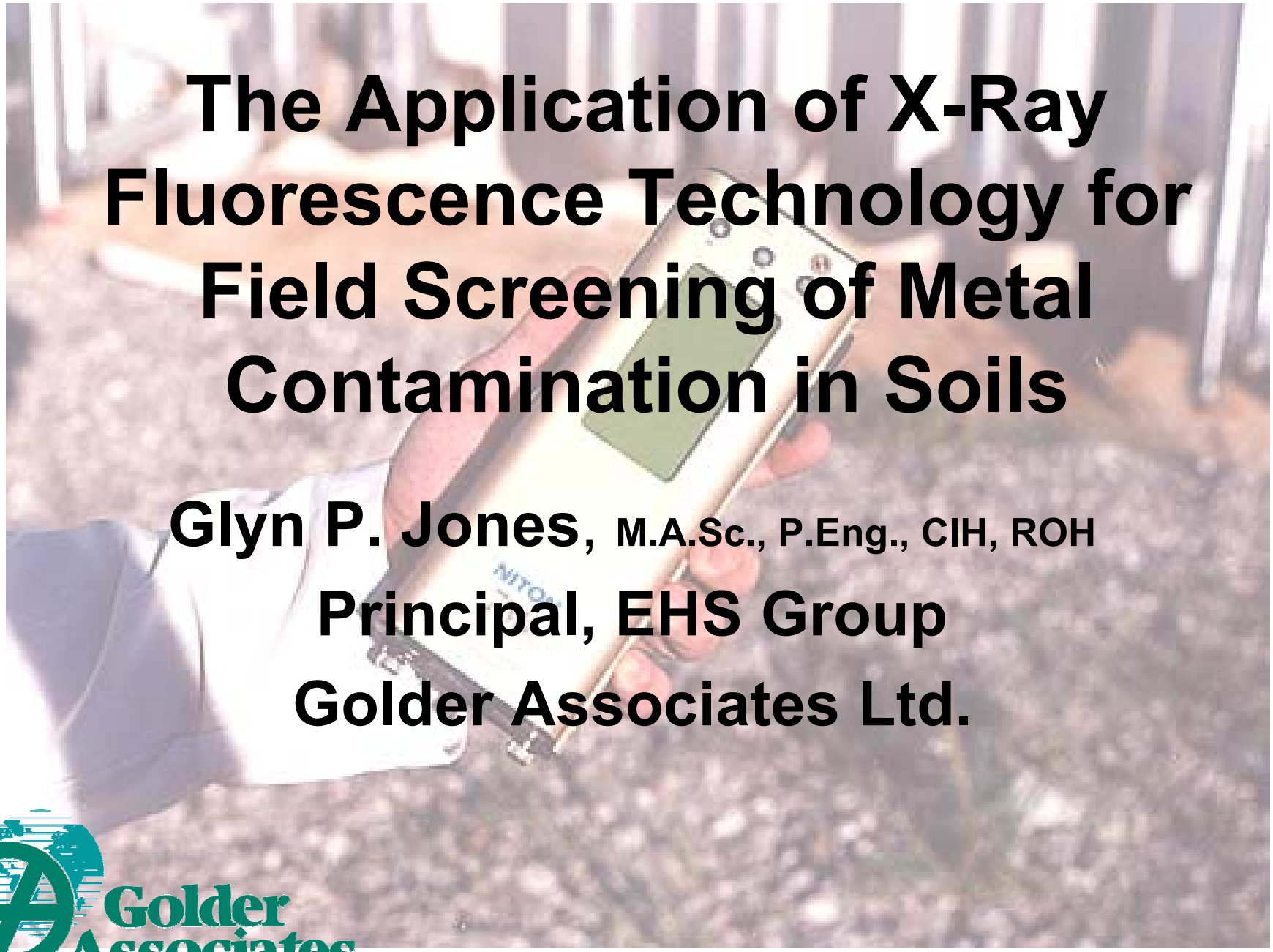

The Application of X-Ray Fluorescence Technology for Field Screening of Metal Contamination in Soils

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Principal, EHS Group

Golder Associates Ltd.

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Introduction

- Environmental site remediation often includes the removal of metal contamination in soil.
- Generally, the degree of contamination and the amount of soil and other material to be removed is dependent on the results of laboratory analysis of samples collected in the field.

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Introduction

- This analysis may take up to a week to complete, and can increase the time required to complete a remediation project.
- Different metals in soil can be measured quickly and non-destructively using an XRF detector.

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Outline

- How does XRF technology work?
- US EPA method 6200
- How does XRF compare to laboratory analysis? – field studies
- Field applications of XRF technology for waste remediation

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How Does XRF Technology Work?

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X-Ray Fluorescence

- When an x-ray emission from a radioactive source strikes a sample, the x-ray can either be absorbed by the atoms or scattered through the material.
- Different metallic atoms give off a characteristic x-ray whose energy level is unique to the elements present.

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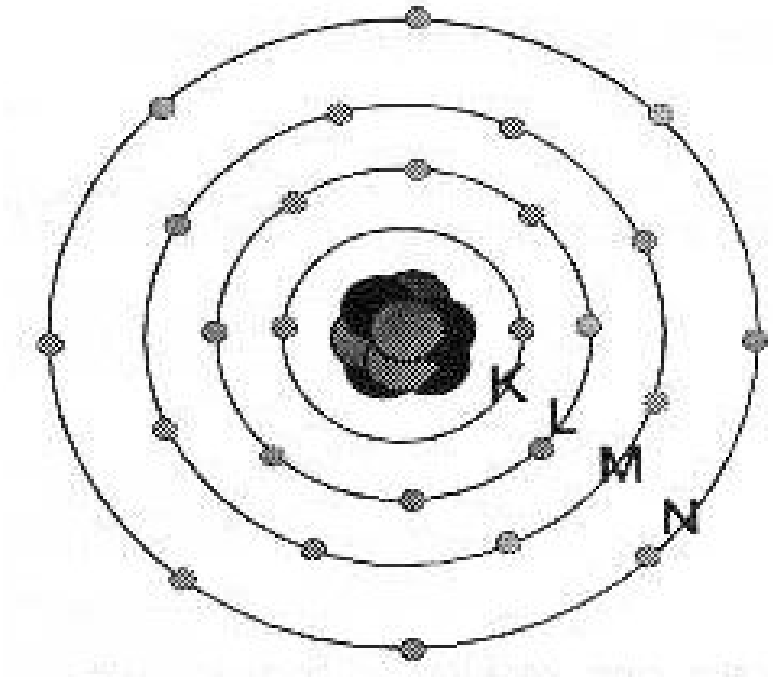
X-Ray Fluorescence



