Environmental Simulation and Testing to Inform Hazard Assessment and Risk Mitigation

REMTECH ALBERTA

InnoTech Alberta
Environmental Services
Simone Levy, M.Sc., P.Ag.
Research Scientist

October 14, 2020

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

1

Overview

- InnoTech Alberta – wholly owned subsidiary of Alberta Innovates, applied research focus (RTO)
- Experimental design approach for 'Environmental Simulation and Testing'
  - Fate and transport
  - Complex mixtures
  - Effects to various receptors
- Examples and case studies – Land, Air, Water

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

2

InnoTech Alberta's Suite of Services

Technology Research, Development & Deployment

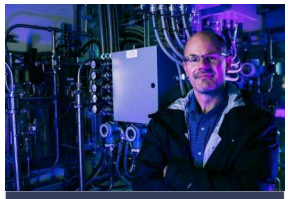
Access to diversified range of scientific, engineering, and technological research expertise and experience

De-Risking & Pilot Demonstration Facilities

Industrial-scale research infrastructure, equipment, and demonstration facilities built to support and de-risk technological initiatives

Analytical, Testing & Monitoring

Dedicated in-house testing and monitoring capacity and expertise with data analytics, sharing, standardization/ informatics, and interoperability services



Innovation & Emerging Technologies

Focus on cross-sectoral emerging technologies including industrial digital life cycle support and sandbox services

Industrial Solutions & Program Execution

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

3

Environmental Services Division

Environmental Impact Risk Evaluation

- Contaminant fate and behavior in the environment – microcosms (anaerobic and aerobic conditions), bench scale columns, above and below ground mesocosms, field investigations
- Water resource investigations and impact assessments using isotopic tracers
- De-risking technologies and processes
- Science based policy recommendations enabled by industry/government facilitated consultation

4

Experimental Design Process

- Characterize the product (where applicable) – physical and chemical
- Co-develop release scenarios with client(s) and collaborators
- Identify 'receiving environment' (i.e., conceptual site model)
  - potential land use
  - human/environmental receptors
  - characteristics (e.g., soil type, vegetation type, water type)
- Determine necessary experimental scale – micro, bench, meso, field
- Refine scope and design to meet needs and budget
- Conduct experiments and testing program
- Analyze results and incorporate into decision making framework
- Gap analysis and additional testing if required

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

5

Land Use and Potential Receptors

Alberta Government

Alberta Tier 1 Soil and Groundwater Remediation Guidelines

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

https://open.alberta.ca/dataset/842becf6-dc0c-4cc7-8b29-e3f383133ddc/resource/a5cd84a6-5675-4e5b-94b8-0a36887c588b/download/albertatier1guidelines-jan10-2019.pdf

6

Land: Support for remediation, reclamation and land management challenges

Source: https://www.golder.com/news/federal-funding-accelerating-the-reclamation-of-inactive-wellsites/

Source: https://www.canadaaction.ca/alberta_oil_sands_reclamation_photos

7

7

Use of Microcosms in Environmental Risk Management

Microcosm culturing is used to investigate microbial growth and activity on compounds of interest.

- Allows the investigation of numerous variables and factors affecting microbial degradation of compounds under a variety of reducing conditions.
- Ease of replication and ability to tightly control treatments and investigation of effects of environmental parameters.

Froth Treatment Tailings Risk Assessment Study:

- To determine the relative degradation rates of diluent in tailings deposits of different ages using microcosms under anaerobic conditions.
- Measure headspace gas composition and methane production rates.
- Identify key microorganisms involved in diluent degradation.
- Identify nutrient and diluent availability or limiting factors affecting microbial activity.
- Combine with geochemical data in development of tailings management strategies.

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

8

8

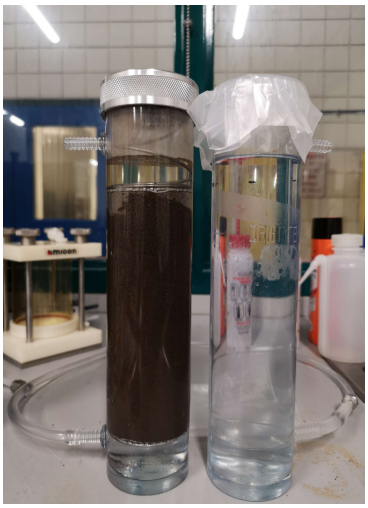
Soil columns with vegetation for root analysis

