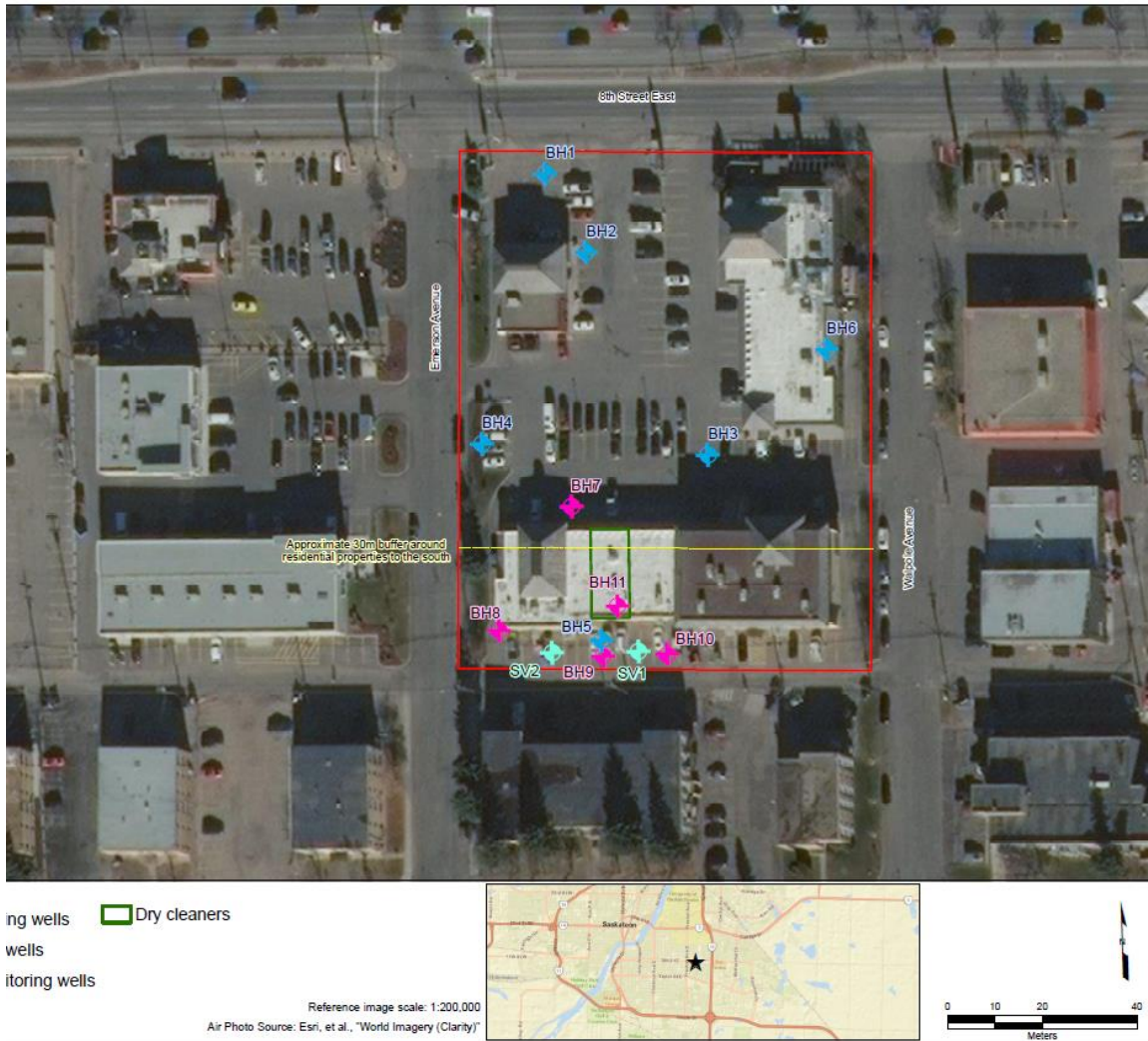




Integrated Remediation and Vapor Intrusion Risk Management for Legacy Dry-Cleaning Impacts in an Urban Mixed-Use Setting

