Rapid Mapping of Soils in China using a Handheld Infrared Device

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Acknowledgements

Contaminated Soil in China

- In 2014, the Environmental Protection Ministry in China published a national soil survey which estimated that 16% of all soil and 19% of arable land exceeds State Pollution Limits.

- In 2016, the Ministry published an Action Plan for the Prevention and Control of Contaminated Soil.

- Clean-up costs are estimated at 158 Billion USD*.

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Site Characterization

0   240   480   960 Kilometers
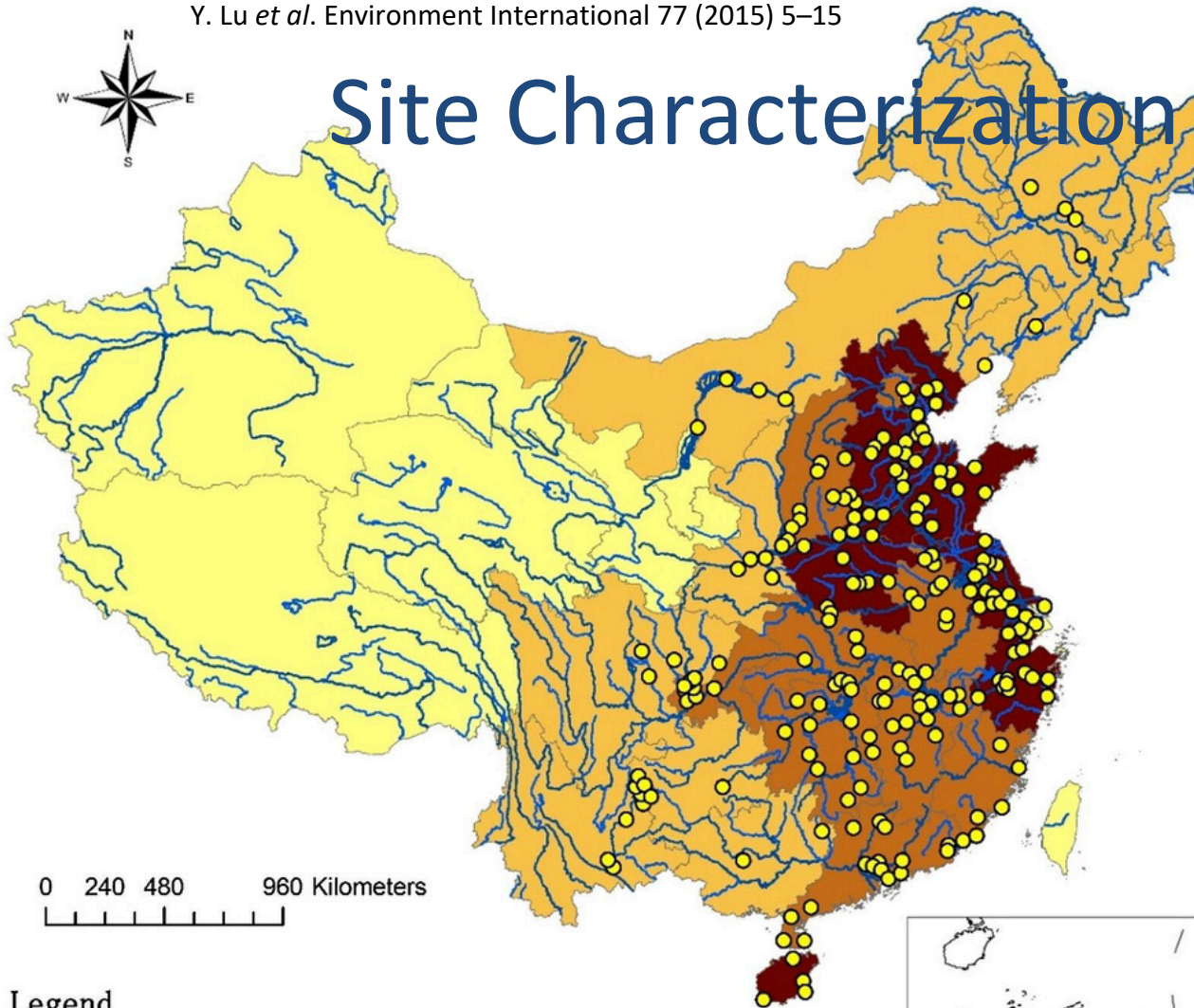
Legend

○ Cancer villages **Cancer Village Density**

—— Main rivers

Blank Area (0)