9

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

9

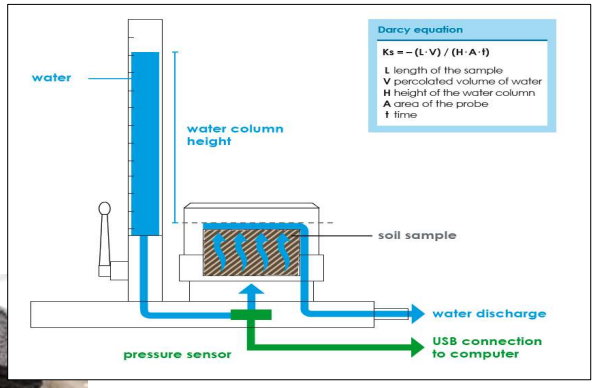
Effective reclamation of hydrophobic soils



Assessment of re-wetting potential and retention

10

Filter cake



Hydraulic conductivity measurement

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

10

Computed Tomography (CT) Imaging Centre

Industrial CT Scanning

https://innotechalberta.ca/research-facilities/computed-tomography-imaging-centre

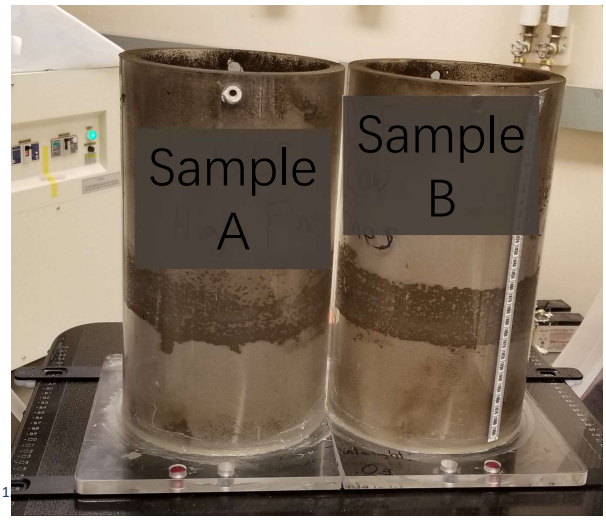
- ***Toshiba Aquilion One X-ray CT scanner – a***
- ***3rd generation 320-slice helical scanner capable of imaging up to 1.9m in length with a field of view up to 50cm in diameter.***
- ***72kW of power and advanced iterative reconstruction, the scanner can acquire low-noise images in seconds or minutes***
- ***72cm bore and 300kg weight limit can accommodate large-scale experiments in a laboratory setting***
- ***Nominal voxel sizes down to 1/3mm available***

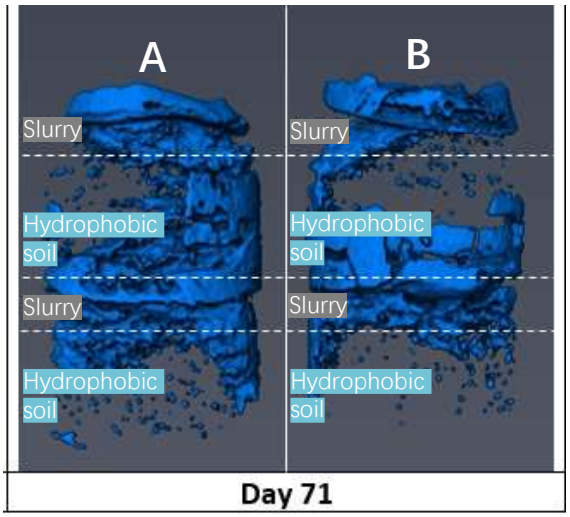
InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

