Remediation in Support of Net-Zero Growth: Executing a Brownfield Expansion



RemTech 2026 (Banff, AB) – October 16, 2026

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OUTLINE

REMEDIATION IN SUPPORT OF NET-ZERO GROWTH: EXECUTING A BROWNFIELD EXPANSION

1. Background

- About Dow & Site
- Site Remediation History
- Site Expansion Project



2. Remediation Support Prior to Development



3. Source Removal Projects at Former EDC/VCM Plant

a) Thermal Hydrolysis

b) Enhanced Bioremediation





4. Closing

- Challenges
- Conclusions
- Q&A



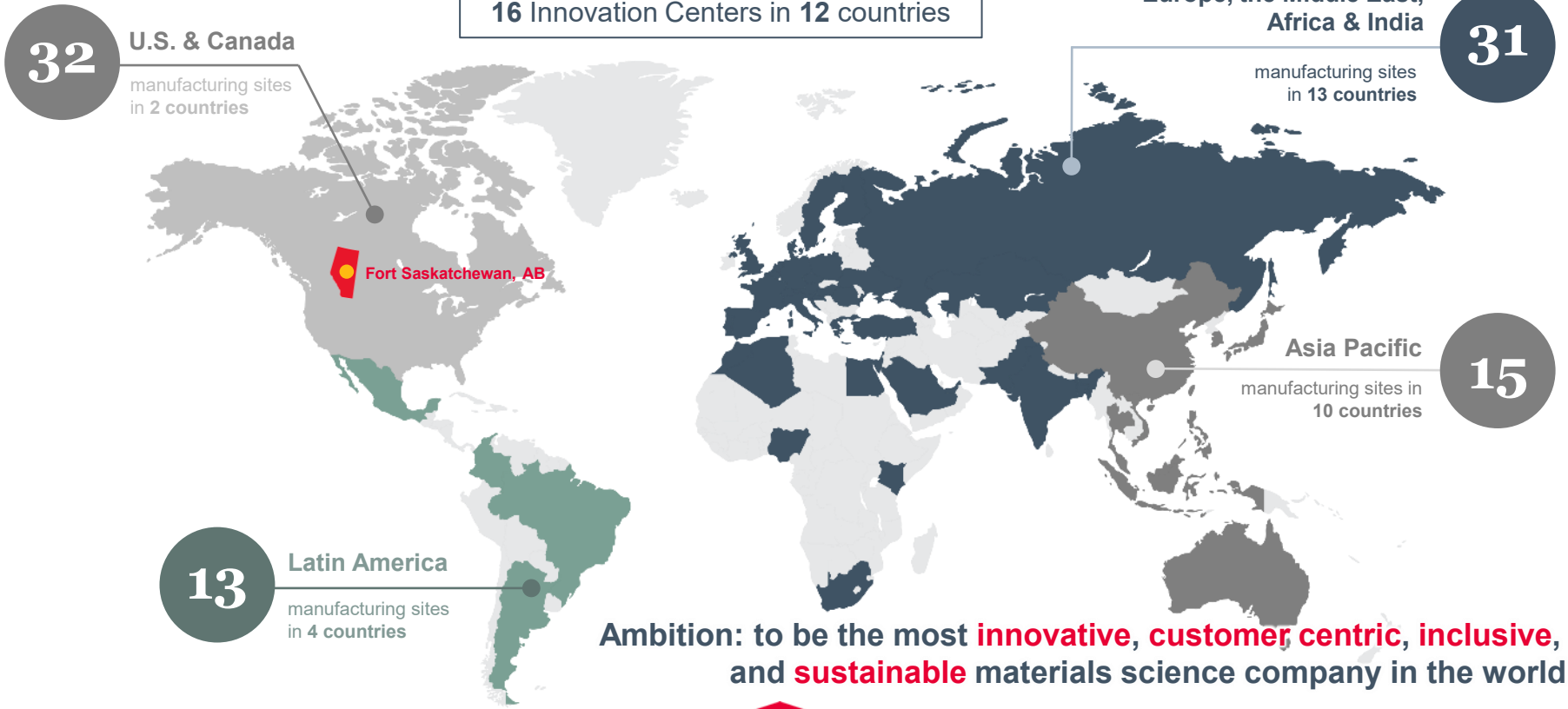
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- Site Remediation History
- Site Expansion Project



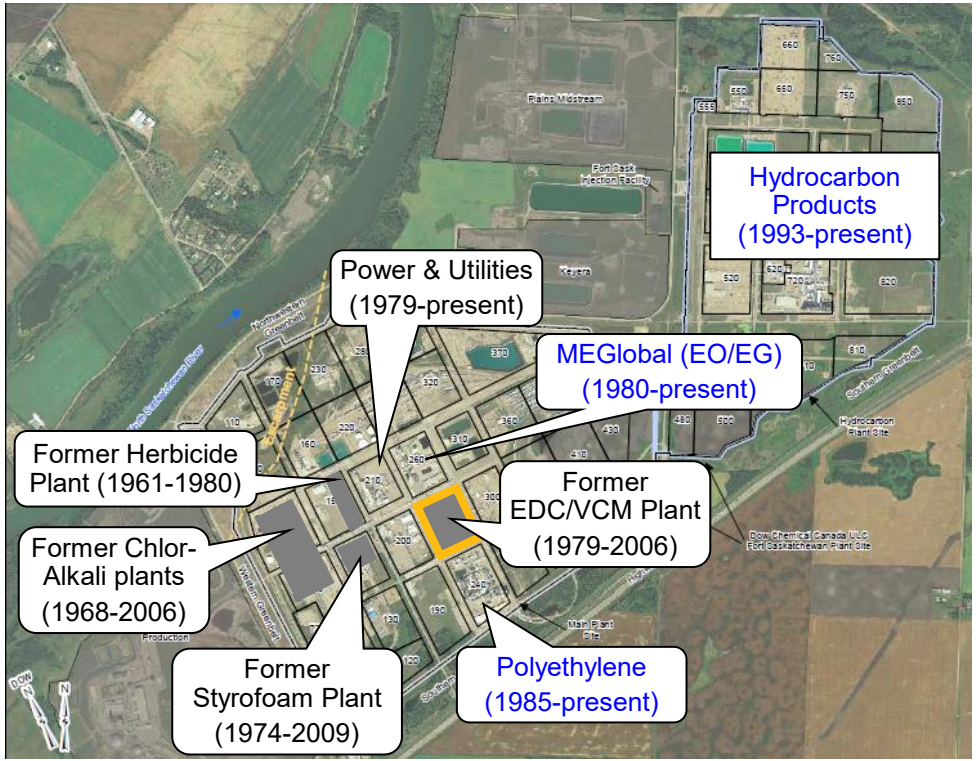
About Dow: Global Scale, Local Reach and Collaborative Innovation