Bohr Model of the Atom
with Electron Shells

Shells always fill from
innermost to outermost

X-Ray Fluorescence uses
this property

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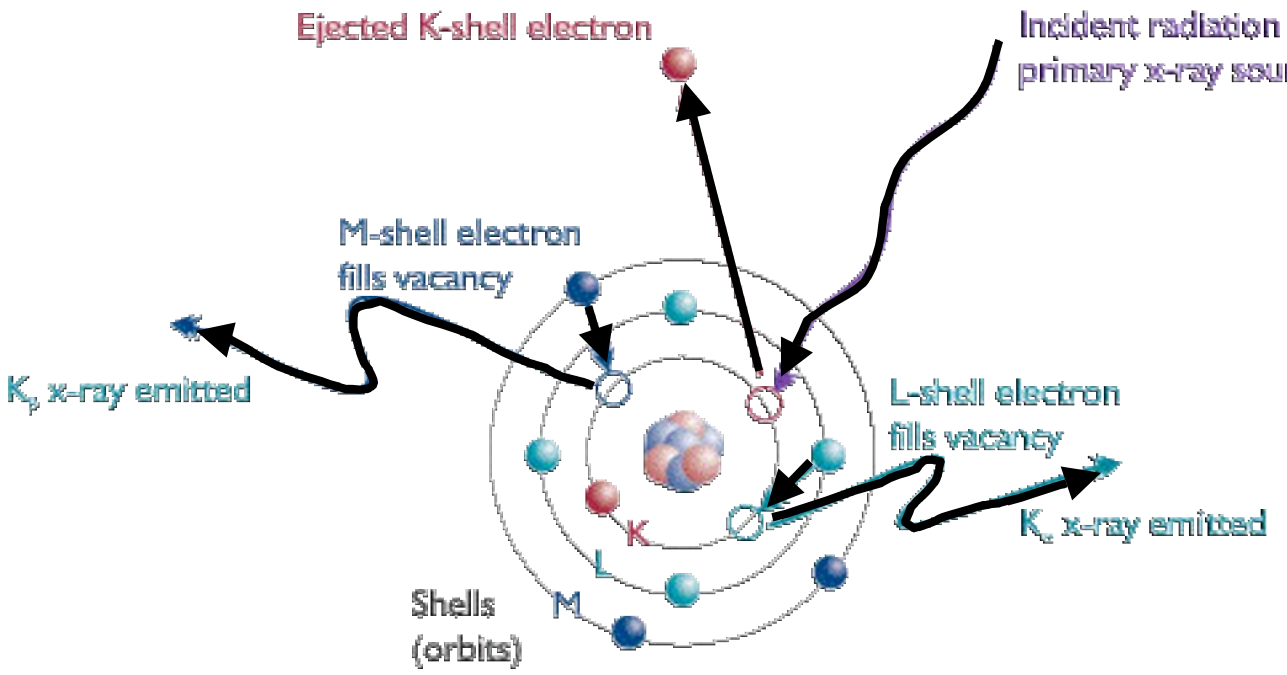
X-Ray Fluorescence



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Jumping Shells

- K-shell or L-shell electron ejected
- Vacancy in shell is filled by a more outer-shell electron (L- or M-)
- Drops to lower energy level, gives off an x-ray (energy always conserved)
- Can be a cascading effect

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XRF Detector

- Radioactive source (creates x-rays)
- Can produce x-rays with different photon energies (in keV)
- Source to use is dependent on elements to be measured

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Cadmium-109 Source

- K-shell x-rays: arsenic, chromium, selenium, zinc, copper, nickel and iron
- K- and L-shell x-rays: lead, mercury, gold and uranium

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Americium-241 Source

- K-shell x-rays: cadmium, silver, barium, tin, antimony

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XRF Detector

- X-ray Detectors
  - Respond differently to different frequencies of x-rays produced by elements in a sample
- Data Processor
  - Uses differing response to determine elements present and amount of x-rays produced by each over a period of time (quantification)

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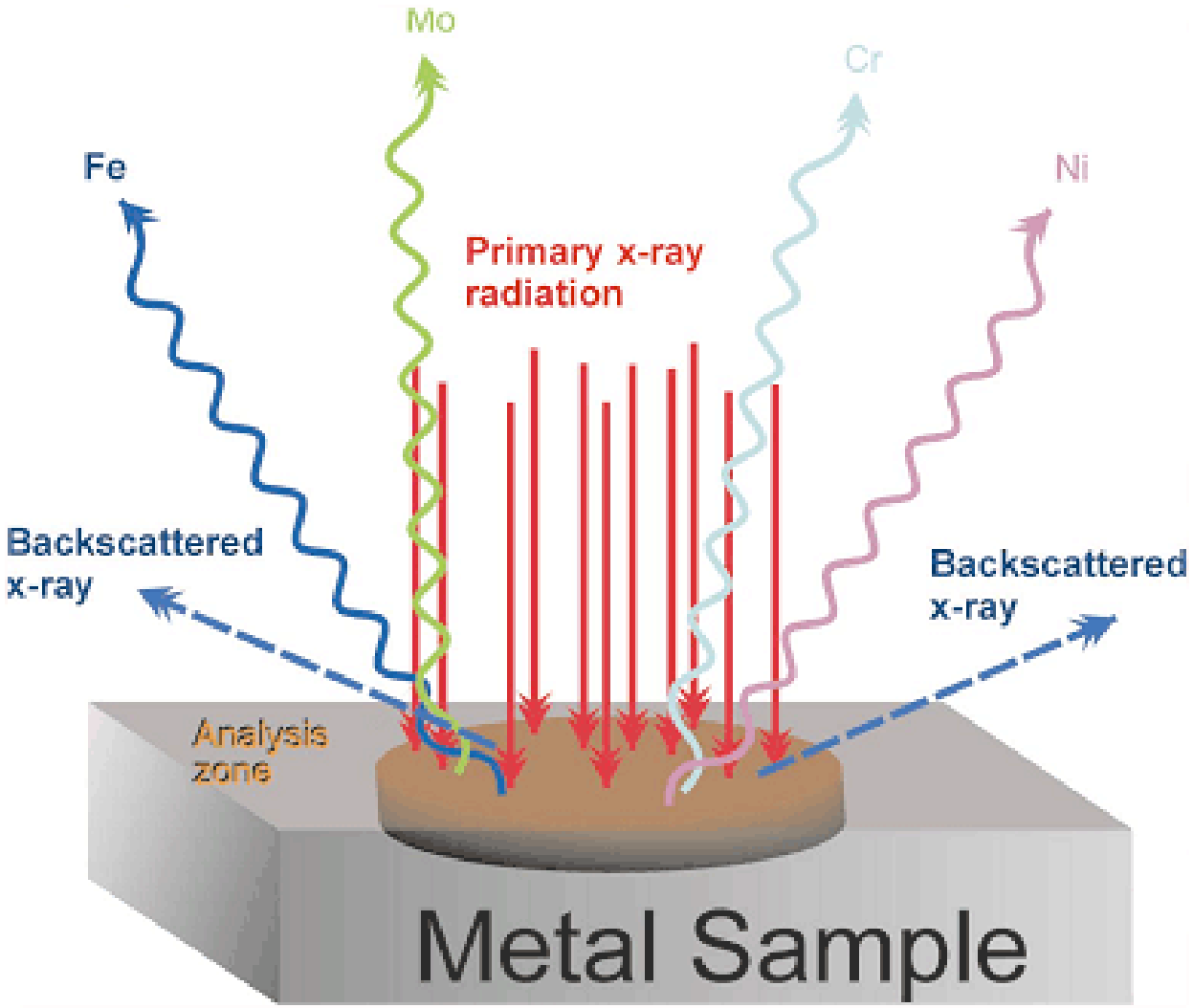
Detecting Metals in a Sample