Sparse Area (0.01-0.06)

Dense Area (0.61-1.40)

The Most Dense Area (1.41-2.67)

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Demand for Field Screening Tools

Tool	Technology	Analytes
XRF	X-Ray fluorescence	Heavy metals
PID	Photo-ionisation	Volatile organics
RemScan	Infrared	Petroleum hydrocarbons

Portable XRF

PID

RemScan

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Validation of a New Technology for the Rapid Measurement of Petroleum Hydrocarbons in Soil

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Background

Battelle was engaged by Ziltek to test the performance of the handheld RemScan technology for the rapid measurement of total petroleum hydrocarbons (TPH) in soil. The study was conducted in line with the former Environmental Technology Verification (ETV) program that was designed "to provide objective and quality-assured performance data on environmental technologies, so that users, developers, regulators, and consultants can make informed decisions about purchasing and applying these technologies". Ziltek made a number of claims relating to accuracy (<12% RSD), repeatability (<7% RSD) and detection limit (<250 mg/kg) which were also assessed as part of this study.

Figure 1: Using RemScan as a screening tool at Site 2.

Methods

Soil samples (100) were collected at each of two US Department of Defense sites; Site 1 was located at the Marine Corp Air Ground Combat Center, 29 Palms, CA and the location of Site 2 remains confidential.

For each site, 60 samples were used to build a site-specific calibration model in the RemScan instrument which was then used to scan the other 40 'blind' samples and predict their TPH concentrations; scanning was undertaken by Ziltek and then repeated by Battelle.

The RemScan predictions were compared to laboratory assay data (US EPA Method 8100 TPH) for each of the samples to determine the accuracy of the technology. Repeatability measurements were also carried out on selected samples. After two hours of formal training, Battelle staff were asked to comment on a number of usability claims and to fill out a usability questionnaire.

Results and Discussion

For Site 1, the accuracy of RemScan was 9.4% RSD compared to accredited laboratory data, and the repeatability was 1.8% RSD. For Site 2, the accuracy could not be calculated due to lack of data points between 5,000 and 10,000 mg/kg and the repeatability was 3.3% (when adjusted for volatilization effects). The detection limit of the method for both sites was around 65 mg/kg (at 1 st. dev.) which compares very favourably with commercial laboratories.

Using a regulatory criteria of 1,000 mg/kg, there were no false negatives or positives for either test site, which means that the RemScan technology could have been used confidently at these sites with no requirements for laboratory analysis.

The main limitation of the RemScan technology is the requirement for soil moisture to be less than 8% for accurate readings. The latest release of RemScan notifies the user when moisture in the sample is too high to obtain accurate results. High carbonate caused an under-prediction of TPH for three samples from Site 1, however in a normal commercial setting this would be overcome by including a wider range of carbonate samples in the calibration model.

Figure 2: RemScan predictions versus laboratory assay values for calibration samples (blue) and blind validation samples (red) for Site 1.

Figure 3: RemScan predictions versus laboratory values for calibration samples (blue) and blind validation samples (red) for Site 2.

