Real Time Total Petroleum Hydrocarbon Measurement Enable the Rapid Environmental Remediation Workflow

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Project Background

Opportunity

Soil samples from hydrocarbon impacted soil in exploration and production operations need to be tested for Total Petroleum Hydrocarbon (TPH)

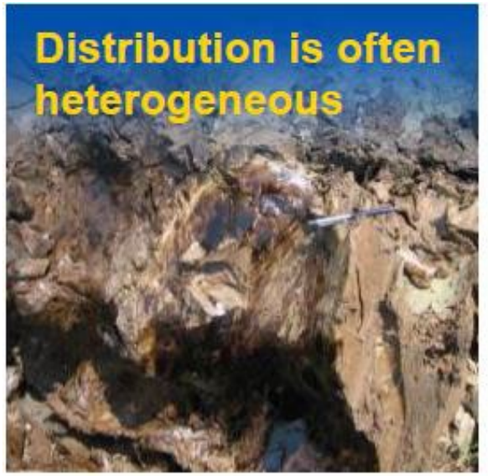
- **Delays in sample analyses** and **decision making** due to large # of soil samples per week needing analysis
- Lab analysis can take 2-4 weeks

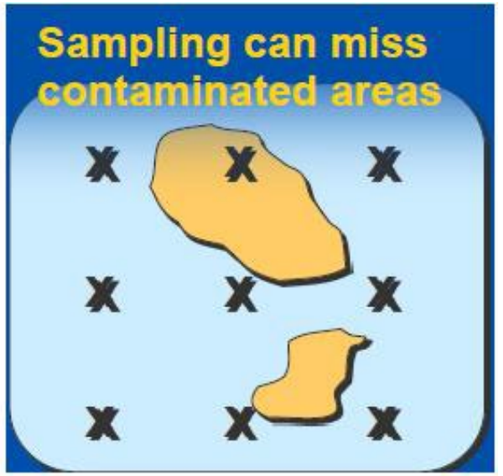
Approach

Development of rapid TPH analytical method to increase accuracy and efficiency

1) Real-time remediation process monitoring

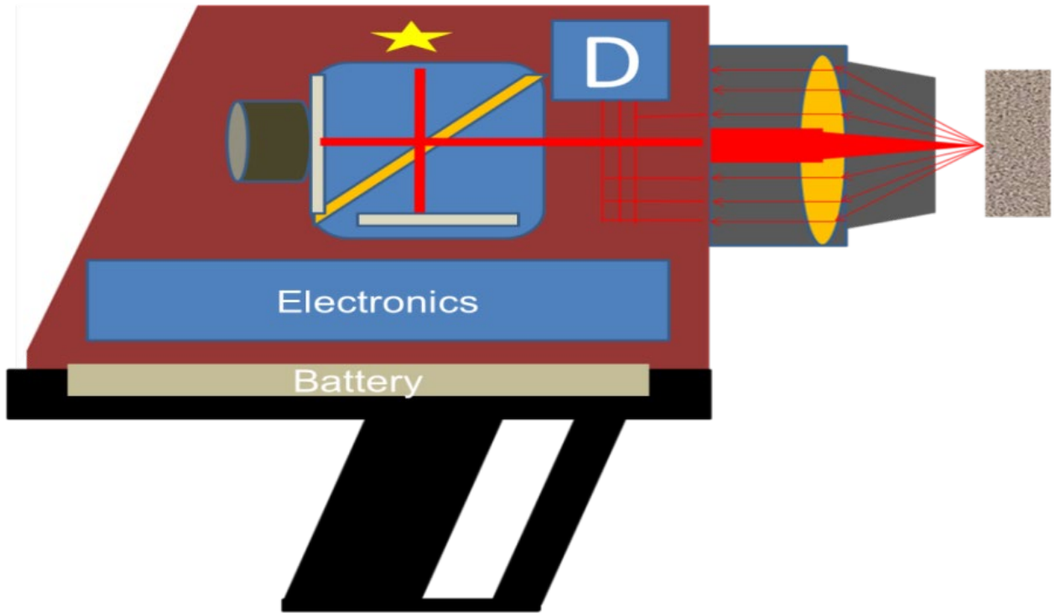
2) Reducing the number of samples going to lab