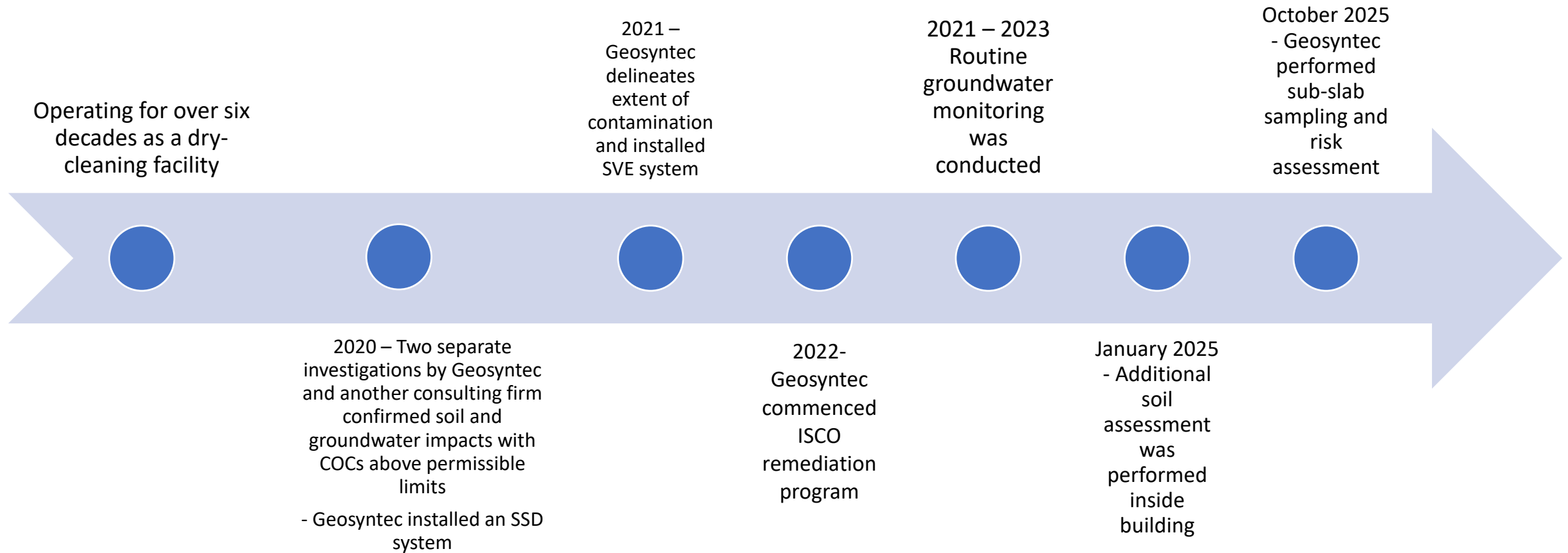
Emmanuel Olisa, Ashkan Arefi, Jennifer Pretorius, Ainsley Inglis, Trevor Carlson, Andrea Wojtyniak