Table 1: Summary of RemScan Performance

	Site 1	Site 2	Vendor Claims Met
Accuracy	9.4%	N/A*	☑
Repeatability	1.8%	3.3%#	☑
Detection limit	66 mg/kg	64 mg/kg	☑
False positives/ negatives (1,000 mg/kg)	Nil	Nil	N/A
Battery life	Full day of continuous use with one battery swap		
Throughput rate	10-20 samples per hour		
Operational cost	No incremental cost		
Instrument cost	70,000 USD		
Breakeven cost threshold	7 days (1,400 samples)		
Formal training required	<2 hours		
Infield calibration time	3 minutes every hour		

*Insufficient data to calculate
#Adjusted to compensate for volatilization effects

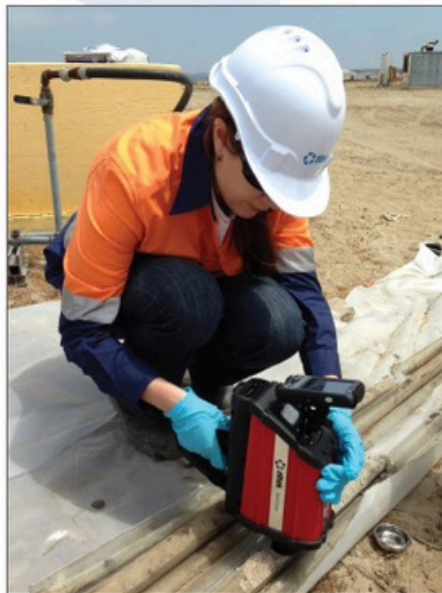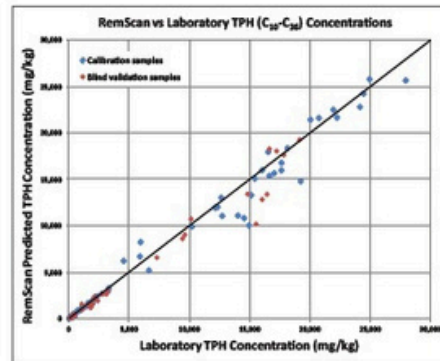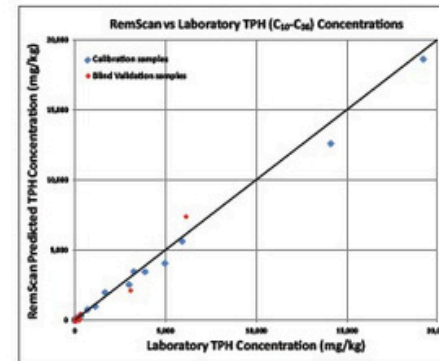VerifiGlobal

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Areas of the World where RemScan has been applied

Validation Study in China February 2018

- A validation study was conducted by Ziltek in partnership with Shanghai Sine Electrician Equipment Co. Ltd.

- The aim of this study was to calibrate the RemScanusing soils collected from across the Shanghai region and validate its accuracy.

- The longer term aim is to develop a RemScancalibration that can be used China-wide.
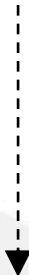

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Soil Collection –Shanghai Region

Methodology

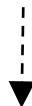Dry, Homogenize and Screen Soils

↓

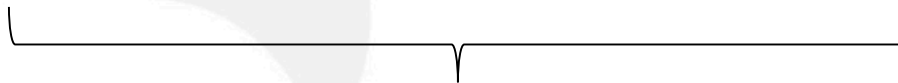Spike Soils with Diesel (0 to 100,000 mg/kg)