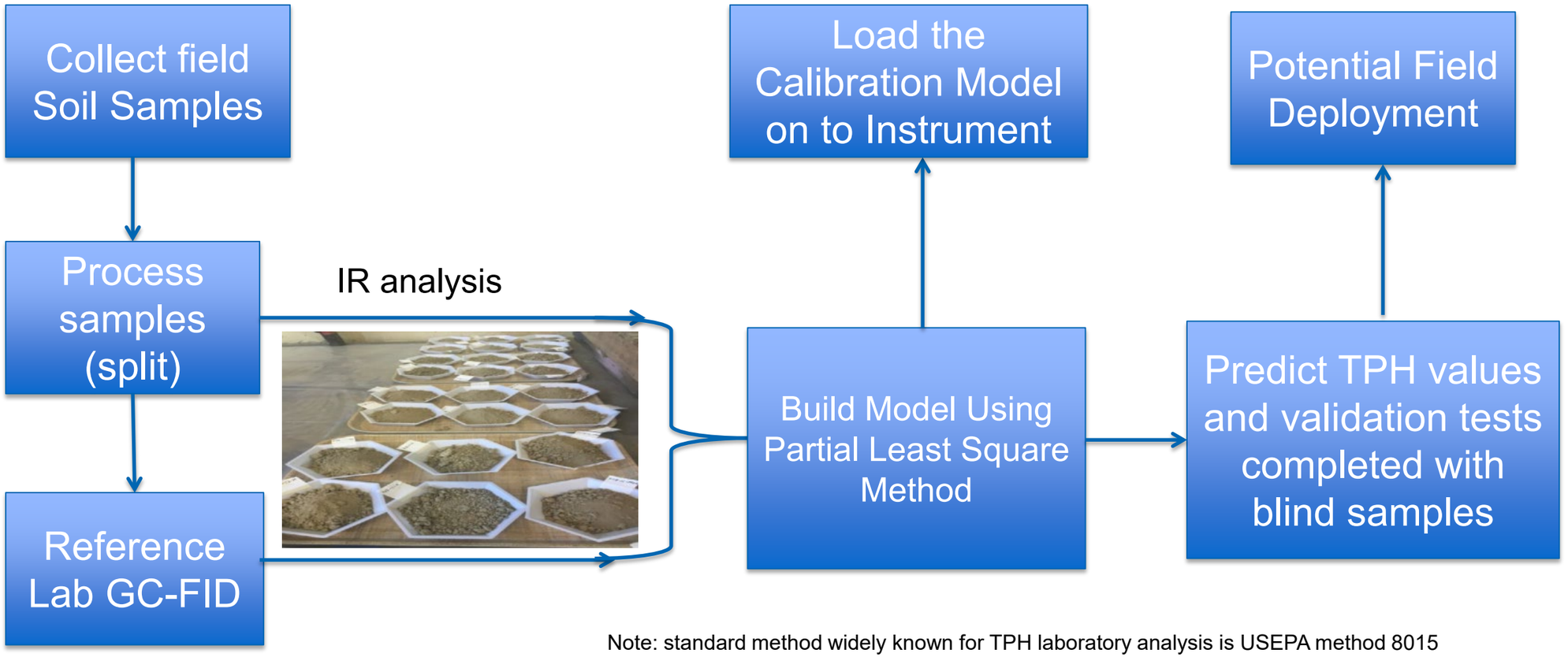
Handheld IR Instrument for Non-Destructive TPH Measurement

- Portable handheld IR instrument
- Diffuse reflectance of IR light reflected from the sample
- The world's first handheld instrument for the direct measurement of TPH in soil
- User simply pulls the trigger for a 15 second reading of TPH (C_{10}-C_{36}) in mg/kg



IR light is emitted
Interacts with the surface of the sample
Light is diffusely reflected back to detector
IR spectrum (readout) is produced

Field Pilot Approach- Work process



Note: standard method widely known for TPH laboratory analysis is USEPA method 8015