91 manufacturing sites in **29** countries
16 Innovation Centers in **12** countries



Ambition: to be the most innovative, customer centric, inclusive, and sustainable materials science company in the world

About Dow Fort Saskatchewan: Operations & History



- Established in 1961
- Size: ~2200 developed acres
- One of the largest petrochemical facilities in Canada
  - Currently: 3 world-scale plants producing about 7 billion pounds of petrochemical products/year

    + Power & Utilities, Site Logistics, site support functions

Shut down of operations, followed by facility demolition, triggered contaminant delineation and remedial actions

From Active Remediation To Primarily Monitoring, Risk Management

Variety of Remediation Applied Across Site Historically:

Ex-situ Treatment

- Enhanced bioremediation
  - Soil mixing with natural or engineered carbon amendments
- Groundwater extraction and treatment

In-situ Treatment

- Permeable reactive barriers
- Fracture and injection
- Thermal hydrolysis
- Phytoremediation

Containment

- Engineered
  - Caps, sheet pile walls, utility cutoff walls
- Natural
  - Lateral: low K lacustrine silts/clays
  - Vertical: low K glacial till

Other

- Excavation & disposal (when appropriate)
- Risk assessments
- Plume stability evaluation

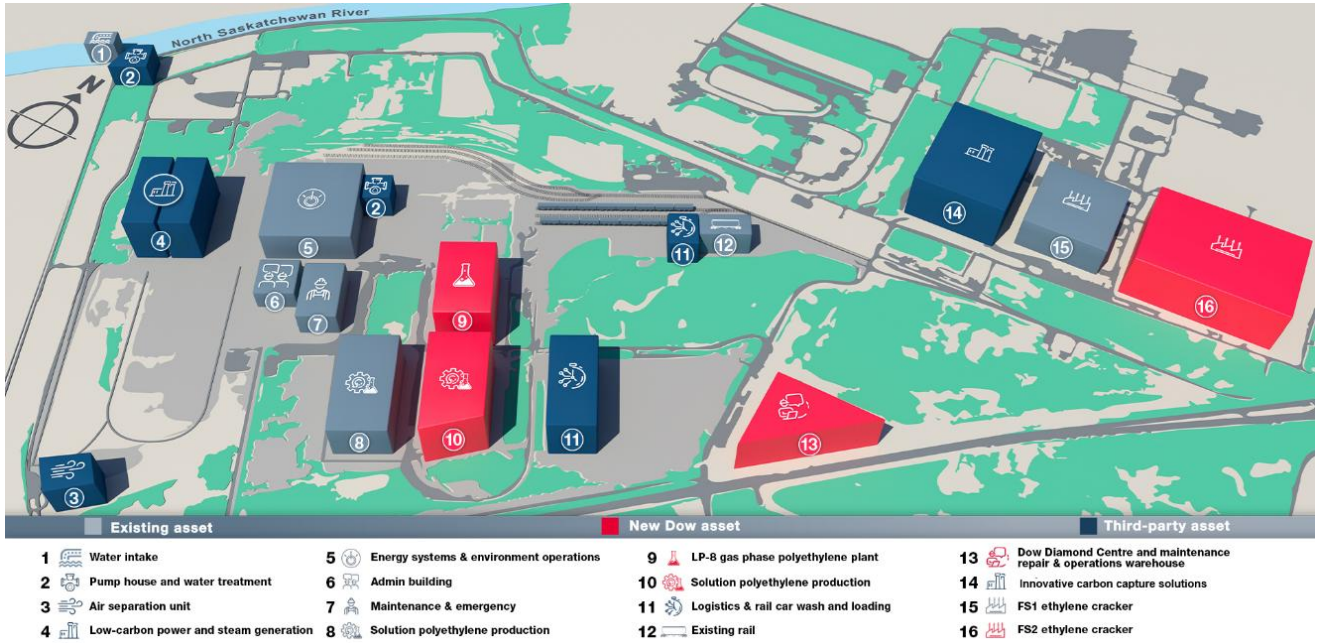
Ongoing: Risk management, exposure control, long-term monitoring, and reporting

Per Authorized Soil & Groundwater Management Plans

FORT SASKATCHEWAN PATH$_2$ZERO PROJECT (PHASED THROUGH 2030)

- World's first net-zero Scope 1 & 2 carbon emissions ethylene cracker and derivatives site

