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Robert Martens, Banff, October 2013

Ex-Situ Chemical Oxidation
a Proven Sustainable Remediation Alternative

Agenda

Cost Analysis

- Excavation and Disposal Volumes
- Safety and Contractor Management

Case Study

- Northern Alberta
- Central Alberta
- GHG Emissions

Opportunity

Conclusion

Cost Analysis
Excavation & Disposal Volumes

- Currently the majority (> 90%) of contaminated soil from downstream/midstream and upstream operations in AB & BC is disposed at landfills
- Several reasons for landfill disposal option:
  - Nature of contaminant(s)
  - Remoteness
  - Spacing requirements
  - Regulatory
- AB / BC landfills reported 925,000 tonnes / 5 year average
- Approximately 30% would be suitable for on-site treatment

Cost Analysis
Safety and Contractor Management

- Transportation Safety Costs
  - 1,400 people injured every year as a result of heavy commercial traffic
  - Since 1998 average of 80 fatalities / year
- General Safety Costs
  - Flagging Crews
  - On-Site Safety Staff
  - Training and Orientation
- Contractor Management Costs
  - Training / Orientations / Contractor Competency Assessments
  - Fit for Work
  - Stakeholder Relations / General Public

Cost Comparison and Case Study 87-9 W6M

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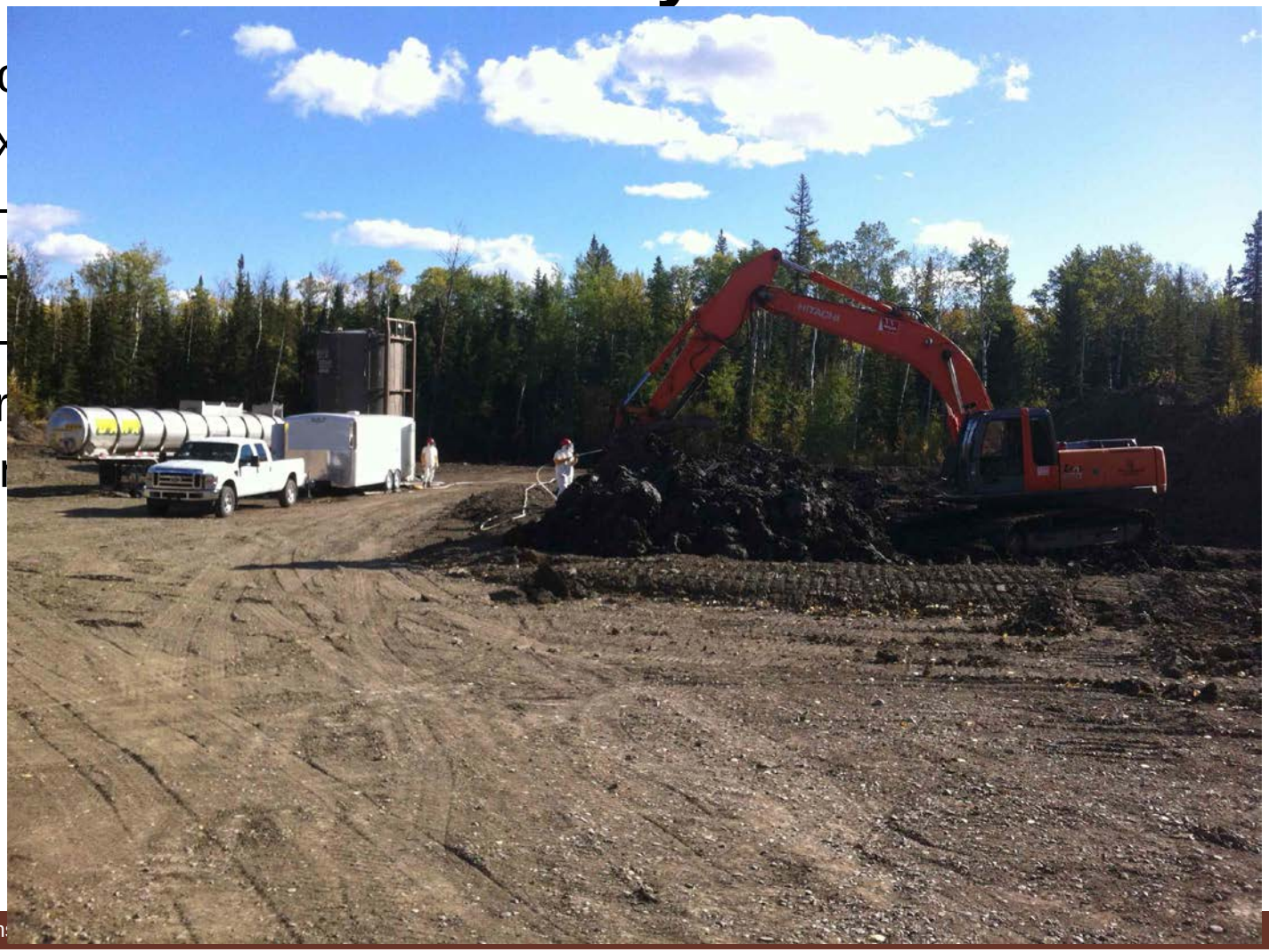