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ANALYZER WORKS

1. Primary x-ray energy is directed at the sample surface
2. The primary energy causes an electron to be ejected from its orbit
3. The vacancy left by the ejected electron is filled by an electron from another shell, resulting in the emission of a fluoresced x-ray, characteristic of the element from which it is emitted.
4. The fluoresced x-ray enters the detector, which registers the event and sends an electronic pulse to the preamp.
5. The preamp amplifies the signal and sends it on to the Digital Signal Processor (DSP)
6. The DSP collects and digitizes the x-ray events occurring over time, and sends the resulting spectrum to the main CPU for processing
7. The CPU, using an advanced fundamental parameters (FP) spectral processing algorithm, mathematically converts the x-ray spectrum into a detailed composition analysis.
8. The composition data is simultaneously displayed on the instrument screen, and stored in memory for later recall and/or download to an external PC

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In-Situ versus Ex-Situ

In-situ testing of soil by placing XRF directly onto the ground. Generally provides screening level data quality.

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In-Situ versus Ex-Situ

Ex-situ prepared sample testing using XRF. With proper sample homogenization, provides analytical grade testing data.

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Advantages of Field Screening with XRF

- Allows focus of sampling for lab analysis
- Assures site meets clearance levels before contractors leave the site
- Minimize volume of hazardous waste for treatment or disposal

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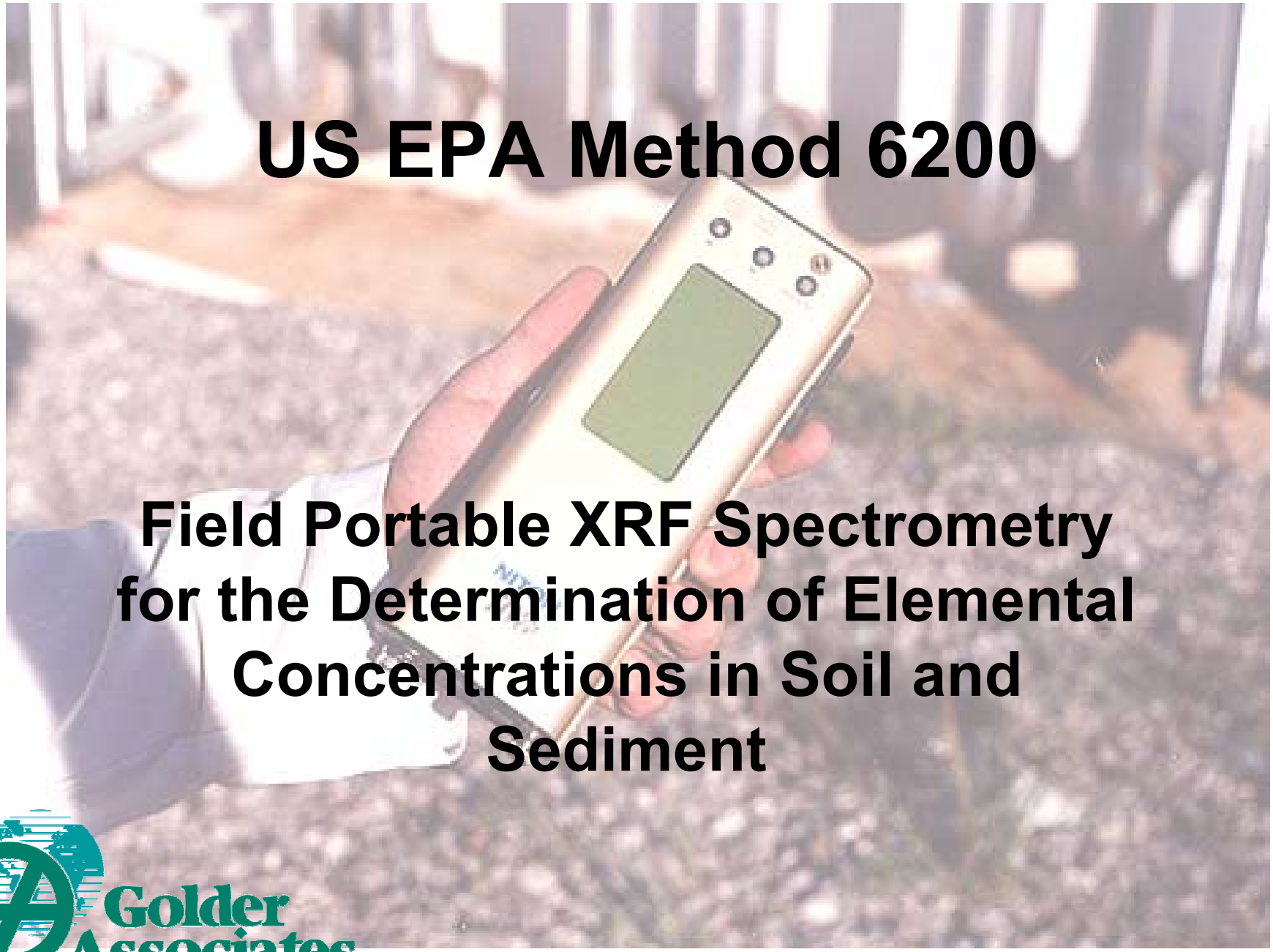

US EPA Method 6200

Field Portable XRF Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment

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US EPA Method 6200

- Specific methodology has been developed to ensure that the results of in-situ (or field) sampling are comparable to the results one would receive if samples were collected and sent to a laboratory for analysis.