↓

Scan using RemScan

TPH Concentration   *Infrared Spectra*

Build Calibration Model and Load into RemScan

↓

Measure Validation Samples with RemScan

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Methodology

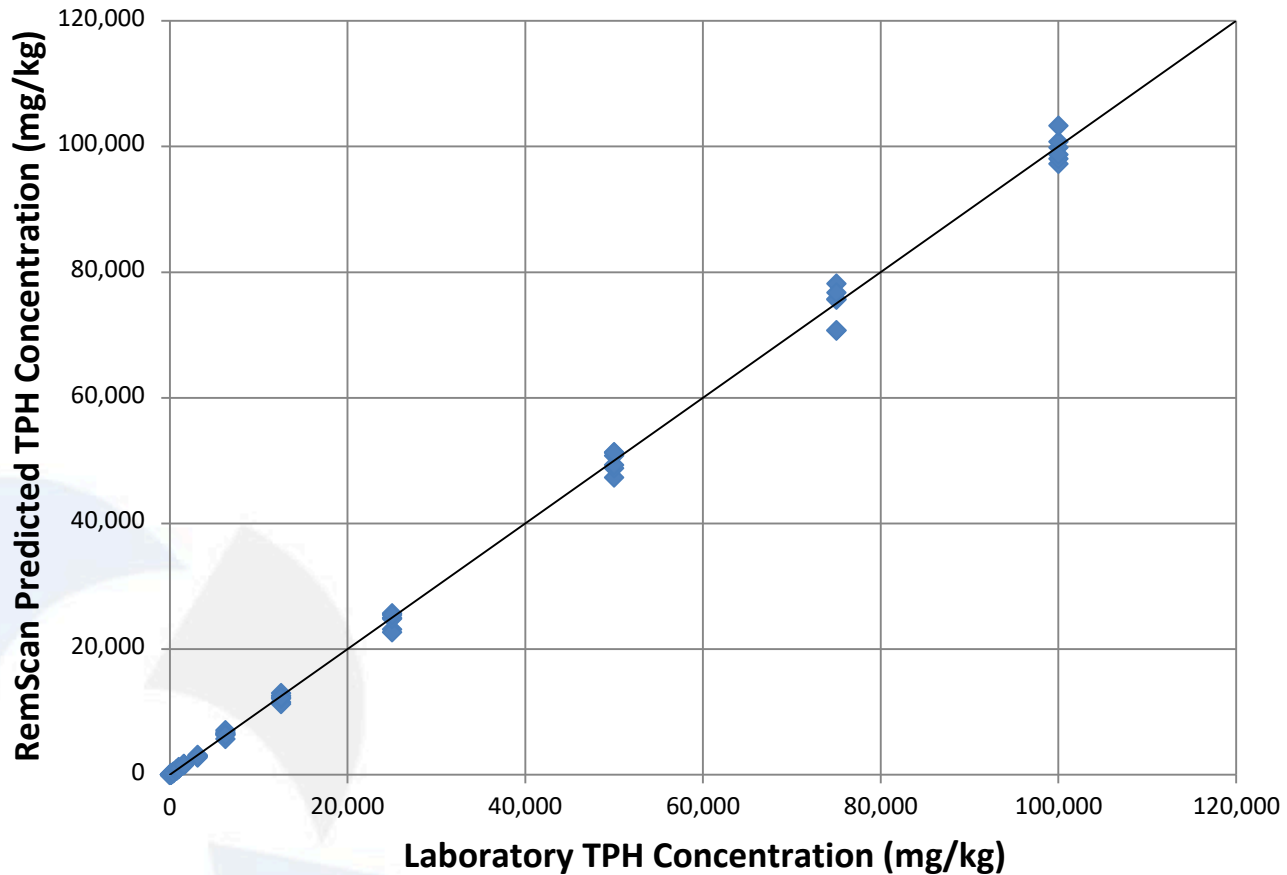Sample collection

Soil preparation

Spiking with diesel

Methodology

Scanning spiked samples

Measuring validation samples