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Cost Comparison and Emissions Case Study Central Alberta

- Contaminant Distribution BETX, F1 and F2
- In-situ System / Passive Remediation
- Risk Mitigation Strategy
  - Two Plant Sites:
    - 7,200 m^3 impacted soil/groundwater
    - Oxidant demand = 655,000 kg to Tier 1
  - Costs First Year: $ 280 K
  - Costs Year 2 to 5: $ 80 K
  - Total Costs: $ 600 K or ~ $ 83.00 / m^3

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Cost Comparison and Emissions Case Study

- 170 km distance
  - Trucking 350 loads = 59,500 km
  - Fuel Use: 7 mpg or 33.60 L / 100 km
  - Fuel Used: ~ 20,000 L
  - CO_2 Emissions from 1 L Diesel: 2.7 kg CO_2e
  - Total Emissions: 54 tCO_2e

- Increasingly important:
  - Full Cost Analysis
  - Social License to Operate
  - Sustainable Operations managing Environmental Liabilities
  - Perception Oil and Gas Industry

Emissions AB / BC
Regional GHG Impact

- Disposal volumes AB / BC 925,000 tonnes / year
- Assumption that 30% or 277,000 tonnes can be treated
- Assume transportation distance to landfill is 150 km
- Fuel Use Transportation: 124,000 L diesel
- CO_2 Emissions from 1 L Diesel: 2.7 kg CO_2e
- Total Emission Reduction 334.8 tCO_2e / year

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Opportunities ?

- Was is the price of carbon ?
  - In 2009, 8.2 billion metric tCO_2e was traded, > 68% from 2008
  - Value: $ 144 billion US
  - EU: € 11.40 or ~ $ 15.75 tCO_2e (credit)
  - US: $ 3 – 5 tCO_2e (credit)
  - UK: £ 4 or ~ $ 6.65 tCO_2e (penalty)
  - BC: $ 14 – 18 tCO_2e (credit)
  - AB: $ 15 tCO_2e non-compliance cost to climate fund / offset credit
- Carbon Trading Transportation Industry ?
- What if 75% can be reused, treated, immobilized ?
  - ~ 700,000 tonnes
  - 312,500 L diesel
  - 844 tCO_2e
  - Every L diesel is ~ $ 0.04 CO_2e

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Conclusions

- Opportunities to reduce remediation cost and associated emissions.
- Opportunity for carbon trading ?
- Corporate Social Responsibility.
- Perception oil and gas industry.
- Social License to Operate.
- Incentive to Suppliers / Contractors ?