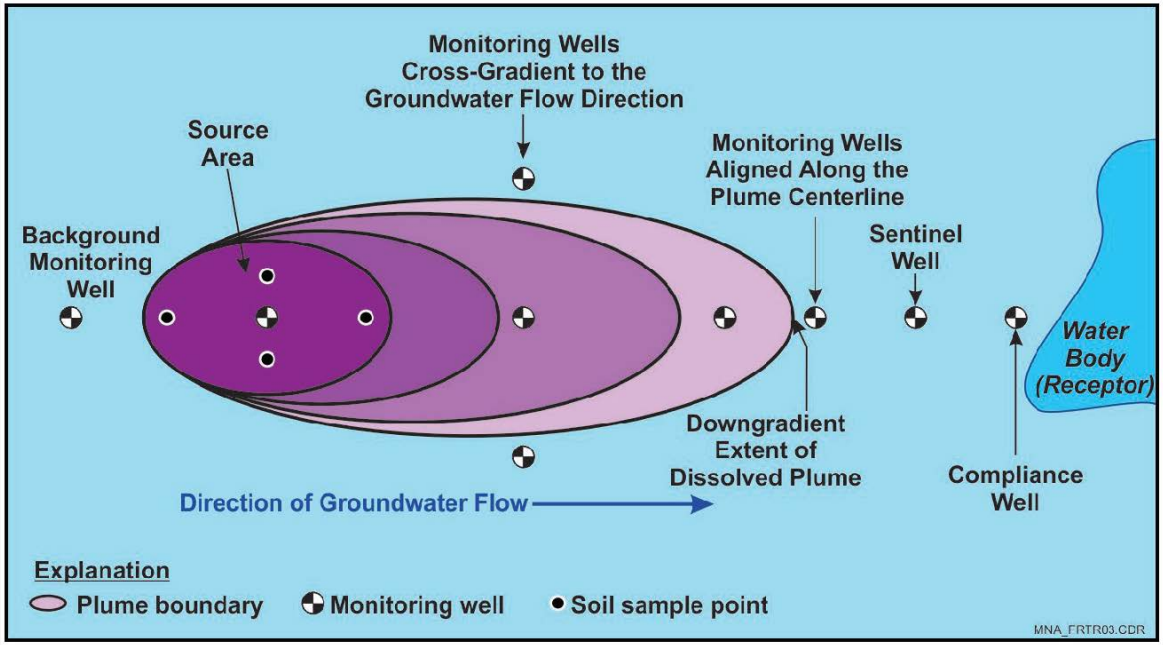
0	3.7	3.8	3.9	4.1	4.2	4.3	4.5	4.6	4.8	4.9	5.1	5.2	5.3	5.5	5.6	5.7	5.7	5.8	5.8	5.9	5.9	5.9	5.8	5.8	5.7	5.7	5.6	5.5	5.3	5.2	5.1	4.9	4.8	4.6	4.5	4.3	4.2	4.1	3.9	3.8	3.7

Components of Adaptive Management Plan

- Identify triggers and response actions
- Contingency plans
- Timelines, milestones, reporting schedules
- Communication plan



https://frtr.gov/

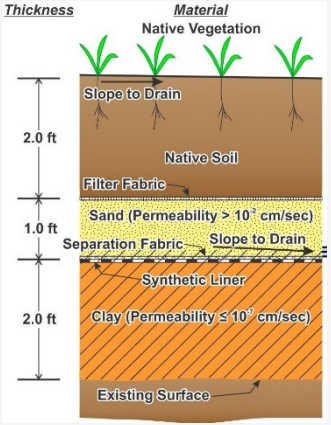
Example of Trigger and Response Action

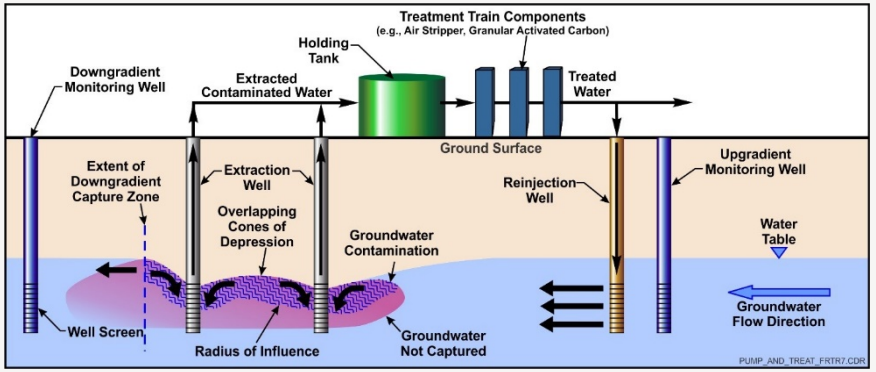
Trigger	Response Action
Increasing trends of SOPCs, above benchmark standards	• Verification of result • Increased monitoring frequency • If off-site risk confirmed, stakeholder notification • Implementation of mitigation options and/or management in place

