Design and Application of a Low Impact MoBile Drill Rig (LIMB DRIG) for Assessment of Petroleum Hydrocarbons in a Remote and Eco-sensitive Environment using Laser Induced Fluorescence (LIF)

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Ben Sweet\textsuperscript{1}, Dean Morrow\textsuperscript{2}, Darren White\textsuperscript{2}, Rob Green\textsuperscript{2}, Kela P. Weber\textsuperscript{2}

\textsuperscript{1}SCG Industries Limited
\textsuperscript{2}Environmental Sciences Group, Department of Chemistry and Chemical Engineering, Royal Military College of Canada, Kingston, Ontario, Canada.
Sable Island

- Newly established national park reserve managed by Parks Canada.
- Four centuries of human presence.
- Environmental site assessments were conducted to inform the park management planning process.
Sable Island

• Sensitive ecosystem: coastal dunes, fresh water lakes and aquifers with dynamic spatial and temporal variability.
How to cost-effectively vertically assess petroleum hydrocarbons in this environment?

- Complex site – hydrogeology; management
- Sensitive environment – fragile & dynamic landscape
- Remote site – extreme logistical challenges

Adapted from “Dominion Diving Delivers Cargo to Sable Island,” by Zoe Lucas, 2012, retrieved from http://www.greenhorsesociety.com/Sealift/Sealift%202012.html
High Resolution Site Characterization

• USEPA, 2013
  
  “High-resolution site characterization (HRSC) strategies and techniques use scale-appropriate measurements and sample density to define contaminant distributions, and the physical context in which they reside, with greater certainty, supporting faster and more effective site cleanup.”
LIF – Laser Induced Fluorescence

• Utilizes in-situ fluorescence spectroscopy to locate Free Phase Petroleum Hydrocarbons.
High Resolution Site Characterization

• LIF high density/real-time assessment of PHC distribution:
  • Help address site complexity
  • Ease logistical challenges.

• Challenge - sensitive & remote environment.
  • Traditional drilling inappropriate.
High Resolution Site Characterization

Creative solution:

• Design and build a hand operated direct push platform for delivery of the UVOST system that is:
  • Light weight (weighing less than 150 lb)
  • Powerful (push force of at least 4000 lb)
  • Compact (fits in airframe)
Solution:

• ESG/RMCC applied and received an NSERC Engage Grant for the design and build of the apparatus with SCG Industries Limited.

• Engage Grant:
  • Develops “new to you” research partnerships between university and industry.
  • Value: up to $25,000 from NSERC
  • Timeline: up to 6 month project period, 4-6 week approval period.
LIMB DRIG: Stage 1 Development

- Low Impact MoBile Drill Rig (LIMB DRIG)
- 10,000 lbs of push force
- Hand assembled and operated
- 120 lbs and fits into a oversized hockey bag
- Compatible with UVOST.
LIMB DRIG: Stage 2 Field Testing

• Field tested at a beach site to mimic Sable Island.
• Addition of a slide hammer component.
• Successfully pushed LIF through sand and clay.
• Identified key operating procedures before deployment to a remote location.
LIMB DRIG: Stage 3 Site Assessment

• LIMB DRIG & LIF:
  • Low cost with low impact methodology to collect real-time, high resolution data
  • Address cost as well as technical and logistical concerns.

• Seven days on site – five active.
LIMB DRIG: Stage 3 Site Assessment
LIMB DRIG: UVOST Results

• LIF and Electrical Conductivity logs - 29 locations.
• Use real-time and high resolution spatial data to target analytical samples.
  • 11 hand augured boreholes
  • 18 samples for lab analysis
LIMB DRIG: UVOST Results
LIMB DRIG: Laboratory Result

- BTEX, Fractional, PAHs
- Targeted samples to depths identified in LIF logs
- Correlation (LIF readings to soil analysis)
  - Practically difficult to achieve
  - Qualitative vs. Quantitative

![Graph showing the correlation between Total PAH Mass and PAH Species of Interest Mass](image)
LIMB DRIG: Site Conceptualization
Project Results

• LIMB DRIG is a compact, lightweight and low impact method of delivering direct push probes in fragile ecosystems.

• Data obtained from UVOST borings resulted in
  • Vertical delineation of PHCs;
  • Identification of confining organic layers within the sand; and
  • Revision of conceptual site model.
• Key information for comprehensive risk assessment.
• Key information for comprehensive park management.
Next Steps

- LIMB DRIG 2.0
  - Powered addition
  - Design revisions
  - Ergonomics

- Additional HRSC technology application:
  - Freshwater aquifer delineation
  - Mapping heterogeneity in subsurface permeability
Acknowledgements

PHC Tech Services
Questions regarding Sable Island National Park Reserve should be directed to Parks Canada:

Sable Island National Park Reserve
Parks Canada / Government of Canada
sable@pc.gc.ca / Tel: 902-426-1993
www.pc.gc.ca/Sable