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US EPA Method 6200

- Field screening method, using in-situ or bagged samples
- Used to thoroughly characterize a site
- Can analyze more samples than generally possible when removing or collecting samples and analyzing at a lab

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US EPA Method 6200

- Provides basic QA/QC methods
- Recognizes that some instruments do not require site-specific calibration
- Minimum of 5% of samples tested by XRF be confirmed by outside lab
- Does not provide sample collection technique

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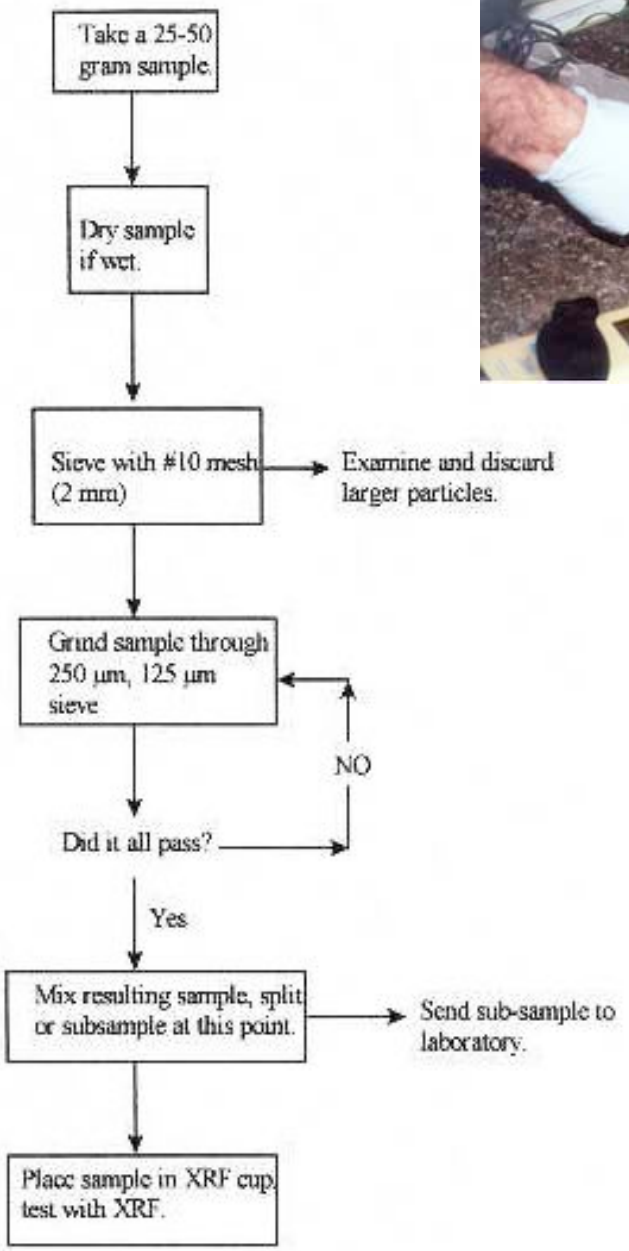
Sample Prep Procedures from NITON



Sample Preparation

- In general, more sample preparation (drying, milling and sieving) will result in greater accuracy
- Better measurements can be collected with drier, finer, and more homogeneous particles

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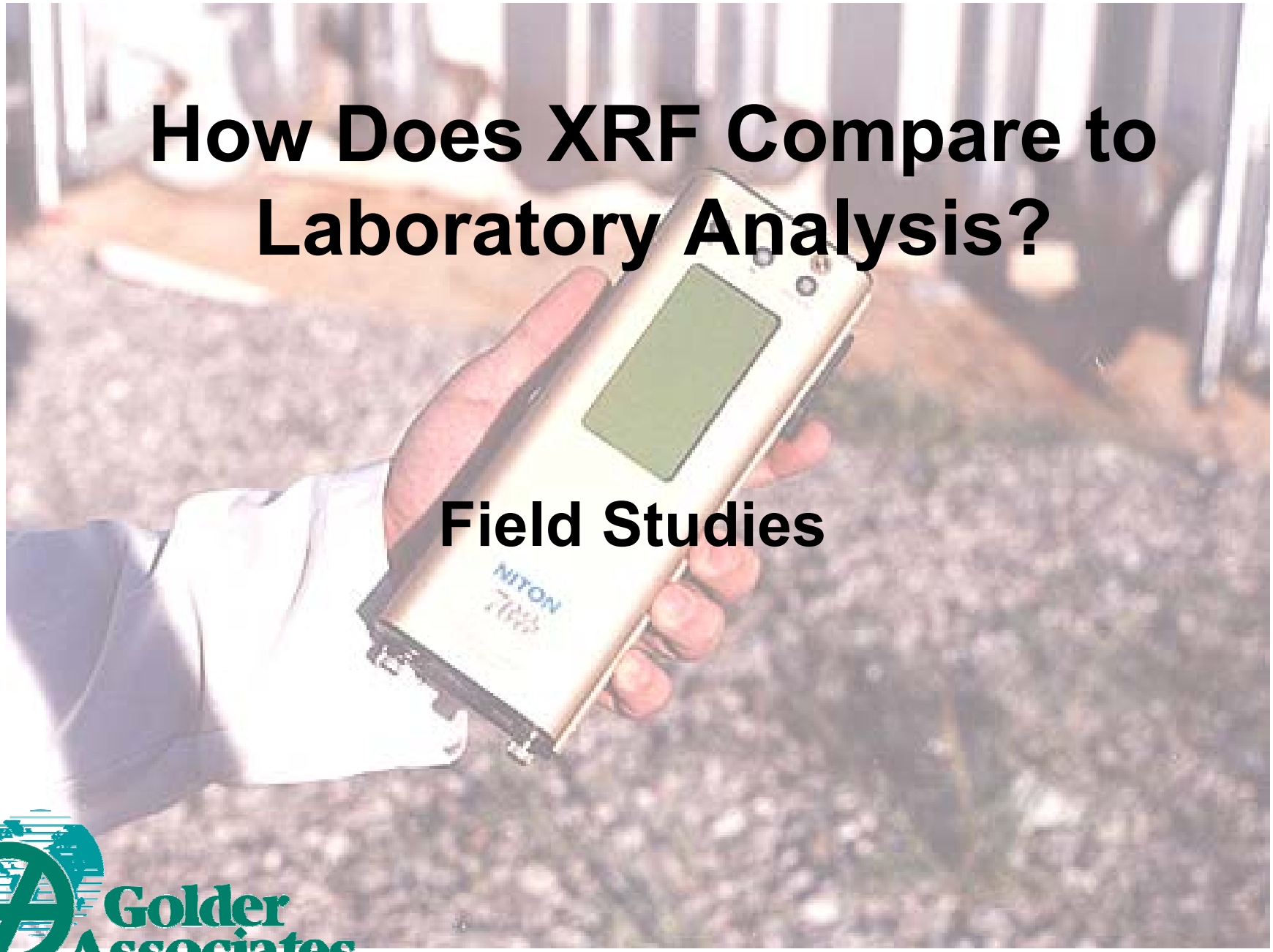
How Does XRF Compare to Laboratory Analysis?