D. Kong, S. Mcmillen, T. Vidra, Y. Kurniawan, S. Chitra, D. Saputra and D. Kumboro
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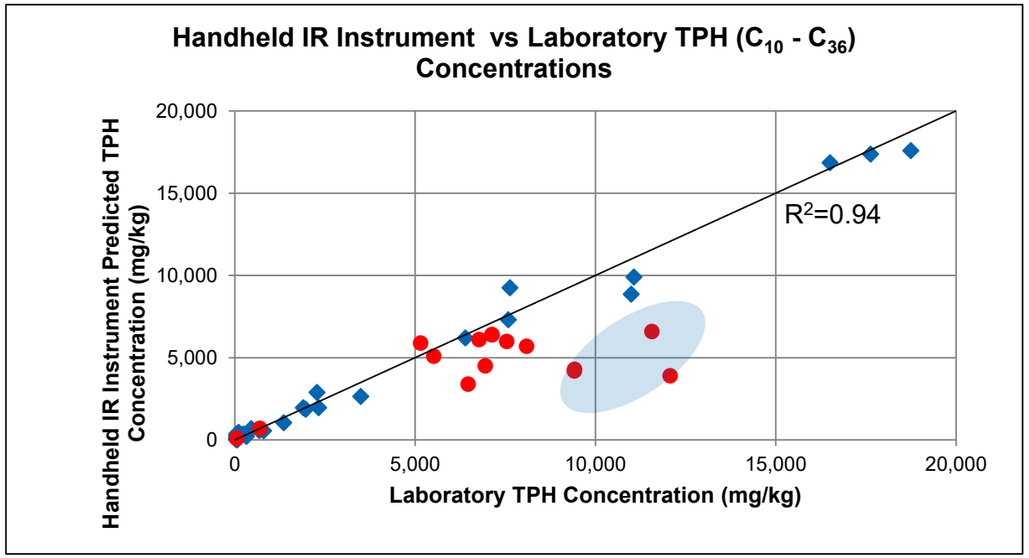
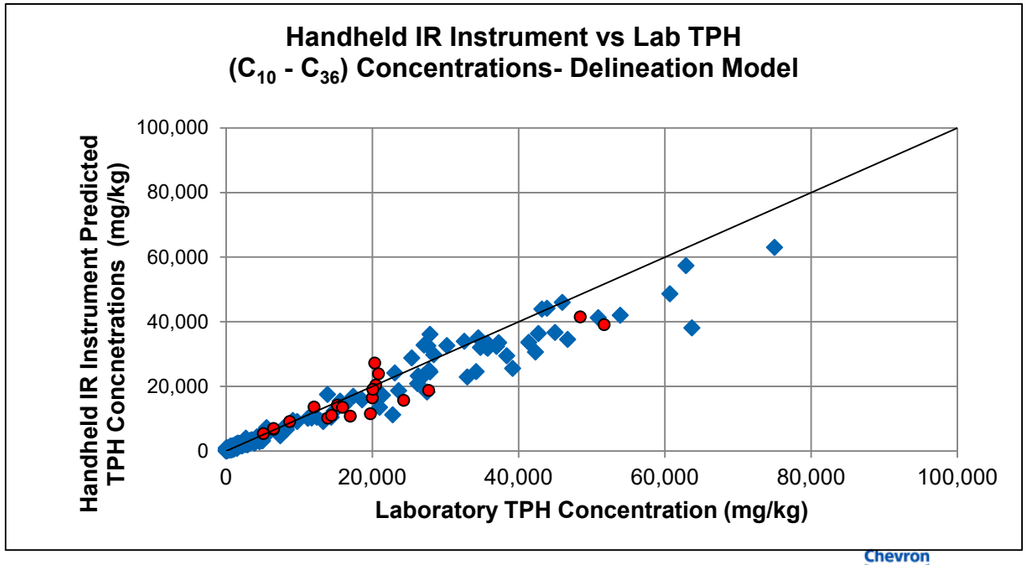
Pilot Studies Results Evaluation – Field A