Site Location

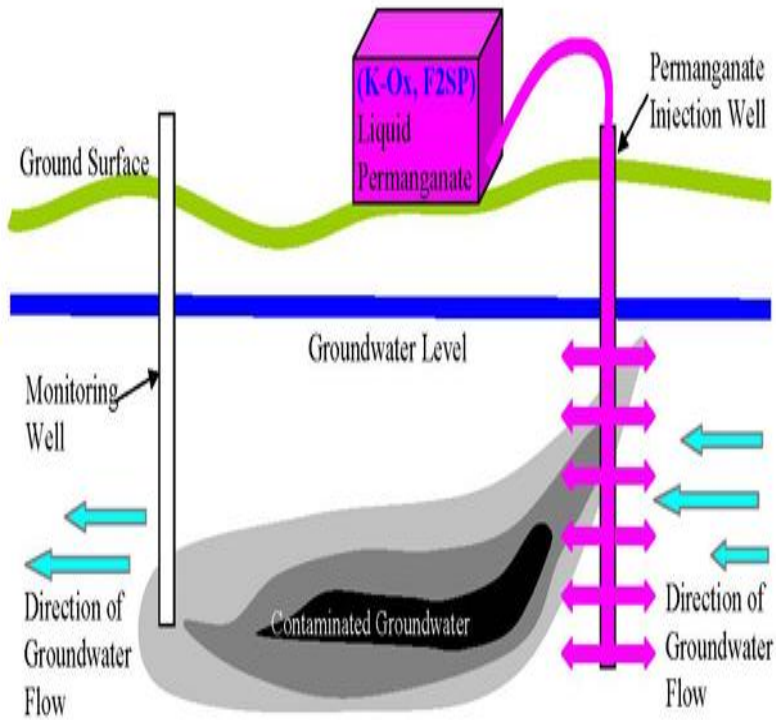


- Located in Saskatoon, Saskatchewan
- Active dry-cleaning facility
- Mixed use urban setting
 - Commercial
 - Residential
 - Industrial
- Site COCs Include:
 - Dry cleaning solvents – PCE & TCE
 - Degradation products

Site Background and History



Remedial Investigation Activities



An Illustration of a Simple Permanganate Remediation System



Installation completed with connection of the KMnO_4 saturator system to the infiltration well

Exceptional Solutions Without Exception

Remedial Investigation – ISCO Using Potassium Permanganate

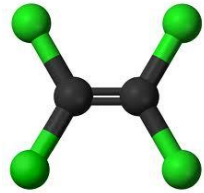
Solubility (5.0 g/100 mL) at 20°C



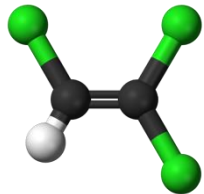
Potassium
Permanganate
Powder Grade



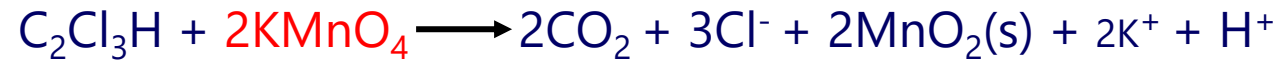
The treatment involves continuous injection of $KMnO_4$ to oxidize chlorinated solvents in soil or groundwater, converting them into harmless substances like CO_2 , water, and chloride ions



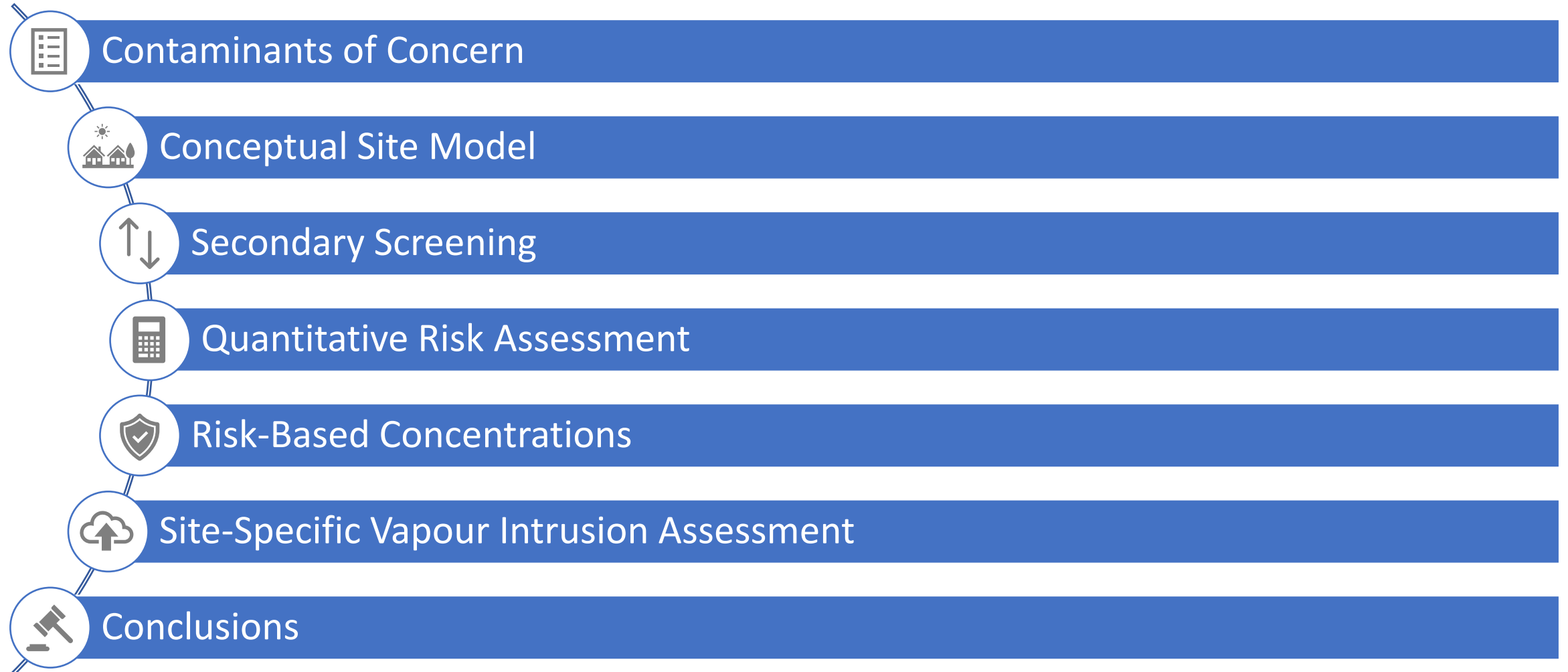
PCE Oxidation:



TCE Oxidation:



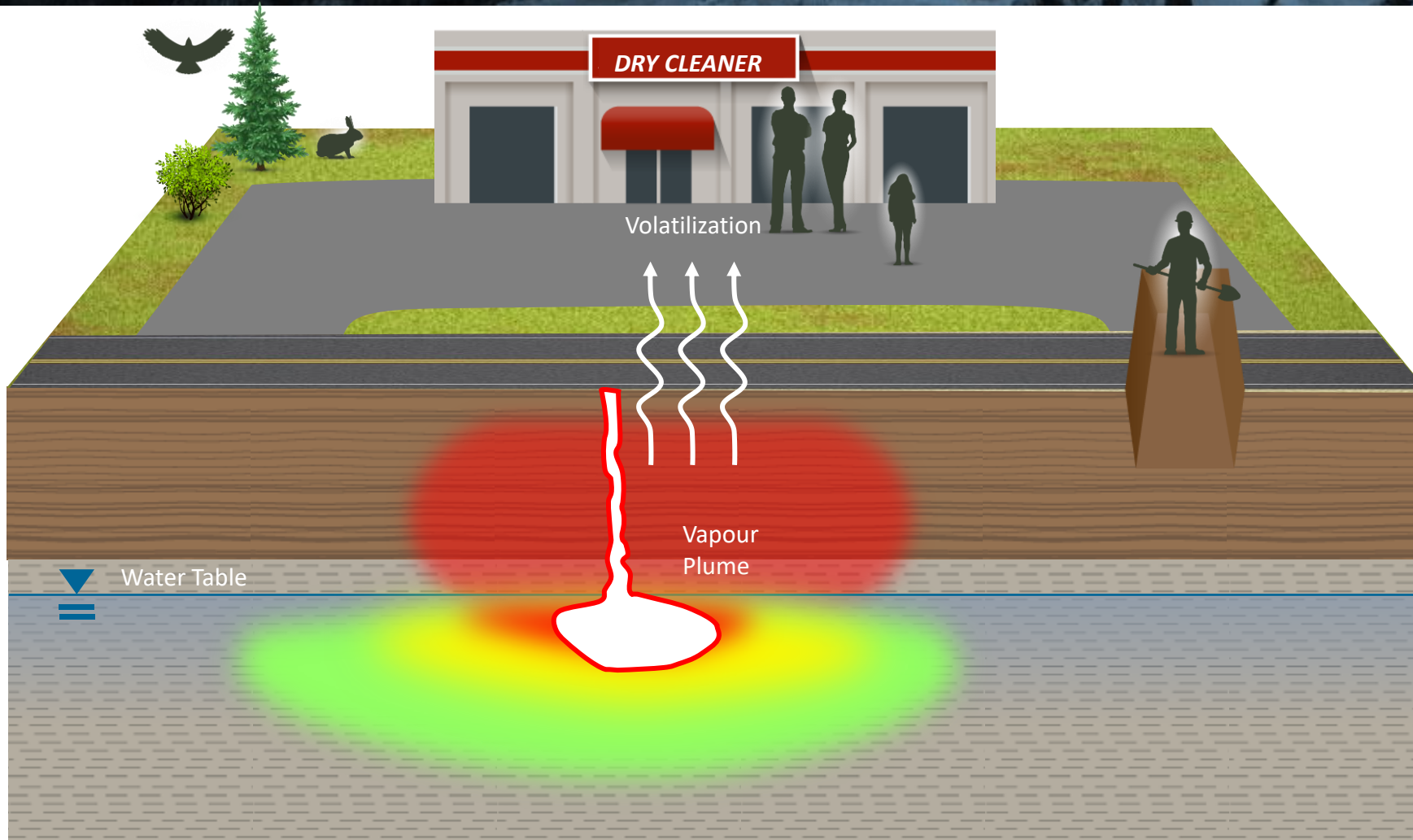
Site-Specific Risk Assessment (SSRA)