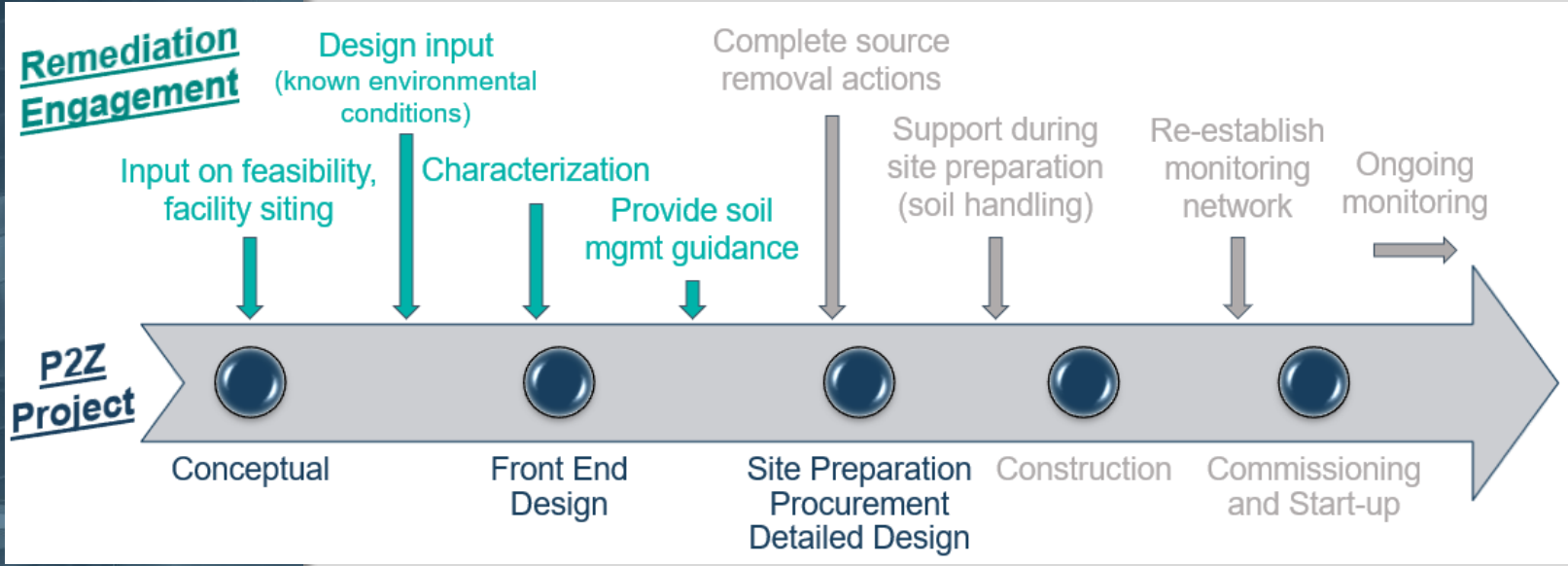
= Brownfield expansion and retrofit of an active manufacturing site



The numbers:

- **$7.5 billion** expansion
- Up to **7000 jobs** at peak construction; up to **500 full-time** permanent jobs
- **~3.2 million MT/year** of certified low- to zero-carbon emissions polyethylene and ethylene derivatives

2. Remediation Support Prior to Development



Early Remediation Engagement in the Path$_2$Zero project

- Siting Advice
  - May prohibit development
- Where redeveloping:
  - New buildings: inform of potential for vapor intrusion
  - Identify and manage conflict with existing remedial systems
  - Assess if additional remedial action is needed. If so:
    a) Risk Management
    b) Treatment or Disposal



Former chemical storage tanks/loading
- ➢ New Rail Wash Facility
- • Provided Vapor Intrusion Assessment

Former caustic storage tank area
- ➢ New Water Treatment Facility
- • AEPA-approved Risk Assessment

Former manufacturing plant
- • Remedial status currently precludes development at this time

Former manufacturing plant
- ➢ New storage tanks (south) + rail laydown, substation, parking
- • Supplemental remedial action where soil will become inaccessible

Former Chlor-Alkali II
- ➢ New 3rd party utility assets
- • Manage conflict with existing remedial system

Brownfield Redevelopment Challenges

- Former underground infrastructure remains in subsurface
- Development in areas of known residual contamination:
  - Exposure management (ex. PPE, air monitoring)
  - Higher development costs (ex. soil disposal, site preparation)
  - Design considerations (ex. material compatibility; piling method)
  - Vapour intrusion evaluation or mitigation
  - Contaminant migration protection (ex. piling depth; utility corridors)
- Active infrastructure within footprint of redevelopment
  - Monitoring wells part of active network will need abandonment then replacement post-construction
  - Strategies to shutdown or replace active remediation systems
- Integration into ongoing operating assets

Greenfield:



- Like new home construction
  - ✓ Fresh start
  - ✓ More straightforward build

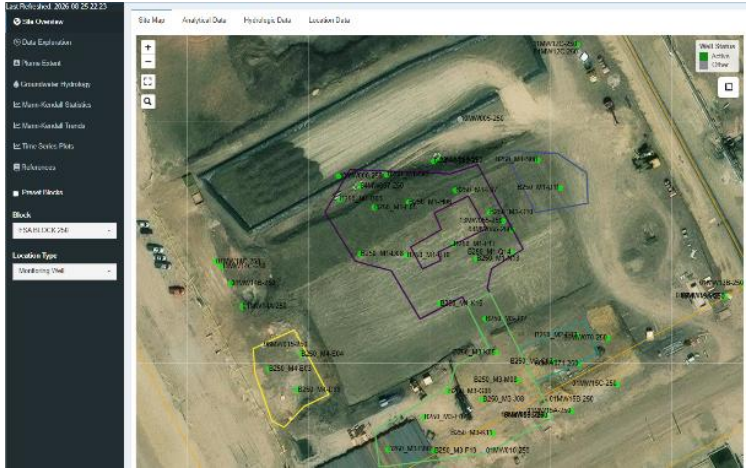
vs. Brownfield:



- Think home-renovation TV (ex. “Love It or List It”)!
  - Similar surprises/challenges, only underground.