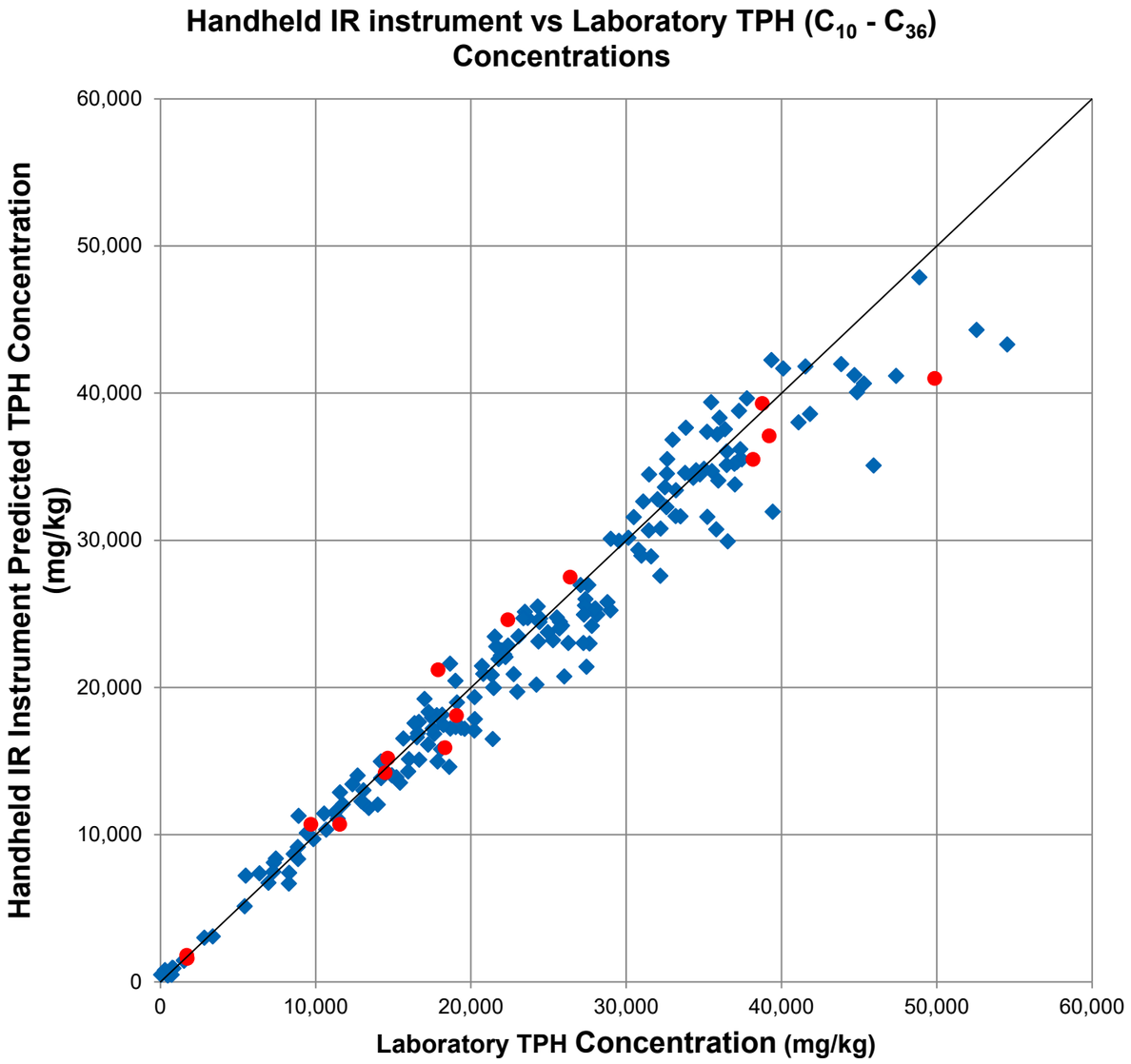


- Calibration model completed with 111 soil samples from Field A at TPH range 0-120,000 mg/kg
- Using calibration model A vs. GCFID Data for validation Test
- Validation Samples (•)& Calibration Samples (◆)
- Outliner analysis - spectrum suggests the high clay contents of those samples
- Detection limit of this model - 170 mg/kg



- 5 different sites collected 250 soil samples to populate more soil type in Minas area
- All samples were tested by GC-FID and measured with existing Field A 1.1.3 model

Pilots Studies Results Evaluation – Field B



Calibration model completed with 200 soil samples from Field B at TPH range 0-50,000 mg/kg