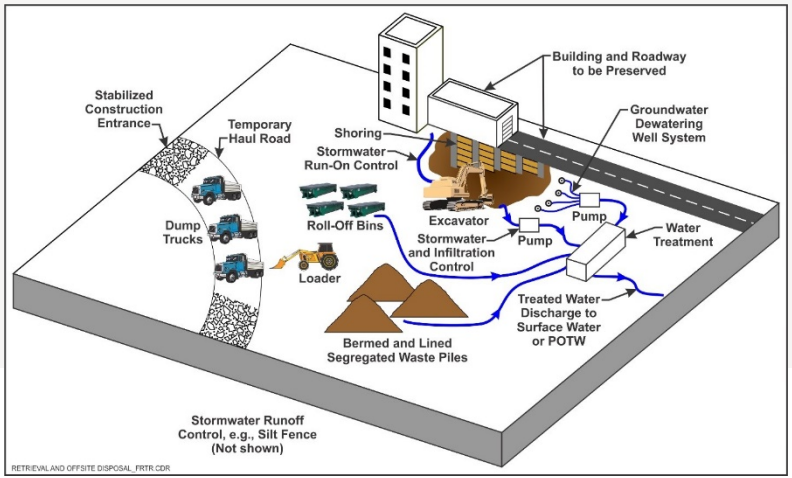
Images from : https://frtr.gov/

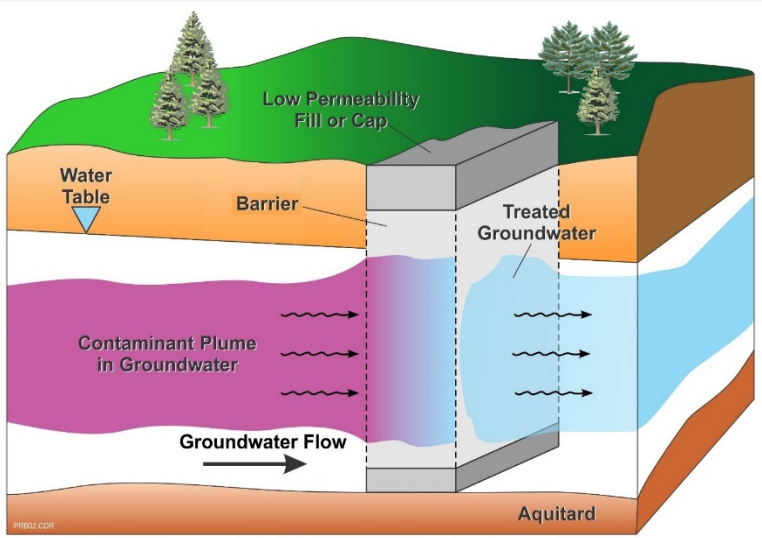
Mitigation Options

- Soil cover
- Pump and treat
- Excavation
- Barrier – PRB, slurry wall, etc.
- Natural attenuation
- Etc.









Contingency Plans

- Must address how the proponent intends to assess and manage area, in the event that the RMP does not meet intended goals (or fails)
- Addresses more serious consequences, such as immediate risk of exposure to receptors
- Outlines what measures will be taken and who will be contacted
- Require approval from the Ministry of Environment, as well as immediate notification if contingency plan must be initiated

Adaptive Management Plan - Summary

- Systematic approach that centers on planning
- Identify priorities by continuous/regular evaluation of environment management outcome
- Improve resource management by managing priority, account new information and site condition changes
- Clearly documented plan with regulatory buy in

Reduce Risk/Uncertainties While Supporting Site Operation

Acknowledgements / Questions

Our values are the essence of our company's identity. They represent how we act, speak and behave together, and how we engage with our clients and stakeholders.

SAFETY

We put safety at the heart of everything we do, to safeguard people, assets and the environment.

INTEGRITY

We do the right thing, no matter what, and are accountable for our actions.

COLLABORATION

We work together and embrace each other's unique contribution to deliver amazing results for all.

INNOVATION

We redefine engineering by thinking boldly, proudly and differently.

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