Contaminant of Concern (COC) Selection

- Dataset
 - Soil data collected between 2020-2025
 - Groundwater data collected between 2023-2025
- Maximum detected concentrations in soil and groundwater compared to **Saskatchewan Tier 1 Environmental Quality Guidelines (Commercial land use, fine soil type)**
- Soil COCs:
 - tetrachloroethene and trichloroethene
- Groundwater COCs:
 - cis-1,2-dichloroethene, trans-1,2-dichloroethene, tetrachloroethene, trichloroethene, and vinyl chloride

Conceptual Site Model



• Receptors

- Indoor worker
- Outdoor worker
- Construction worker
- Property visitor
- Terrestrial ecological receptors (plants, soil organisms, mammals & birds)

• Pathways

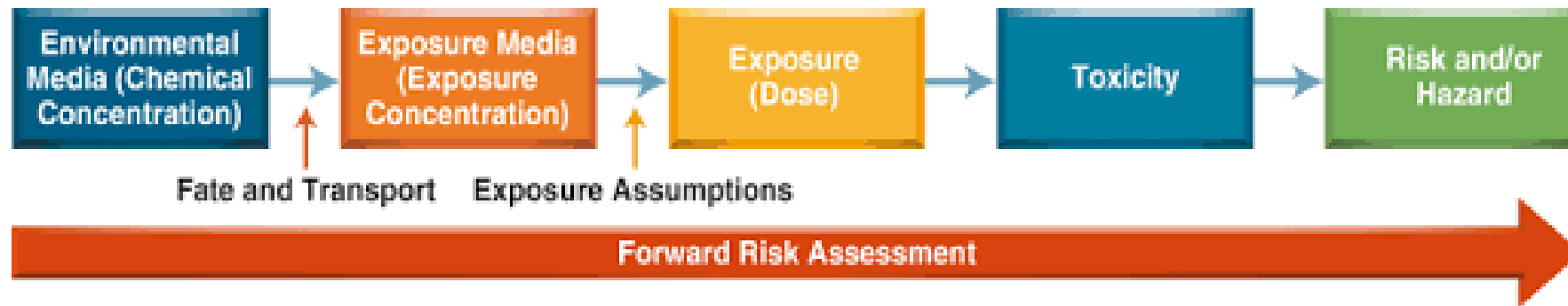
- Direct contact (soil & groundwater)
- Inhalation (indoor, outdoor, and trench air)

Secondary Screening

Secondary Screening Values – Soil Exposure Pathways	Results of Secondary Screening - Soil
Direct Soil Contact (Human)	No exceedances, no further evaluation
Vapour Inhalation	PCE & TCE
Direct Soil Contact (Ecological)	No exceedances, no further evaluation