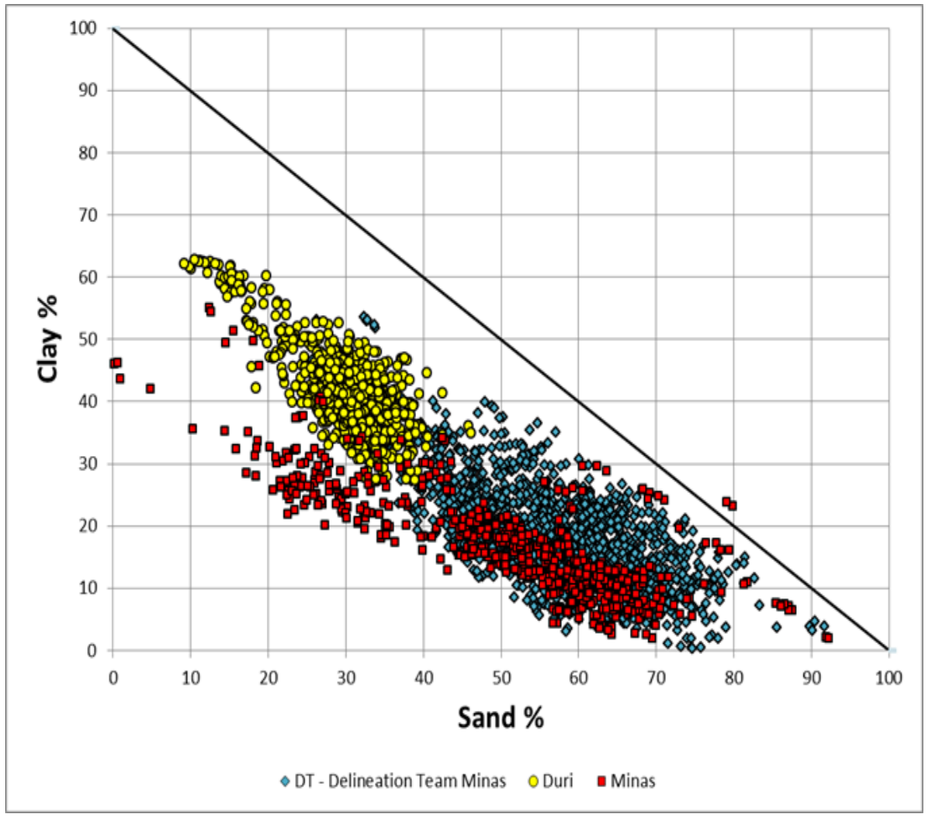
Using calibration model B vs. GCFID Data for validation Test

Validation Samples (•)& Calibration Samples (◆)

Detection limit of this model- 380 mg/kg

Soil Type Comparison

Why different calibration model is needed?



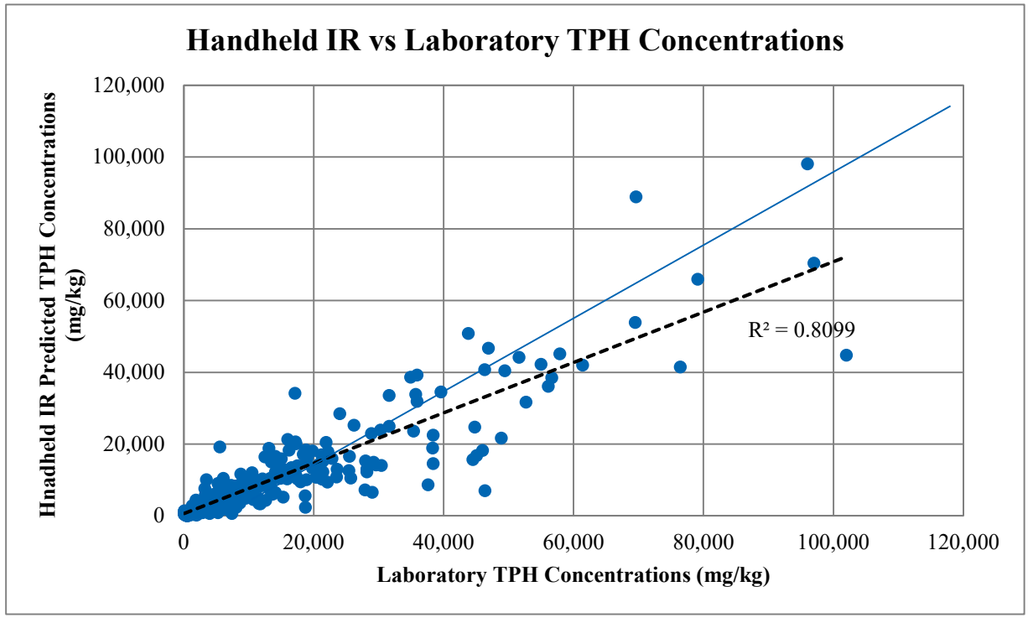
Comparison of Soil Types Field A, B and Delineation Model Calibration