Field Studies



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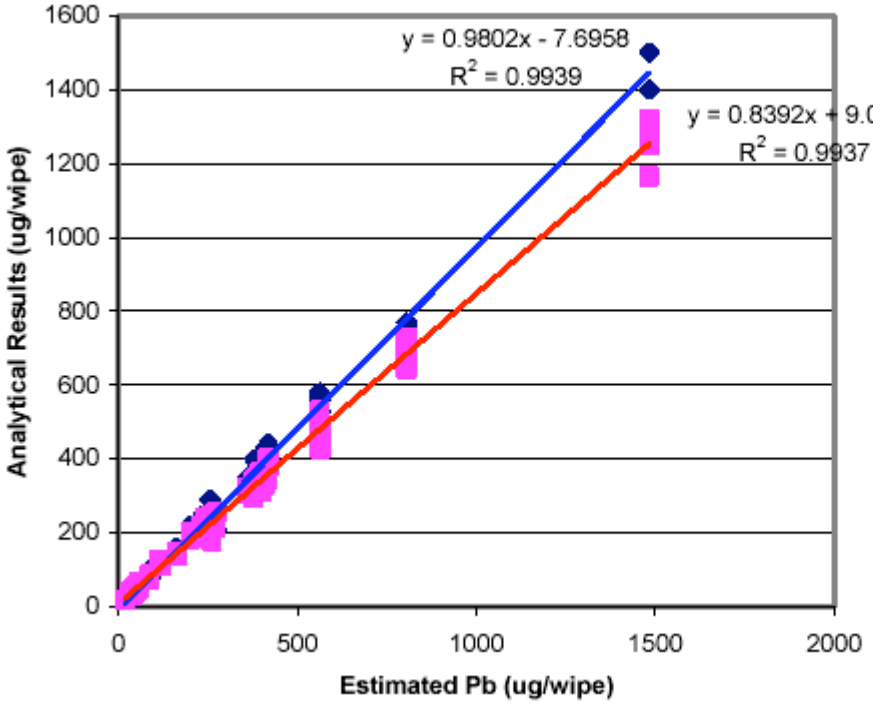
NITON XL-300



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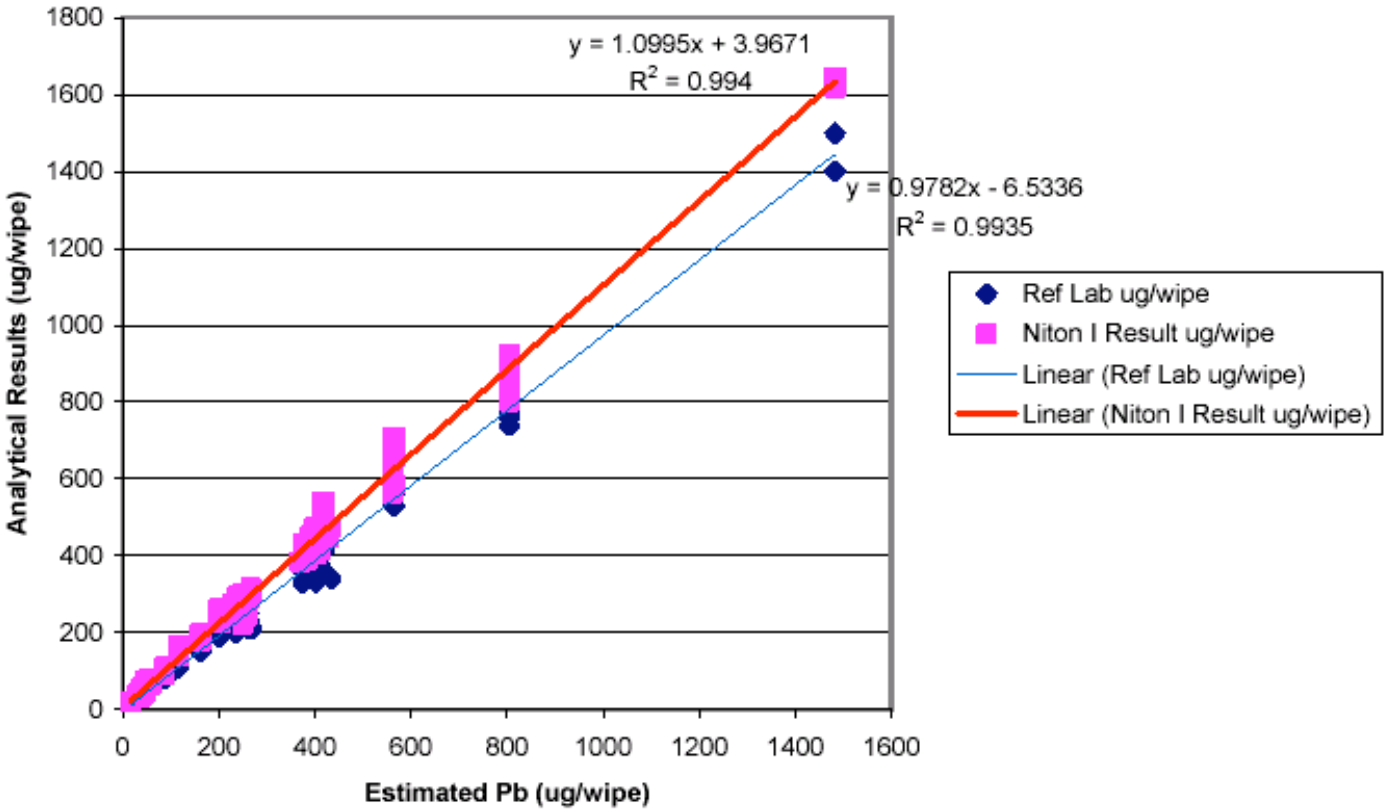
NITON XL-700



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NITON Conclusions

- When comparing the NITON results with those of the NLLAP accredited laboratory, ***both NITON instruments reported fewer false negatives*** (defined as a result below the 40 µg/wipe action level where the "Estimated Pb" is above 40 µg/wipe) ***than the NLLAP accredited reference lab.***