Secondary Screening Values - Groundwater Exposure Pathways	Results of Secondary Screening - Groundwater
Direct Contact (Human)	cDCE, PCE, & TCE
Vapour Inhalation	cDCE, tDCE, PCE & TCE
Direct Groundwater Contact (Ecological)	Incomplete (depth to groundwater >3 mbgs)

Quantitative Risk Assessment



- The risk assessment starts from the measured concentrations of the COCs in environmental media (exposure concentration), defines exposure assumptions, calculates dose, identifies toxicity values, and estimates a cancer risk or noncancer hazard
- Risk assessment completed in accordance with federal RA guidance documents

Quantitative Risk Assessment

Pathway	Risk Assessment Results
Indoor air inhalation (soil and groundwater)	<ul style="list-style-type: none">• Potential for unacceptable risk from TCE (soil and groundwater) and PCE (groundwater)• Further evaluation required
Outdoor air inhalation (soil and groundwater)	<ul style="list-style-type: none">• No unacceptable risk
Trench air inhalation (soil and groundwater)	<ul style="list-style-type: none">• Potential for unacceptable risk from TCE (soil and groundwater)• Risk management required (health and safety plan)
Direct contact (groundwater)	<ul style="list-style-type: none">• Potential for unacceptable risk from TCE (groundwater)• Risk management required (health and safety plan)

Risk-Based Concentrations

- Risk-based concentrations developed based on the same site-specific exposure assumptions applied in the quantitative risk assessment
- Depending on site conditions, can be higher than the generic Tier 2 values
- Benefits:
 - Define areas requiring risk management measures
 - Define areas requiring remediation

Vapour Intrusion Investigation

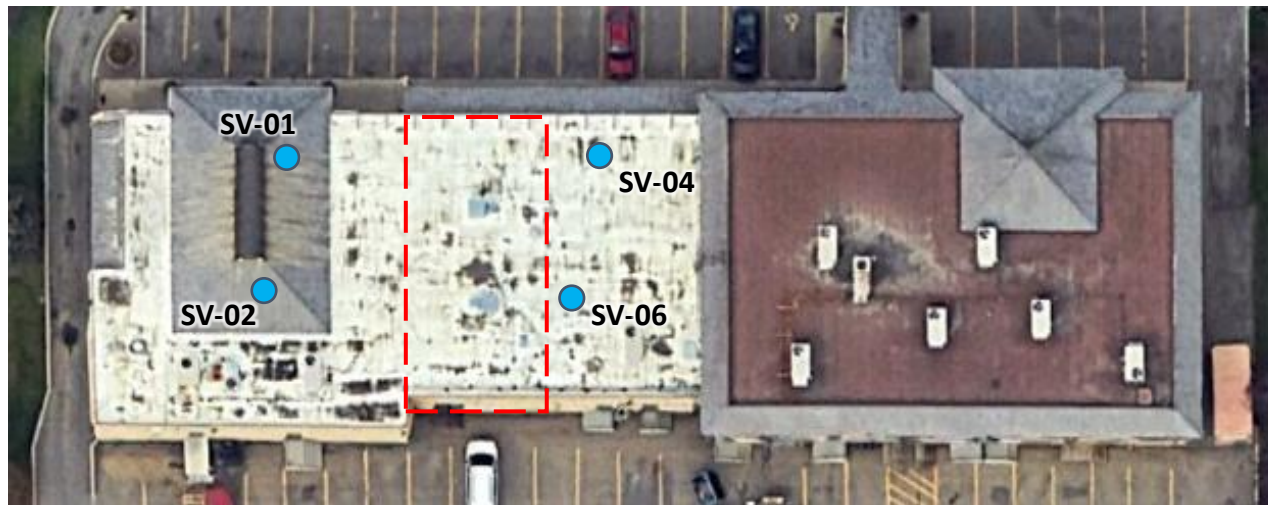
Objectives

- Confirm current subslab vapour conditions following:
 - SSDS installation (2020)
 - Pilot-scale ISCO remediation (2022)
- Update site-specific attenuation factors using additional pneumatic data
- Reassess vapour intrusion risk for adjacent commercial units
- Support the Site-Specific Risk Assessment (SSRA)

Passive Subslab Vapour Sampling

Scope:

- Subslab vapour sampling in units adjacent to dry-cleaner adjacent to previously sampled locations
- Waterloo Membrane Samplers® (WMS-VP) used for passive sampling – deployed for ~ 1 week



Legend:



Approximate Location of Subslab Soil Vapour Probe



Approximate Location of Current Dry Cleaner Unit

Passive Subslab Vapour Sampling

Waterloo Membrane Samplers for Subslab Vapour (WMS™-VP):

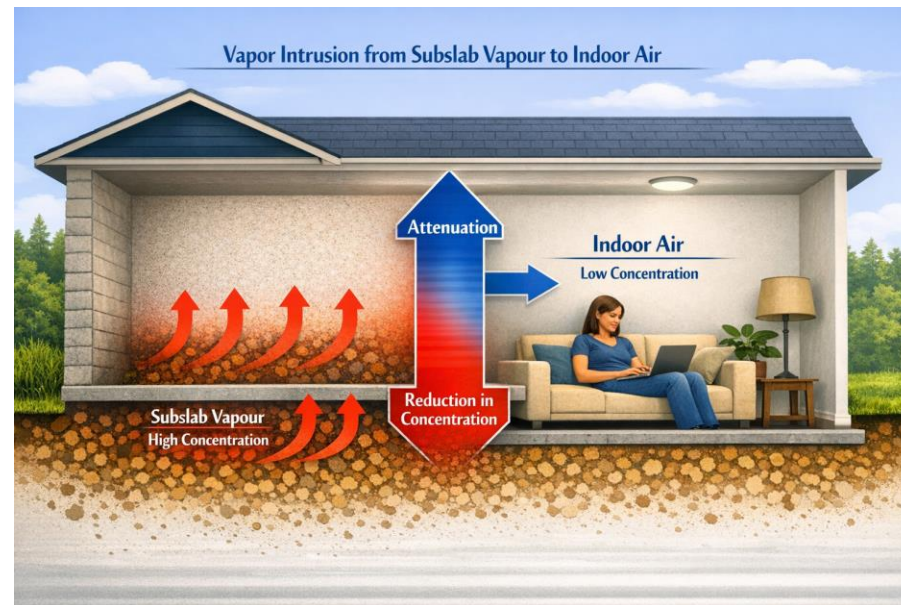
- Time-weighted average concentrations minimizes temporal variability
- Allows active & passive sampling from same probe
- User Friendly Deployment
- Discrete Design
- Low Shipping Cost



For more information on WMS™ visit  **SiREM**:
<https://www.siremlab.com/waterloo-membrane-sampler/>