Red dots- Minas model soils – Field A
Yellow dots- Duri model soils- Field B
Blue dots- Delineation trial soils

- Clay and Sand % are estimated based on the IR spectrum- data are not normalized;
- The rest components could be organic matter, water.

Field Deployment

- Data monitoring program was set up to ensure data quality and determine if any outliers are related to new or unique site soil types.
- Up to 5 % monthly duplicates were sent for GC-FID method 8015 then compared against handheld IR instrument readout.



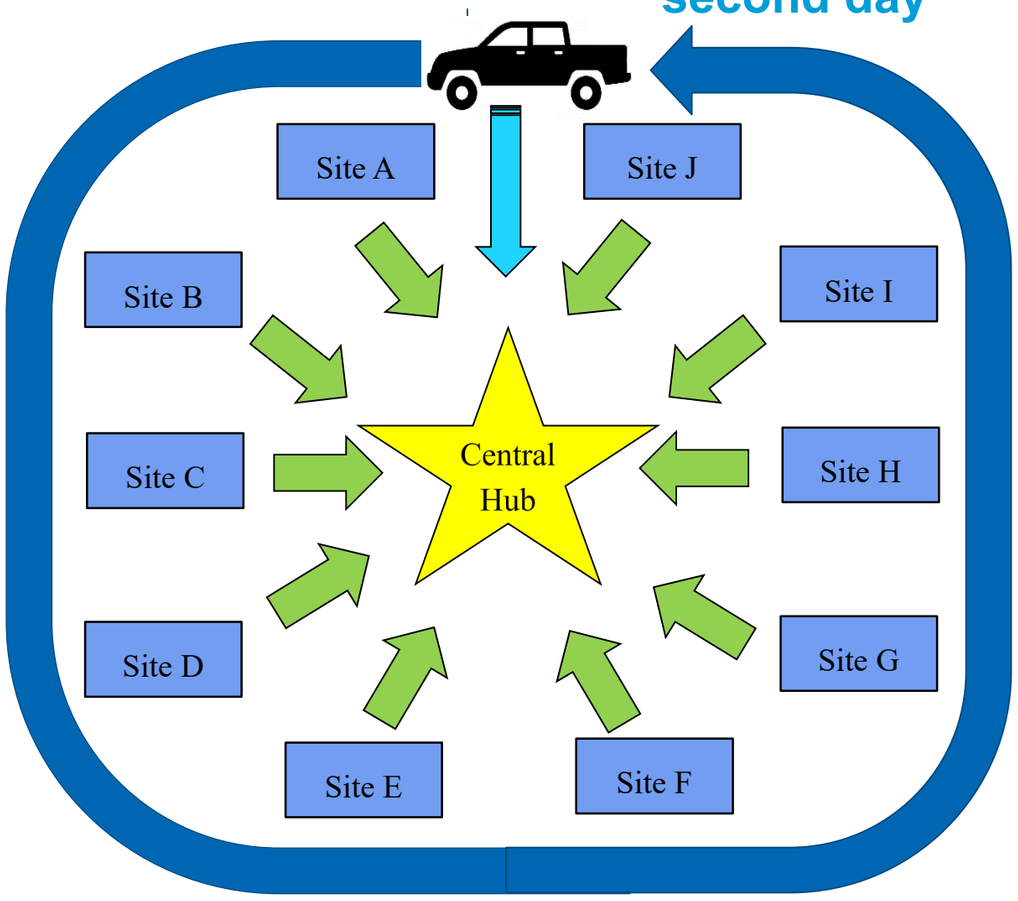
Field deployment monthly monitoring results September 2016 - October 2017

RMSD = 8013 mg/kg or 0.8 % TPH

- Deployment team working with vendor to populate soil database with various soil type to increase predictive model robustness.