Understanding Environmental Condition Needs Knowledge & Data

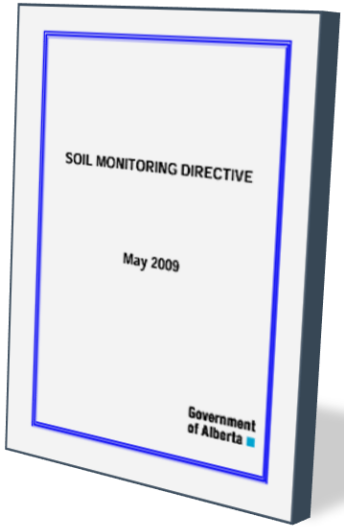
- Importance of understanding environmental condition:
  - Where can facilities be sited?
  - What are the implications to design?
  - How to appropriately manage soil, water, waste?
  - Are workers protected?
- Sources of understanding:
  - Institutional knowledge
    - ✓ Lead Remediation personnel: onsite in Environmental or Remediation capacity since 2004/2008
  - Past Reports: reference for historical detail
  - Alluvial Database: historical and most recent data at finger tips
  - Plus, new data in footprint of redevelopment
    - ✓ Sampling wells slated for abandonment in footprint of development
    - ✓ Assessment of ongoing remediation areas



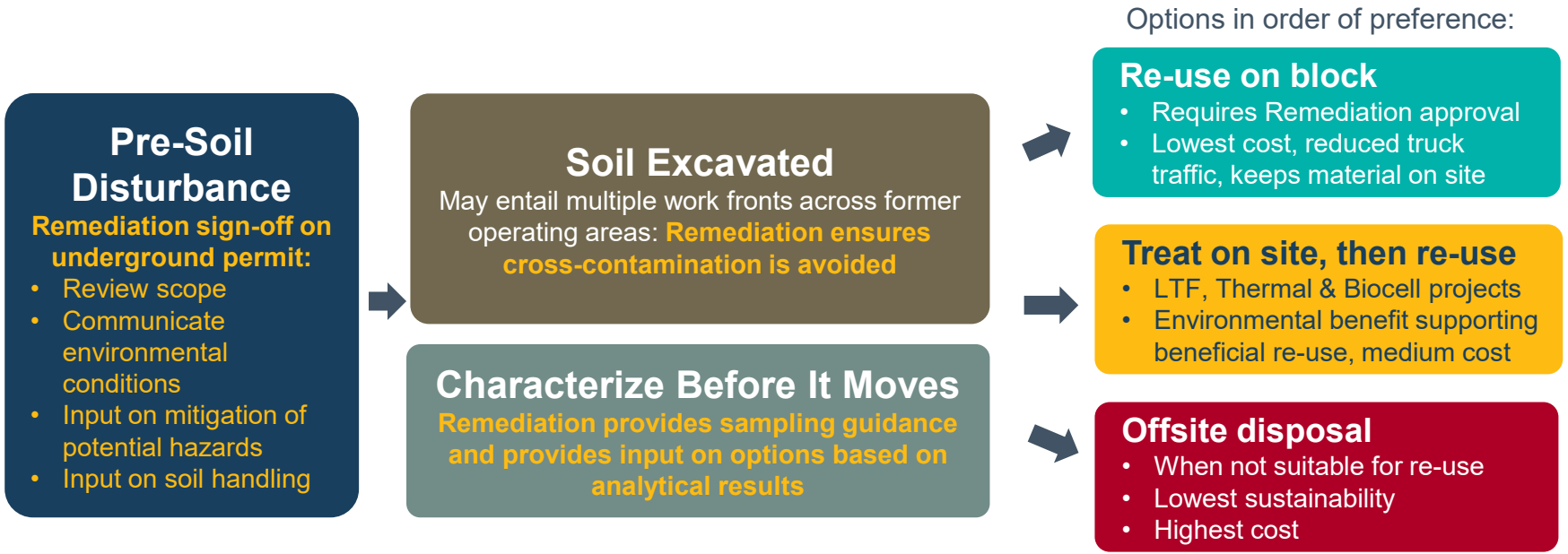
Dashboard with soil, groundwater, and hydrogeological data viewable on maps, in tables, trend charts, etc.

Additional Characterization Conducted in Development Footprint

1. General soil and groundwater characterization
   - Purpose: Input to waste management and/or beneficial reuse of soil
   - Purpose: Characterization of areas not historically sampled
2. Supplemental data in areas of known contamination
   - Purpose: verify remedial progress or higher resolution of data
   - Ex. Geophysics, groundwater sampling, soil borings, and high-resolution screening (MIP, DyeLIF)
   - Data used to identify if (supplemental) remediation required
3. Plus, additional soil characterization per Soil Monitoring Directive
   - Demolition of certain assets may require characterization of soil
   - New assets require baseline sampling but may already be satisfied by existing data



Managing Soil Across a Large Brownfield Site Needs Care

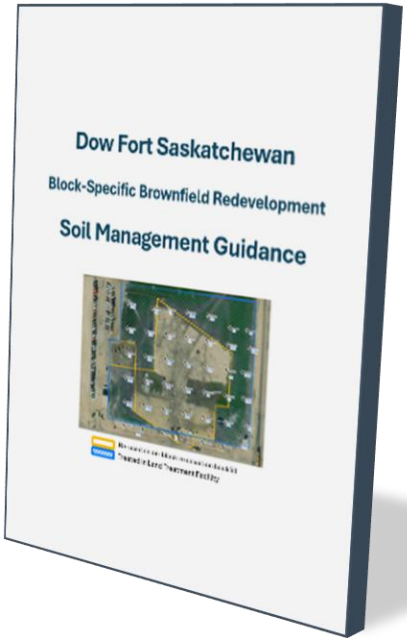


Additional considerations:

- Field visits beneficial to confirm soil management requirements are followed
- Duty to conserve any topsoil removed

Remediation Input Into Administrative Controls

- Developed area-specific soil management guidance:
  - Provides summary of environmental condition of area
  - Advises on soil re-use (per previous slide)
  - Guidance on handling contaminated soil:
    - Stockpiling on impervious liner with run-off and dust control until characterized and disposed
    - Exposure monitoring guidance
    - Appropriate decontamination and good hygiene practices
    - Dust control practices during soil excavation, loading, transport
  - Waste management per regulations