11

11

Layering approach – CT Scanning to view 3D moisture distribution

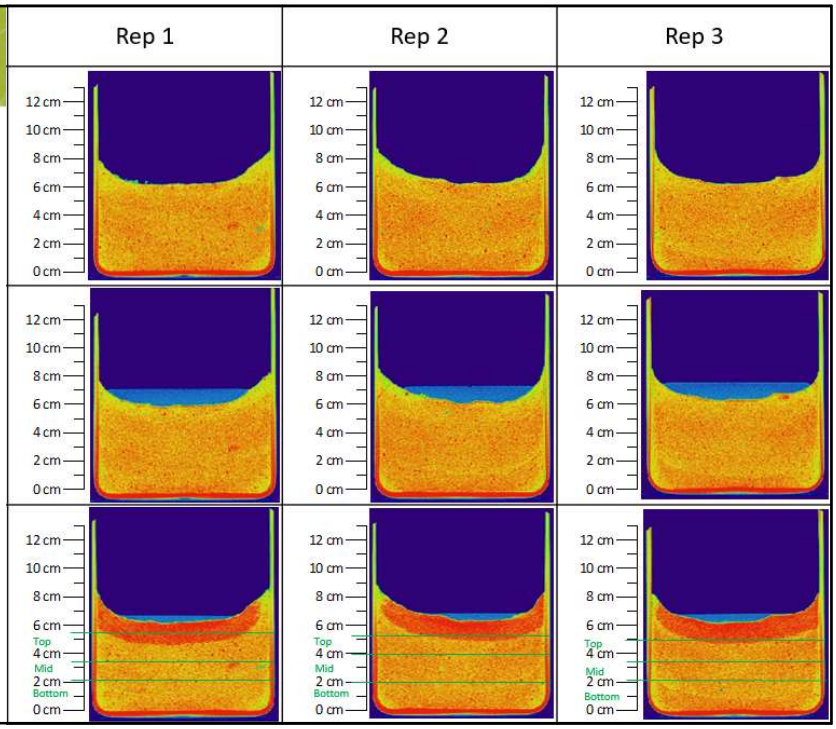




12

Spill to land scenario

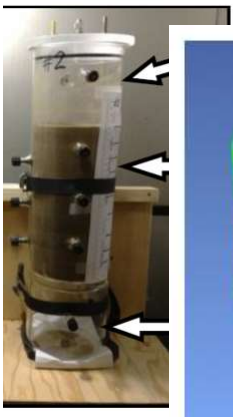
Legend	
Air	
Sand	
Product	
Product and Sand	
Sample Layers	

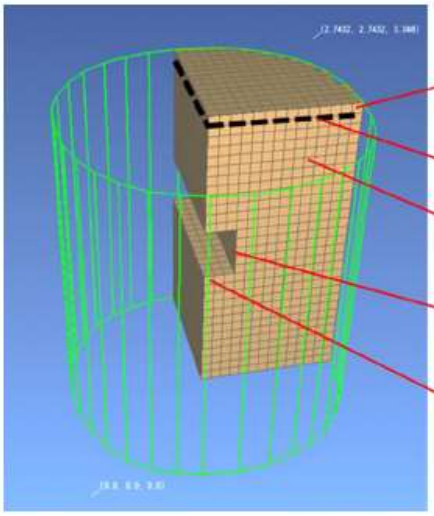


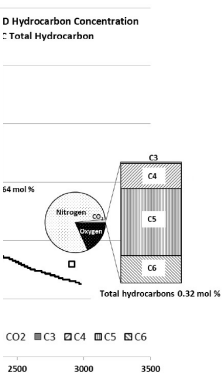
13

13

Numerical Modeling and Bench-Scale Validation







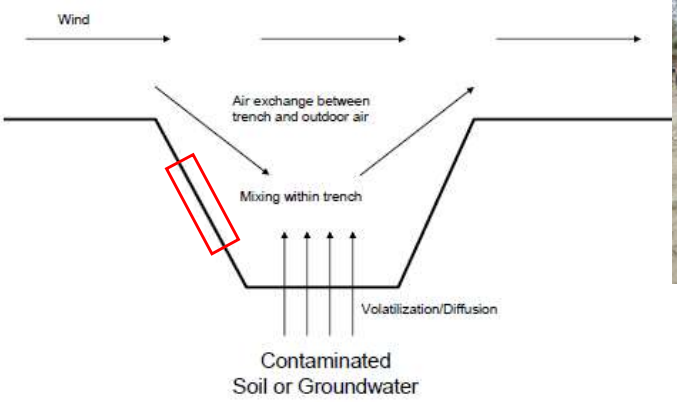
14

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

Citation: LABORATORY AND NUMERICAL SIMULATIONS OF PIPELINE LEAKAGE BEHAVIOUR; VOLATILE ORGANIC COMPOUND (VOC) MIGRATION THROUGH POROUS MEDIA AND SUBSEQUENT ATMOSPHERIC DISPERSION - Proceedings of the 2014 10th International Pipeline Conference; IPC2014

14

Air: Model inputs – volatilization of hydrocarbons into trench



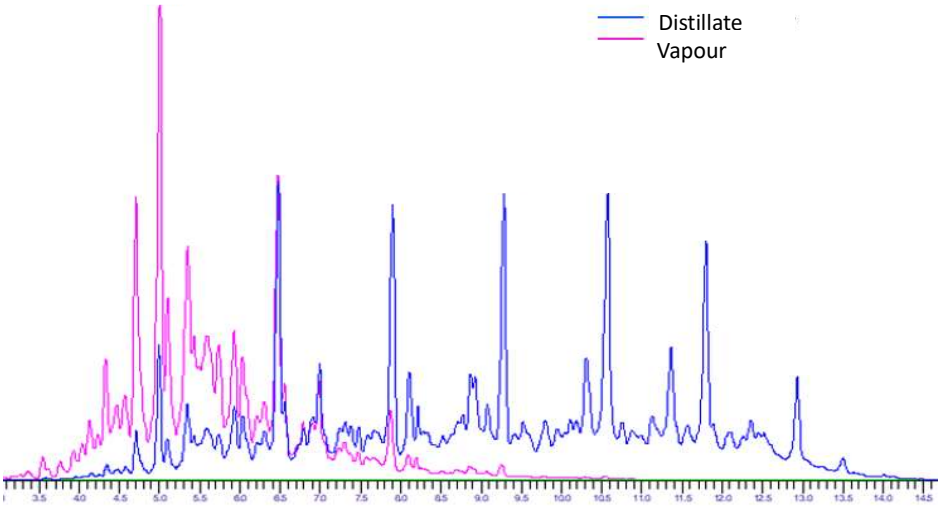
Source: https://www.ccme.ca/files/Resources/supporting_scientific_documents/pn1455_n_hexane.pdf