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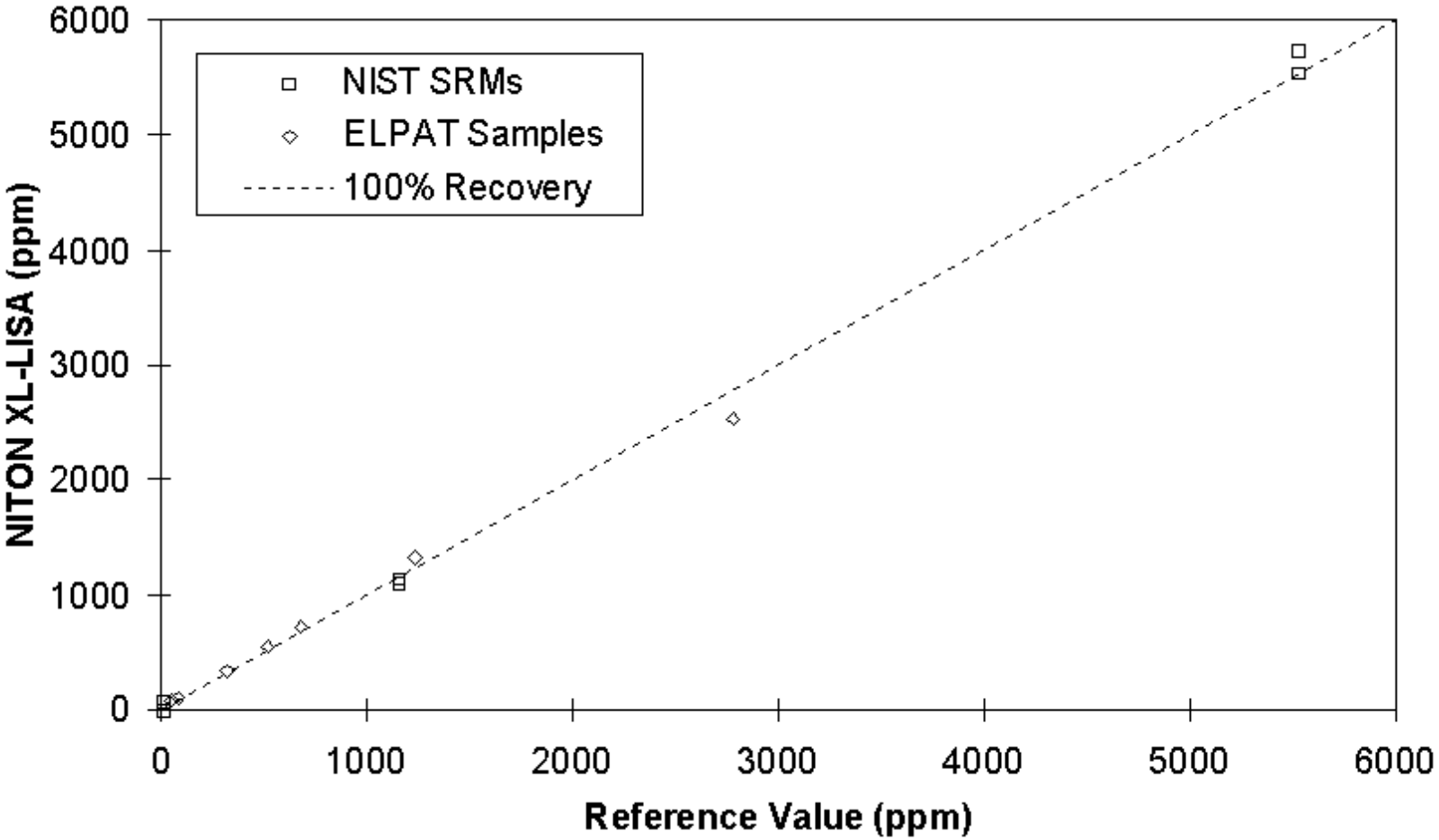
Performance of Field-Portable XRF for Lead-in-Soil Reference Materials



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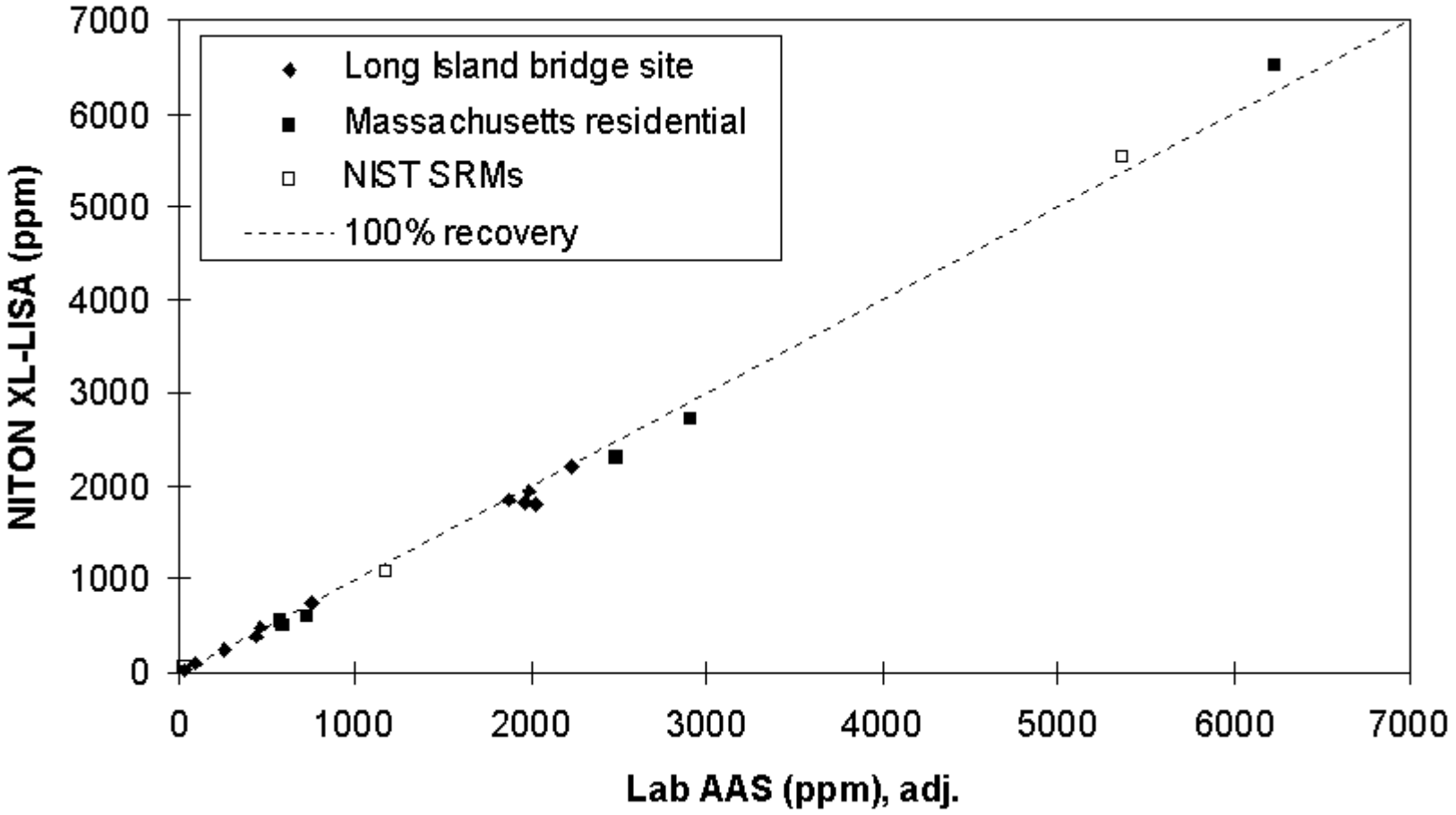
Comparison of fully prepared XRF (oven dried, screened, ground to 0.125 mm or less, and cupped) and laboratory AAS results