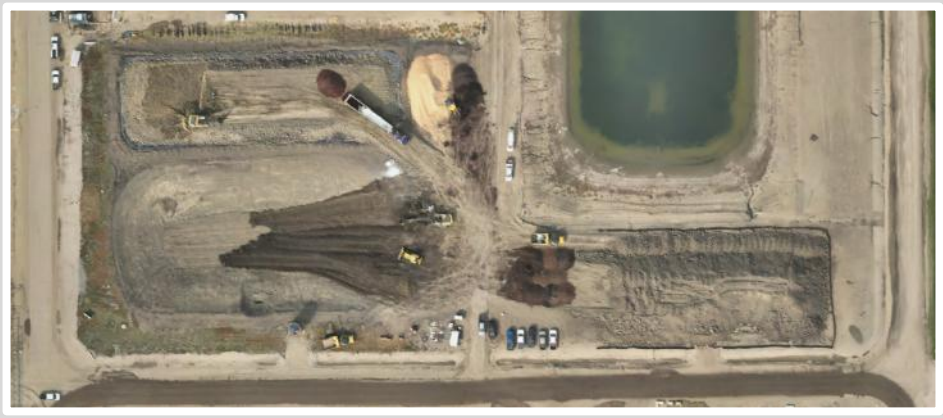


3. Source Removal Projects at Former EDC/VCM Plant

a) Thermal Hydrolysis

b) Enhanced Bioremediation

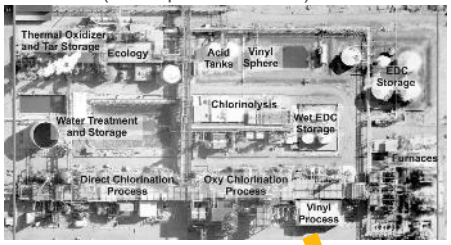




About Former EDC/VCM Manufacturing Block

- 1979 to 2006: Active manufacturing
- 2007/2008: Decommissioned, demolished
- 2008 to 2010: Remedial investigations
  - MIP, soil borings, groundwater wells, etc.
  - COC: primarily 1,2-DCA
- 2010 to 2013: Extensive remediation
  - Soil mixing with engineered ZVI/carbon (Daramend™) for source-level 1,2-DCA
  - Clean, abandon stormwater sewers
  - Installed utility cut-off walls and permeable reactive barriers
- 2014+: Long-term monitoring, exposure control and risk management

Before (aerial pre-demolition)



After (post remedial actions)





Plot plan: remedial actions



Ex-situ Soil Mixing (2012, 2013)

When is Supplemental Remedial Action Warranted?

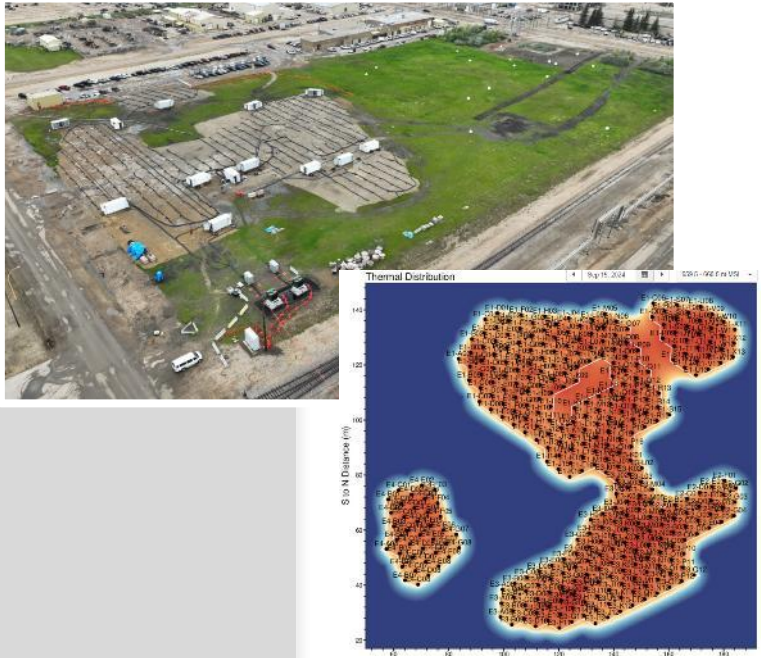
Remedial Action	✓ 2010 – 2013: extensive remediation completed
Containment	✓ Lacustrine silts/clays K: 10^{-8} m/s = lateral containment ✓ Glacial till K (at 10-m depth): 10^{-10} m/s = vertical containment
Natural Attenuation	✓ Expected to continue
Long-term Monitoring	✓ Assesses containment and natural attenuation
Administrative Controls	✓ Remediation sign-off on Excavation Policy
Engineering Controls	✓ VI evaluation required for any new building
Future Contingency	❑ Available where soil still accessible (no infrastructure)

Supplemental action triggered if:

- Potential source-level concentrations
- Development impedes future access

Action must be…

- Fast
- Effective on concentrations present
- Supported by regulator
- Not cost-prohibitive



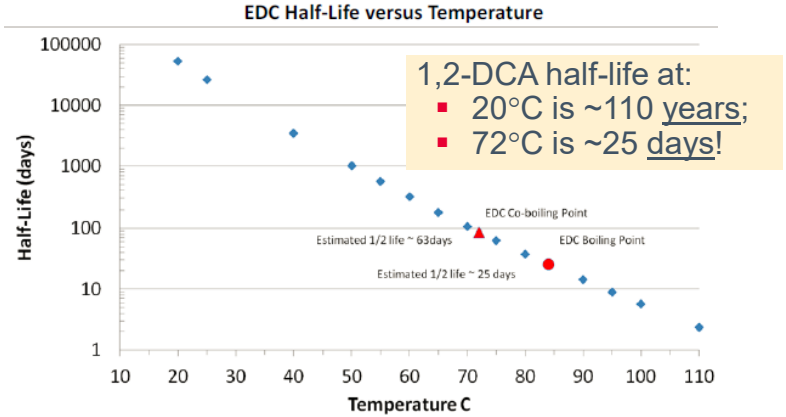
Full-Scale Thermal Hydrolysis

About Thermal Hydrolysis

- 1,2-DCA hydrolyzes to ethylene glycol in an abiotic chemical reaction with water:

$$C_2H_4Cl_2 \text{ (1,2-DCA)} + 2H_2O \rightarrow C_2H_6O_2 \text{ (ethylene glycol)} + 2H^+ + 2Cl^-$$

- Reaction is exponentially faster with increase in temperature



1,2-DCA half-life at:
- 20°C is ~110 years;
- 72°C is ~25 days!