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Results

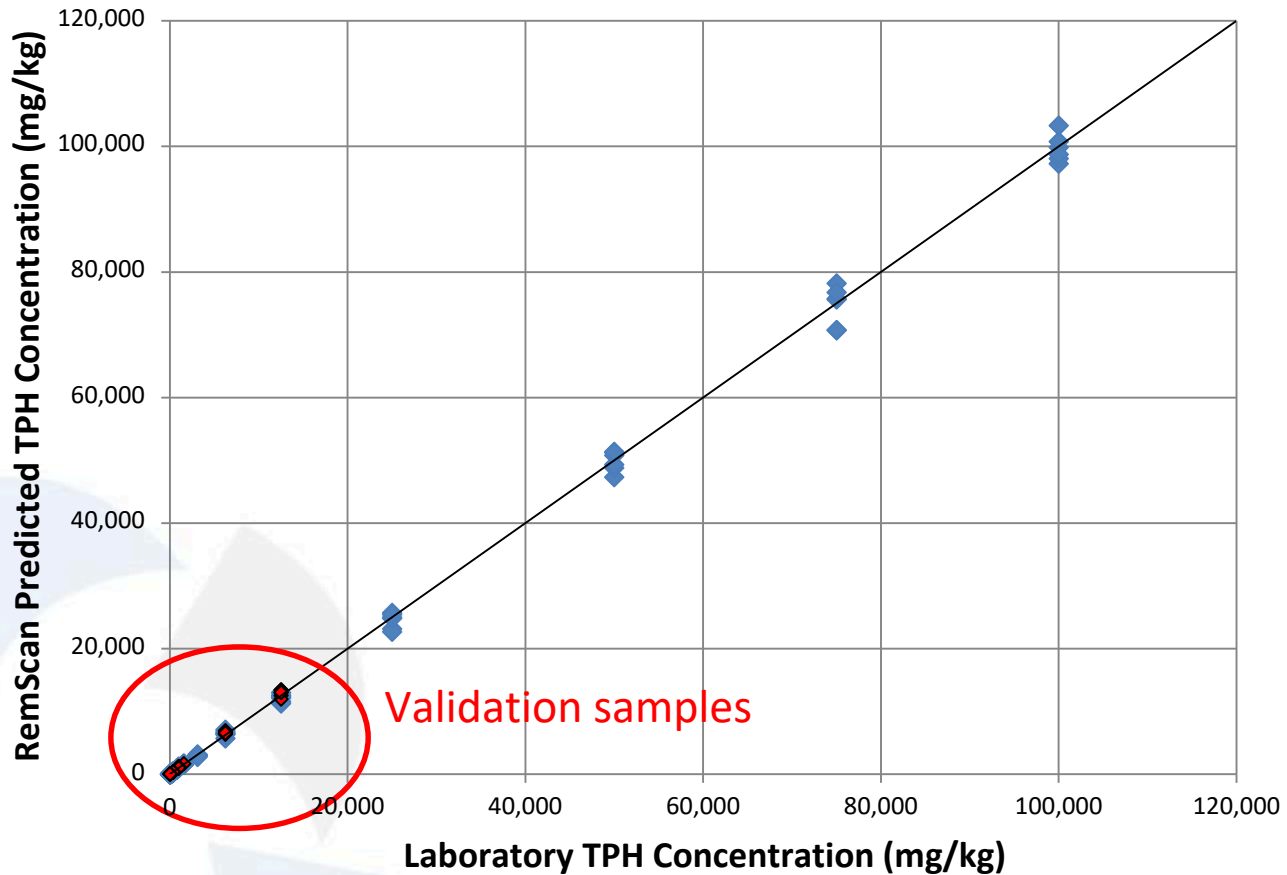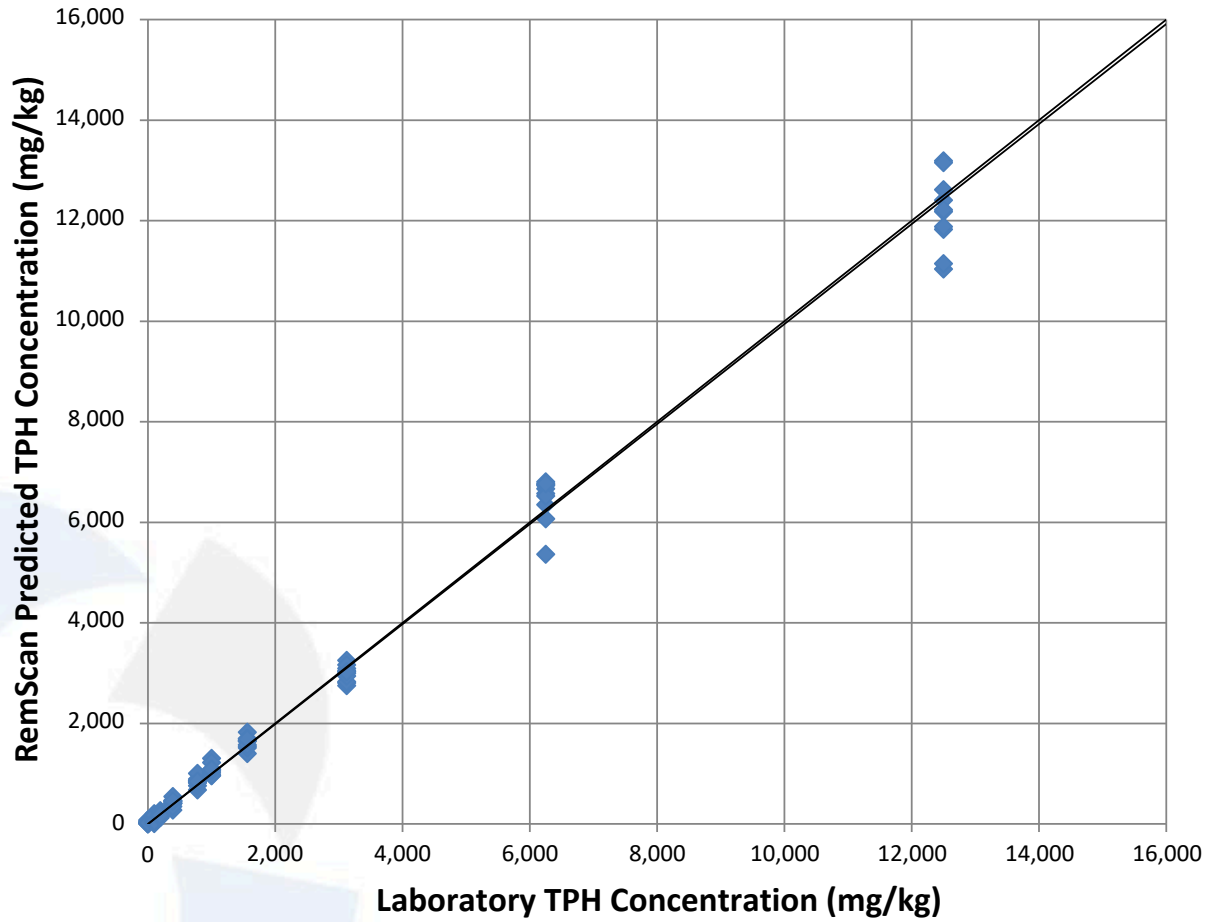**Calibration for Shanghai Region: 0 -100K mg/kg**