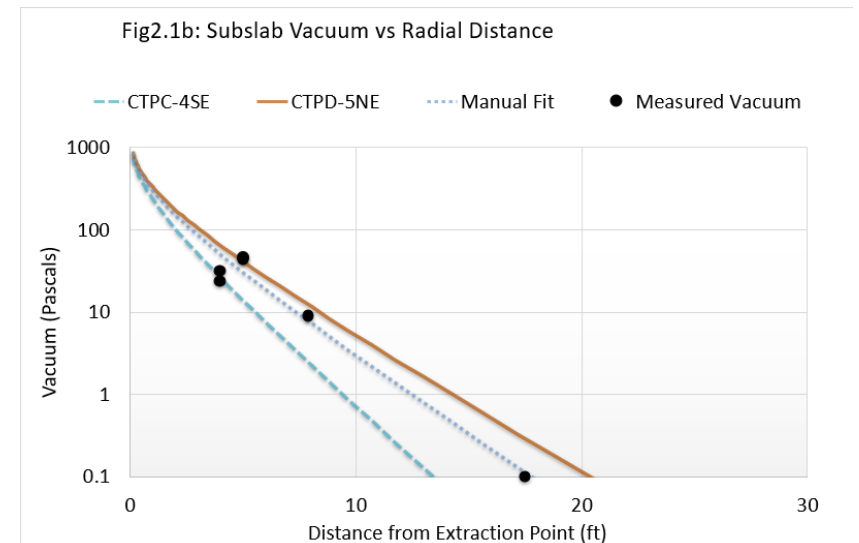
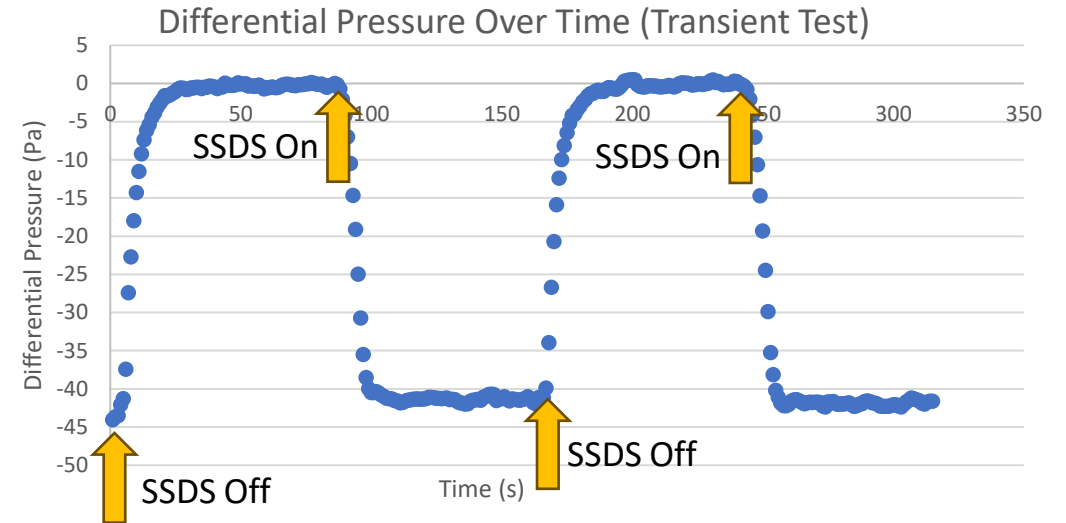
Soil Vapour Attenuation Factor

- Reduction in soil vapour concentration as it moves into the building
- Ratio of concentration in indoor air to soil vapour
- Varies with specific building conditions and generic attenuation factors can be conservative



Attenuation Factor Estimation

- Site-specific modelling using field data:
 - Subslab differential pressures
 - Transient differential pressure response testing at subslab probe
 - SSDS flow
- Modelling tools – used to estimate building transmissivity (T) and leakance (B):
 - AQTESOLV
 - Geosyntec Vapor Intrusion Mitigation (VIM) Model



Attenuation Factor Estimation

- **Attenuation Factor (AF) Inputs:**

- Building-specific air exchange rates (AER)
- Estimated transmissivity (T) and leakance (B) using from modelling using:
 - Subslab material properties and thickness
 - Measured SSDS flow and differential pressure data
- Building height (h)
- Cross-slab pressure (ΔP) assumptions informed by literature and field data

$$AF = \frac{T \Delta P}{B^2 h AER}$$

Vapour Intrusion Risk Results and Conclusions

- Subslab vapour concentrations decreased since SSDS installation
- Estimated indoor air concentrations (using subslab vapour data and estimated attenuation factor) below acceptable Health Canada indoor air criteria
- Existing SSDS continues to mitigate vapour intrusion risk – continued operation necessary
- Residual subslab vapours not expected to result in unacceptable indoor air impacts

Conclusions

Pathway	Risk Assessment Results
Indoor air inhalation (soil and groundwater)	<ul style="list-style-type: none">No risks provided that the SSDS remains operational on a continuous basis
Outdoor air inhalation (soil and groundwater)	<ul style="list-style-type: none">No unacceptable risk
Trench air inhalation (soil and groundwater)	<ul style="list-style-type: none">Risk management (limited area)
Direct contact (groundwater)	<ul style="list-style-type: none">Risk management (limited area and excavation depth)
Direct Contact (soil and groundwater) – Terrestrial Ecological Receptors	<ul style="list-style-type: none">No unacceptable risk
Off-Site Migration of Groundwater to Surface Water – Aquatic Ecological Receptors	<ul style="list-style-type: none">No unacceptable risk



Geosyntec 
consultants

Questions?