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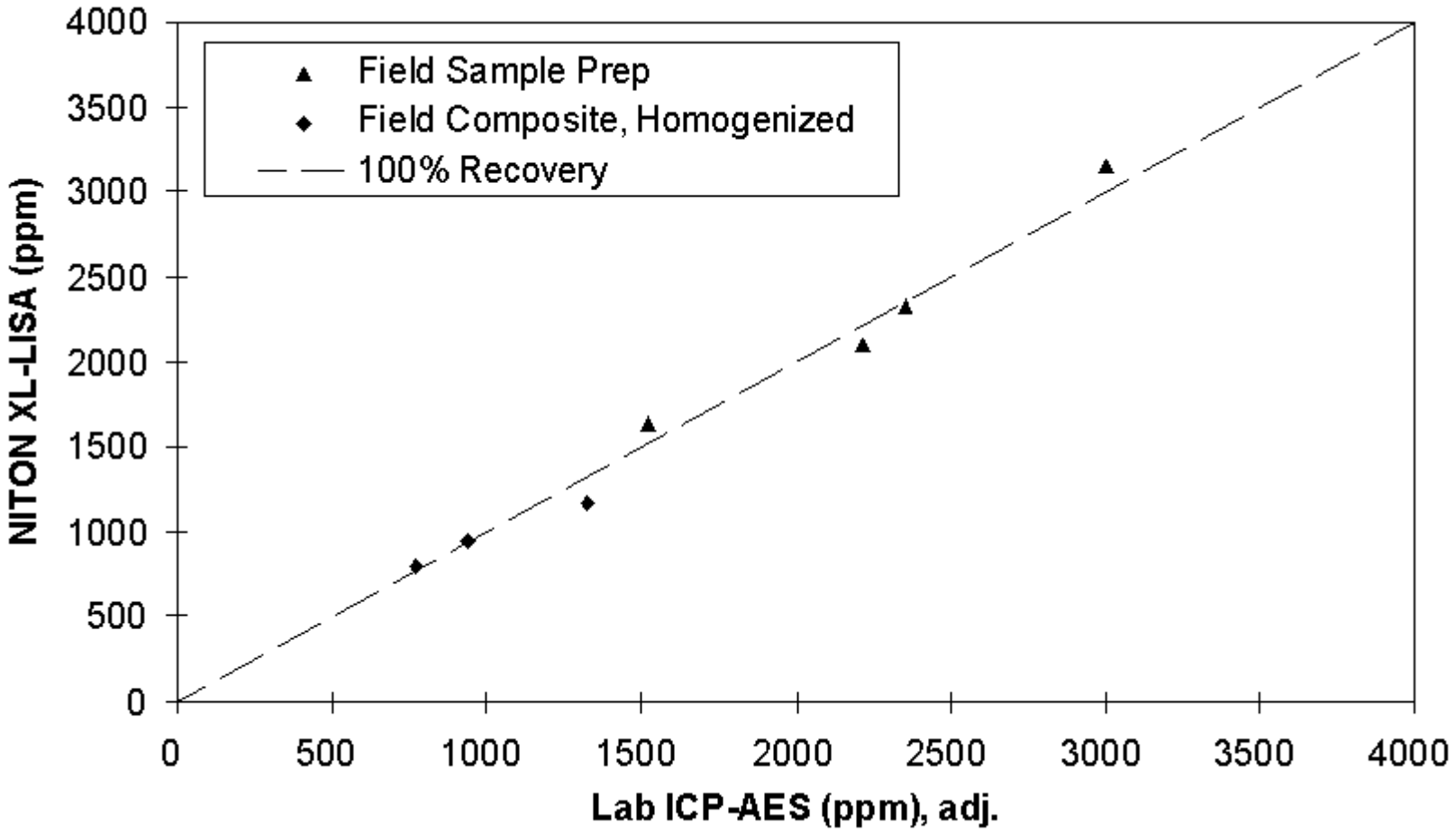
Comparison of field prepared XRF (field dried, screened, ground to 0.250 mm or less, and cupped) and laboratory ICP-AES



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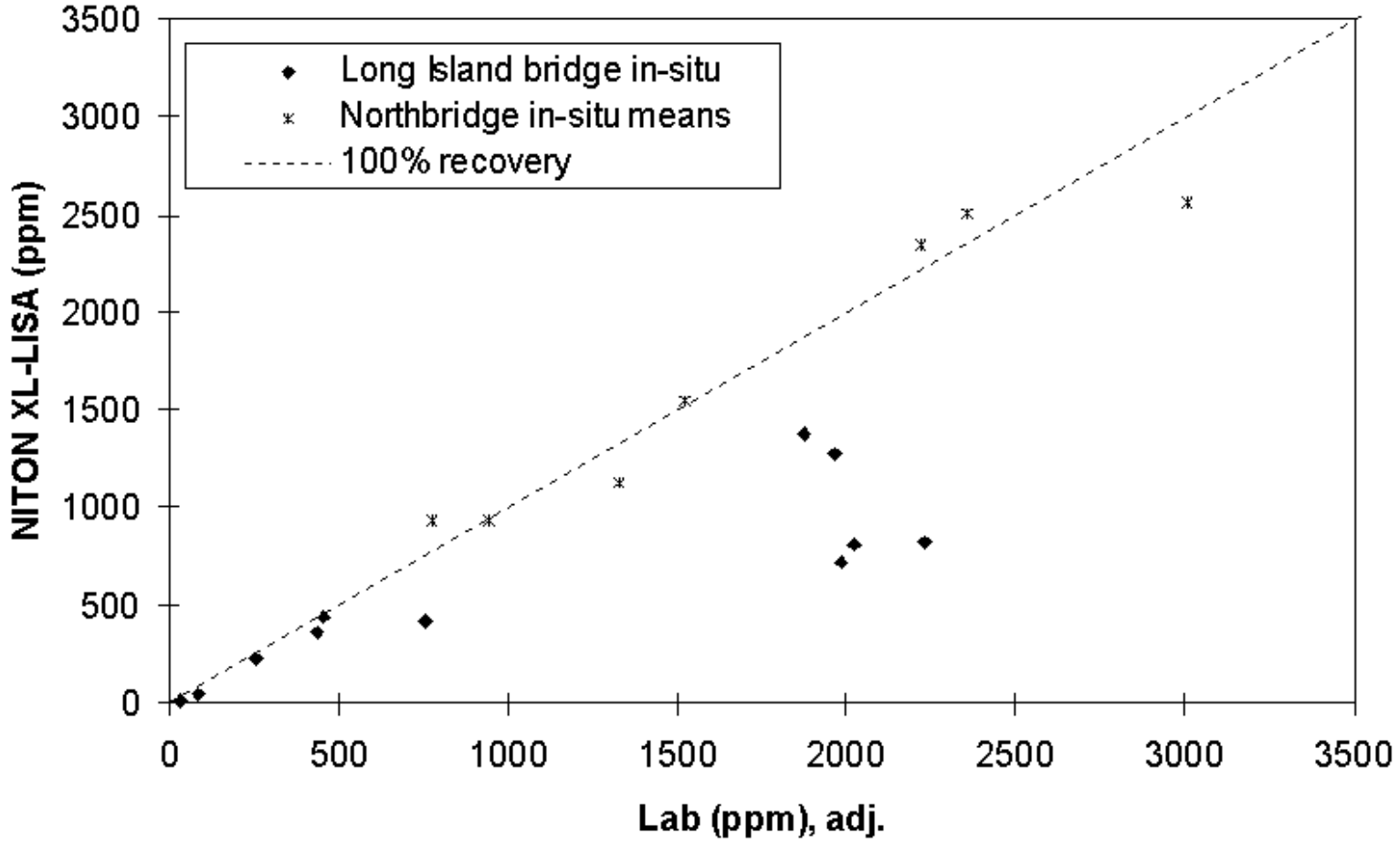
Comparison of in-situ XRF results with laboratory AAS and ICP-AES



The Long Island bridge site in-situ measurements exhibit strong negative bias, probably due to the concentration of lead in relatively large particles (paint chips).