Results

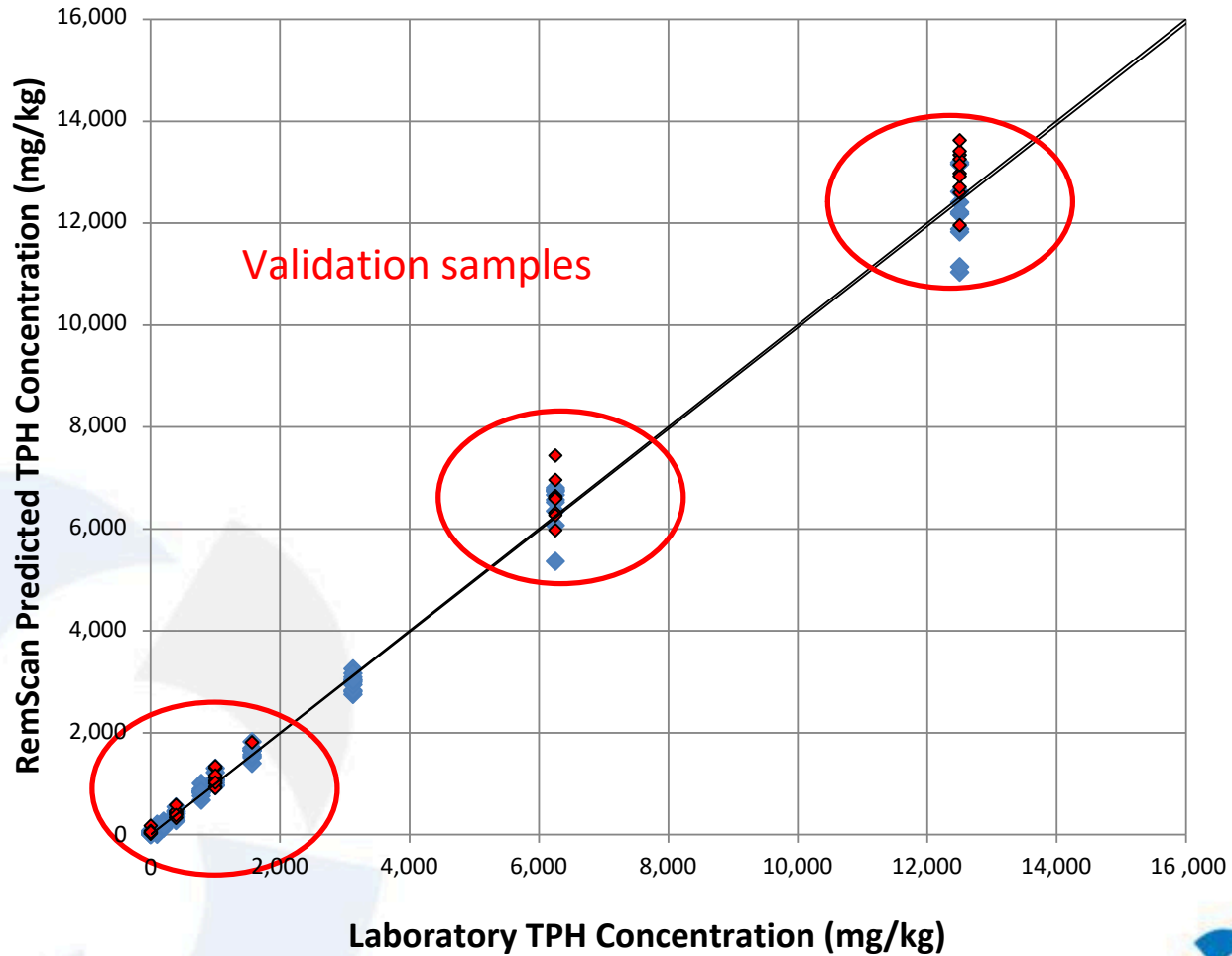**Calibration for Shanghai Region: 0 -100K mg/kg**

Results

Calibration for Shanghai Region: 0 -15K mg/kg

Results

Calibration for Shanghai Region: 0 -15K mg/kg

Summary of Calibration Model

TPH Concentration Range(mg/kg)	No. Samples	RMSECV* (mg /kg)	Relative Error	R2
20,000 -100,000	170	1,451	7%	0.998
10,000 -20,000	140	542	5%	0.994
3,000 -10,000	130	307	10%	0.992
0 - 3,000	110	102	10% (@1,000 mg/kg)	0.99

*RMSECV = Root mean square error of cross-validation (at 1 standard deviation)

Detection Limit = 77 mg/kg

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Conclusions

- A single calibration model was built for 21 soils collected from across the Shanghai region (Yangtze Delta)

- Independent validation showed similar accuracy to lab analysis

- This paves the way for the development of a China-wide calibration model

- Proof of concept achieved in China.

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Commercial Applications

- Site characterization and audits
- Emergency spill response
- Site remediation (validation and monitoring)

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Visit Booth 1008 for a RemScan demonstration