Field Deployment- Centralized location for multiple ongoing delineation sites

Centralized Hub to receive the samples twice a day- Data available on second day



Suitable for:

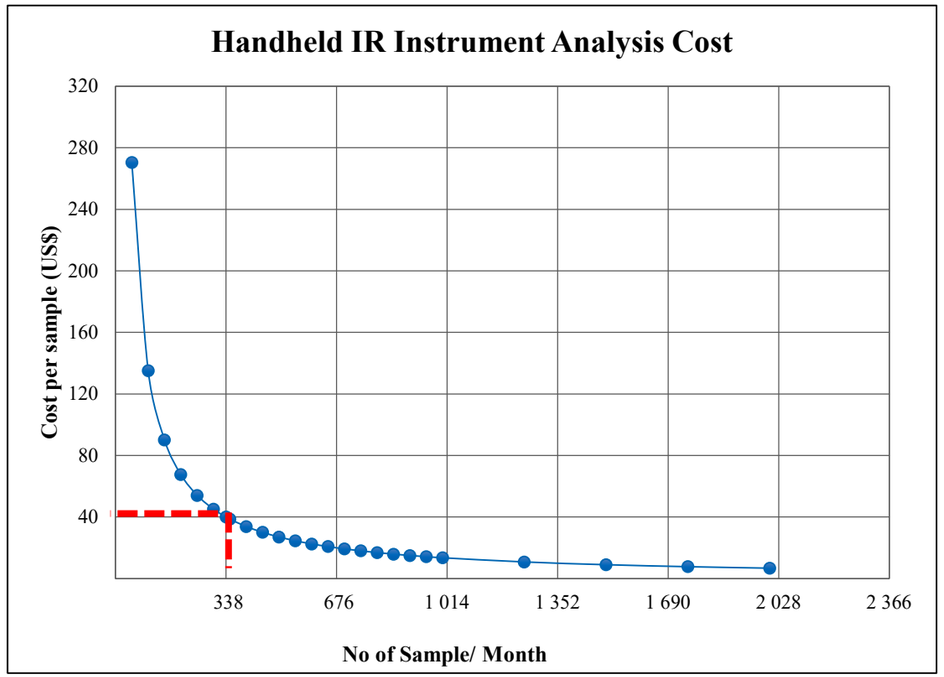
- ✓ Multiple active sites
- ✓ Sites spread out with traveling time between sites more than 30 minutes
- ✓ Limited no. of unit vs no. of remediation site
- ✓ Double shifts for data processing

Reduced Project Cycle Time

- ✓ Full Integration of RemScan™ Technology into delineation, excavation and soil treatment process to significantly reduce the project cycle time and enabled completion of 272 delineation work in one year.
- ✓ RemScan™ analytical method has received ISO 17025 accreditation as a field TPH measurement method through local country accreditation body to gain the regulatory acceptance.




Cost Benefit



Cost of analysis per sample vs no of sample per month

No. of Sample/ Month	Cost Saving (US$)
500	6,480
1,000	26,480
1,500	46,480
2,000	66,480
2,500	86,480
3,000	106,480
3,500	126,480
4,000	146,480
4,500	166,480
5,000	186,480

Theoretical cost saving generated by certain amount of samples analyzed per month

- In current sample load, estimate cost saving generated > $ 100,0000/ month
- Based on:
  - $ 40 analysis cost for TPH GCFID (C10 – C36) from commercial laboratory
  - Cost structure is based on all service rental scheme (rental including: instrument, consumables, manpower, reporting, and monthly QC)
  - Sample load around 3,000 per month

Summary

- This portable handheld IR Instrument will enable rapid and accurate delineation of sites & allows real time process monitoring for different remediation technologies
  - **Significant time reductions**
    - Real-time process monitoring
    - Rapid, field-based testing
    - Improve data density for site assessment
    - Less waiting time for soil excavation and transport
  - **Improved Safety**
    - Prevents worker exposure and generation of waste by eliminating the use of solvents (used in the lab and in other field test methods)
  - **Cost Savings**

Acknowledgements

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