15

Unique headspace method – Atmospheric Pressure

16

Volatile vs. distillate fraction analysis



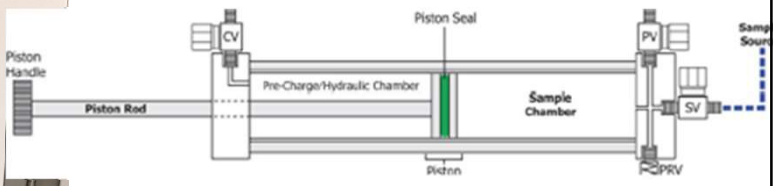
17

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

17

Case-specific headspace analyses

Incubation at elevated temperature – product in Tedlar bag



Manual piston method – V/L ratio of 4:1 (modified ASTM D8236)

Headspace vial – direct GC analysis (1:1)

18

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

18

Water: Hydrocarbon behaviour in water

Product in water with and without sediment

Hydrocarbon release to water experiments

Collaboration with CanmetENERGY (NRCan)

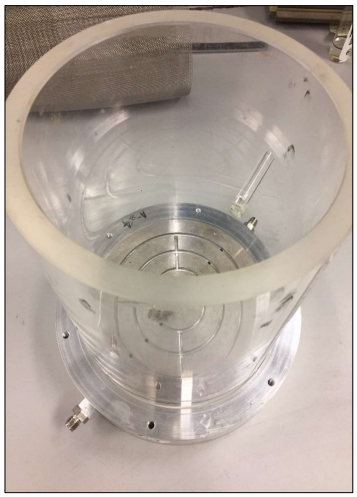
https://www.nrcan.gc.ca/simply-science/science-diluted-bitumen-task-1-nrcan/21288

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

19

19

Soil Leaching Columns



InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

20

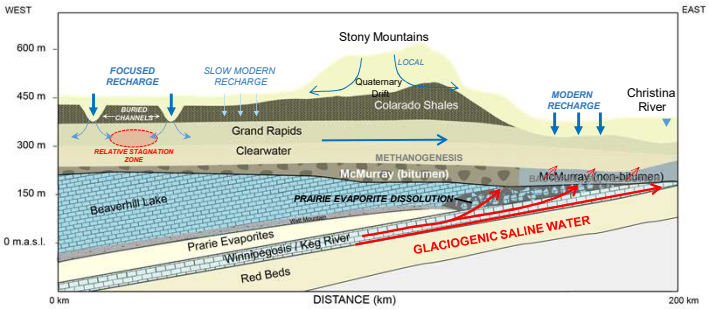
OSPW Characterization and Risk

OSPW Characterization

- Ultra high-resolution MS characterization of OSPW and linking water quality to ecotoxicity.
- Projects with industry and with Alberta Environment and Parks Oil Sands Monitoring and OSPW Science Team to develop criteria for water return.
- Leading OSM Technical Advisory Committee to develop a long-term monitoring plan for groundwater.
- OSPW treatment evaluation combining organic characterization and toxicological assessments.

Conceptual Model Development

- Using geochemical and isotopic tracers to develop conceptual models for groundwater flow to inform water management.
- Hydrocarbon and microbiological characterization of oil sands tailings deposits to help develop conceptual models of pond evolution for closure strategies.



(Birks et al., 2019)

21

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

21

Conclusions

- Research questions and design based on challenges presented by industry, consultants and government
- Experimental design process key to effective simulation to inform management, mitigation or environmental guideline selection
  - Scale
  - 'Worst case' vs. realistic
- Results can be incorporated from multiple experiments at different scales, sometimes through modeling
- Keys to success: 1) involvement of key stakeholders and 2) creating multi-disciplinary teams

22

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

22

Contact Information

Simone Levy, M.Sc., P.Ag.
Research Scientist – InnoTech Alberta
Environmental Services Division
Edmonton, AB, Canada
simone.levy@innotechalberta.ca
(780) 450-5210

23

24