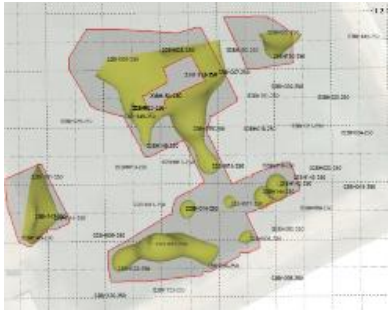
- ☑ **Fast:** <1 yr design/install, <1 yr operation
- ☑ **Effective:** Per 2013 pilot-scale project
- ☑ **Supported by regulator:** Plan approved
- ☑ **Not cost-prohibitive:** Less complex, lower cost than conventional thermal; lower cost than dig and dump

- Thermal hydrolysis involves in situ soil heating to a moderately elevated temperature, but below boiling point at local pressure conditions, to promote this hydrolysis reaction.
- No vapour cap nor soil vapour capture and treatment needed (vs. insitu thermal treatment)

Record Speed Thermal Hydrolysis Remediation Implementation

Schedule: Path2Zero needed the land by Q1 2025

- Nov 2022, June 2023: High resolution screening investigations (MIP, DyeLIF)
  - More surgical → save costs (implementation, operation)

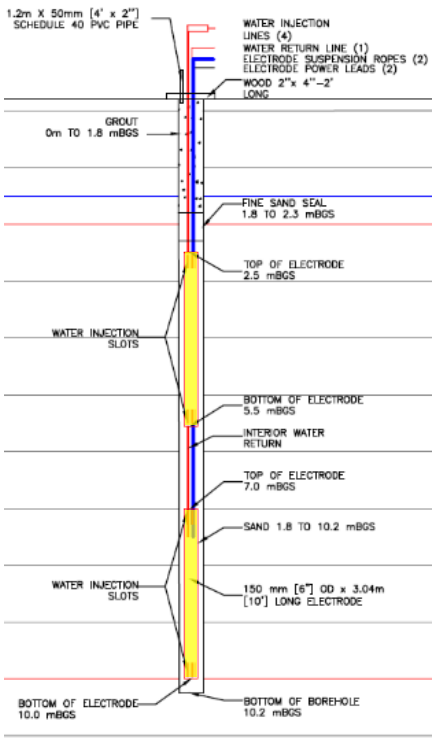


Target Treatment Zone:
- Depth: 2 (or 4) to 10 m
- Area: ~5,688 m^2
- Volume: ~45,512 m^3

~3000 dump trucks worth!

- 1H2023: Engineering Design
  - Pre-design soil buffering capacity bench test
  - Heat soil to below boiling point at local pressure using electrical resistance heating
- May 2023: Regulatory approval (2-week review!)

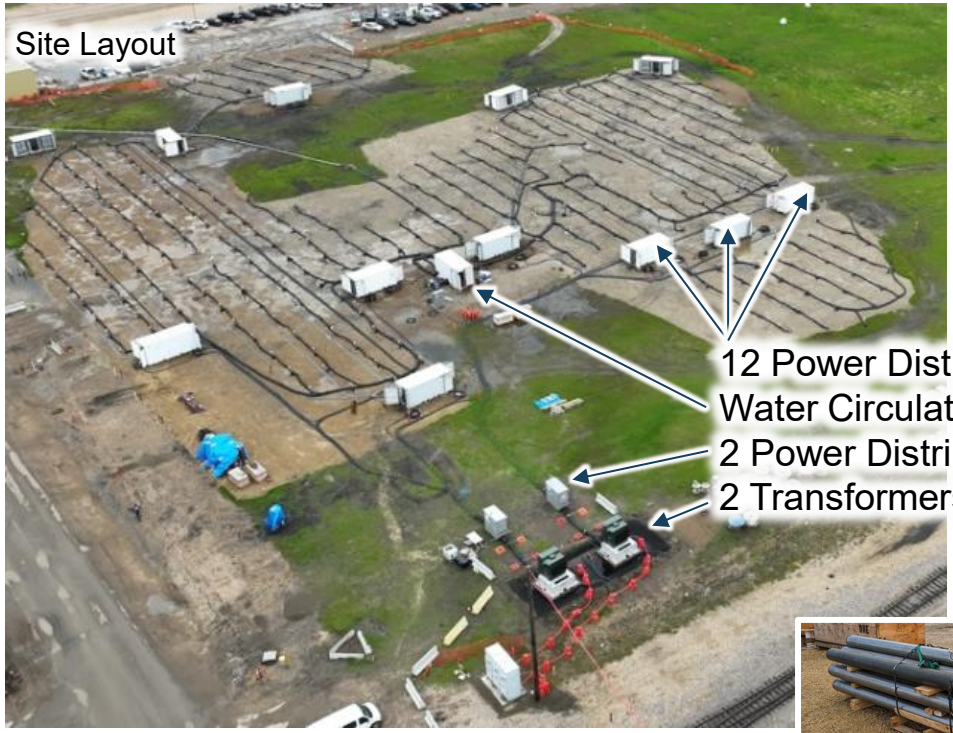
Double-stacked Electrode Well



Environmental consultant: Jacobs
Thermal sub-contractor: McMillan-McGee

Record Speed Thermal Hydrolysis Remediation Implementation

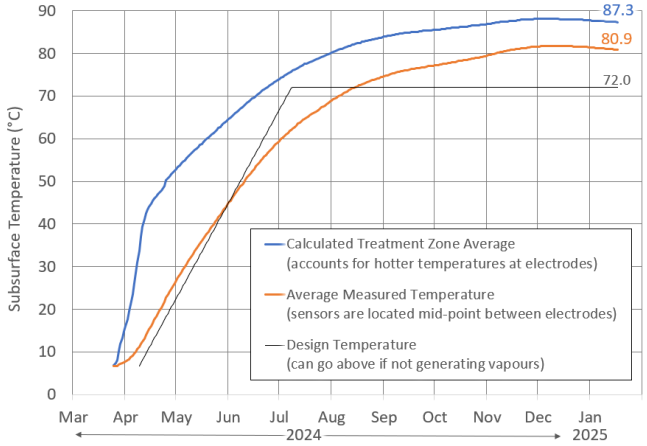
- June – Sept. 2023: subsurface construction (4.5 km of drilling depth!)
  - 350 locations = 700 electrodes
  - Monitoring points
    - ✓ 58 Temperature Sensor Wells
    - ✓ 28 Groundwater Wells
    - ✓ 28 Soil Vapor Monitoring Points
    - ✓ 30 Grounding Rods
- October 2023 – March 2024: system install and commissioning (60 km of cables!)
- April 2024 – January 2025: ~9.5 months of operation
- January – March 2025
  - Decommissioning
  - Confirmation sampling
  - Well abandonments



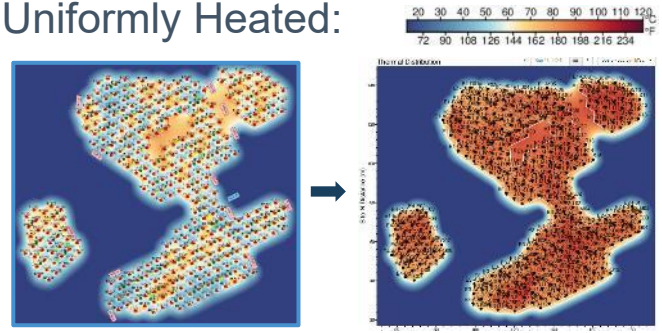


Heating Operation Results & Performance Monitoring Results

1. Target Temperature Achieved



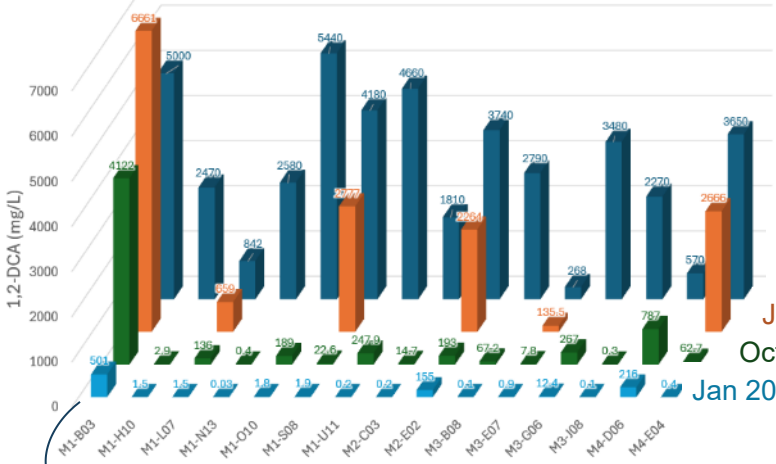
2. Uniformly Heated:



3. Soil Sampling Results: ⬇ 99.45+%

- Pre-remediation estimates for 1,2-DCA mass in soil was **53,000 kg** (>500 mg/kg)
- Post-remediation estimates for 1,2-DCA mass in soil is **290 kg** (> 1 mg/kg)

4. Groundwater Monitoring Results:



Oct 2023 (Baseline)

Jul/Aug 2024

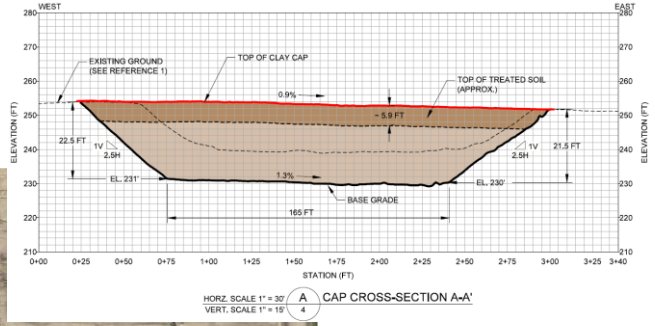
Oct/Nov 2024

Jan 2025

Subsequently further reduced with continued thermal hydrolysis during cool down + enhanced bioremediation

Bioremediation via Ex-situ Soil Mixing (Biocell)

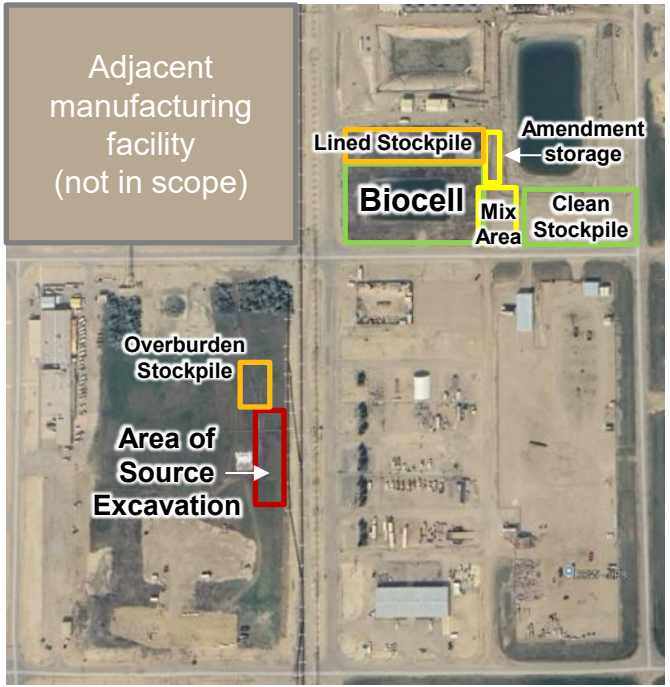




Bioremediation via Ex-situ Soil Mixing

Environmental consultant: WSP

- Objective: Remove and treat soil exceeding 1,2-DCA action level below footprint of future rail spurs
  - Even shorter timeframe available!
- Source Area (crew 1):
  1. Excavate overburden; stockpile for reuse as backfill
  2. Excavate underlying soil exceeding action level
  3. Transfer excavated soil to Treatment Area
  4. Following confirmatory sampling, backfill excavation
- Treatment Area (crew 2):
  1. Enlarge existing depression to capacity needed
  2. Mix soil with amendments to enhance bioremediation
  3. Place treated soil in Biocell and compact in lifts
  4. Cap Biocell (later finished as laydown area by others)
- Included dust and industrial hygiene emissions monitoring



✓ Similar approach to historical treatment of soil

Treatment Scope: Optimal, Site-Specific Amendments for Bioremediation

- Bench-scale testing to get the right mix
  - Nutrients, moisture content, organic material
- Site-specific amendment recipe:
  1. **Hydrated lime** (0.04 to 0.08% by weight) to:
     - ✓ Maintain optimal pH range for biodegradation
     - ✓ Reduce cohesiveness of clay soils; increase soil permeability (i.e. increased soil-amendment contact)
  2. **Organics**:
     - Proposed: Roasted chicken manure (10% by volume) + wood chips and/or straw (15% by volume)
     - ✓ Actual: Due to sourcing challenge, substituted both for **poultry manure-based spent mushroom compost** (25% by volume)
- Mixed with screening bucket
  - Excellent soil/amendment contact





Pile ready for mixing (lime = white powder)



Pile preparation: soil to be treated on right, organics on left, lime yet to be added

Project Implementation Successfully Met Schedule Constraint

- May 2025: Regulatory approval of Remedial Action Plan (2-week review!)



0. July 10, 2025
Pre-project



1. Aug. 5, 2025
Preparations



2. Sept. 2, 2025 Execution

- Untreated soil in lined stockpile
- Amendments stockpiled
- Mixing operation
- Placement of treated soil

2 months to meet schedule of intended land use!



3. Oct. 2, 2025
Project Completion



4. Nov. 4, 2025
Work By Others
(laydown yard)

4. Closing



- Challenges
- Conclusions
- Q&A

How Remediation Overcame The Challenges

The Challenges

- Active industrial site with legacy environmental conditions
- ? Initially, brownfield redevelopment implications not well understood by non-Remediation teams
- Aggressive development milestones
- Multiple concurrent construction and remediation work fronts
- Need for rapid, risk-based decisions

The Enablers

Remediation met challenges thanks to:

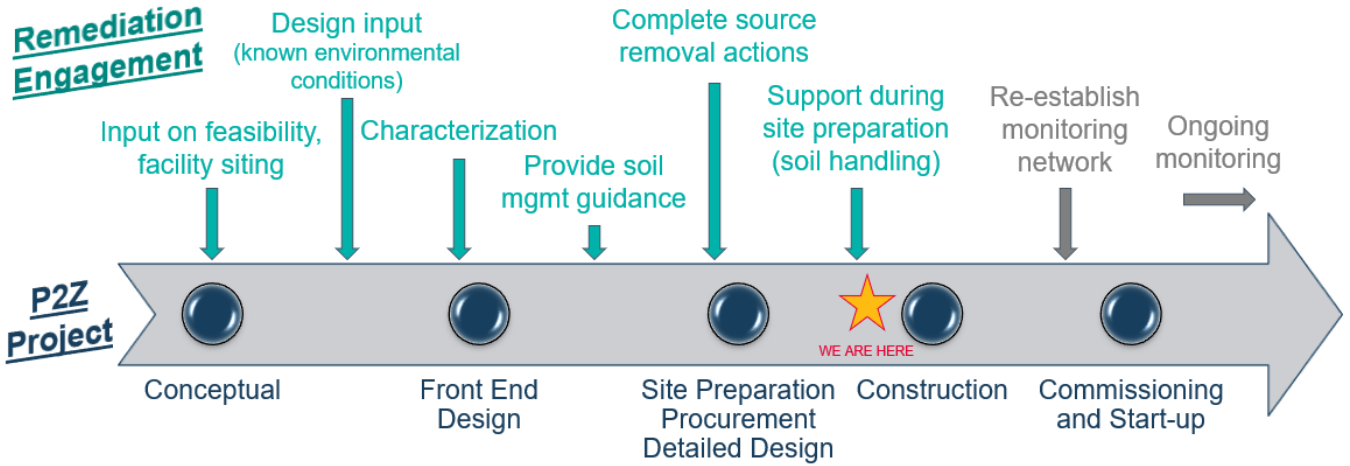
- ✓ Early integration, communication with Remediation and Path2Zero Project
- ✓ Strong existing site knowledge
- ✓ Accessible environmental datasets
- ✓ Prior on-site remedy demonstrations
- ✓ Established consulting partnerships
- ✓ Collaboration with construction teams
- ✓ Regulatory support and alignment



Conclusion: Remediation as a strategic enabler of net-zero growth

- ☑ Brownfield redevelopment can support sustainability and growth objectives
- ☑ Remediation must be integrated into project execution, earlier the better

Remediation in lock step with P2Z Project:



- ☑ Collaborative, risk-based approaches protect schedule & environmental outcomes

Collaborators:

Fort Saskatchewan PATH2ZERO DOW GROWTH & NET-ZERO TRANSFORMATION

Jacobs

WSP

DOW



Seek

Together™