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Arsenic Sampling

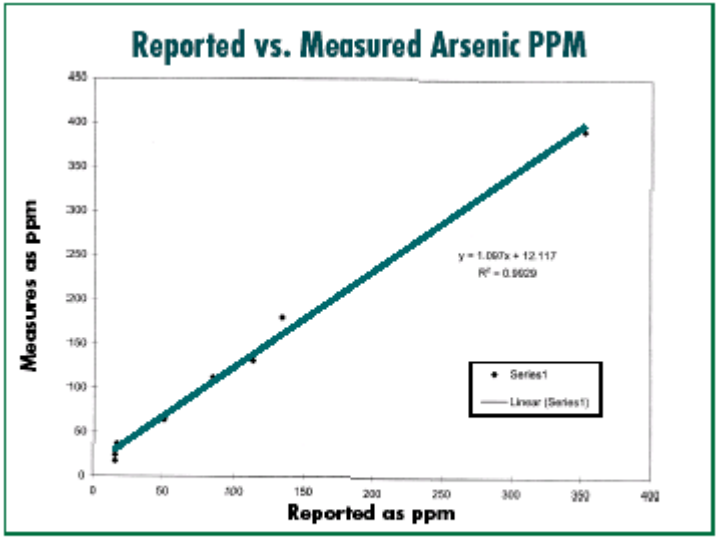

Figure 1. Comparison of reported arsenic ppm vs. measured arsenic ppm for the Canadian powerplant.

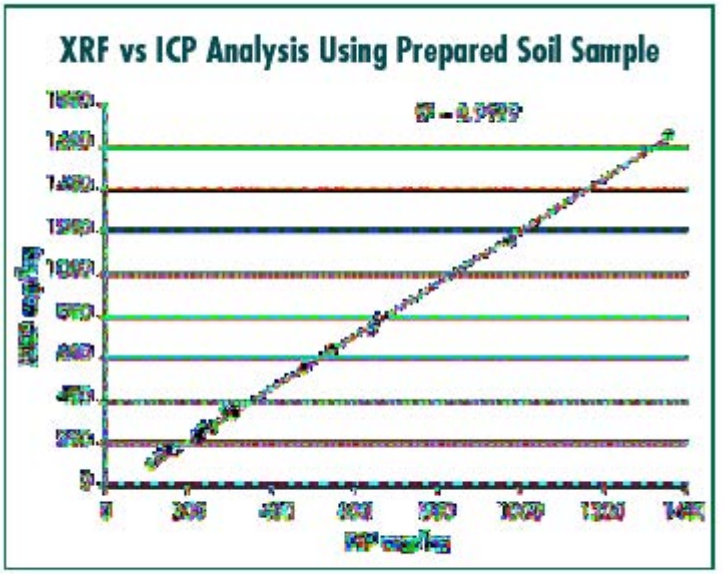

Figure 2. Comparison of NITON XRF results to laboratory results for arsenic in soil.

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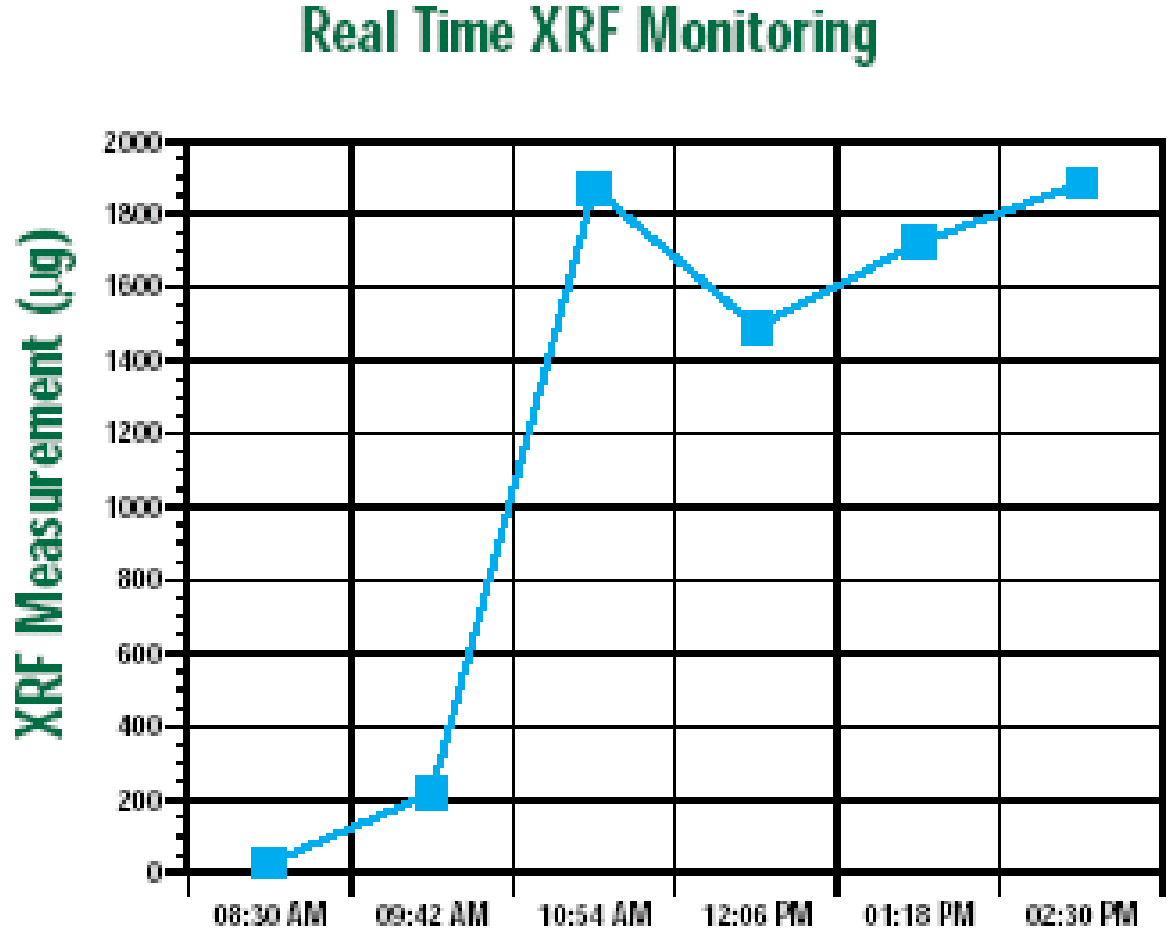
Real-Time Monitoring of Lead on Filters



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Field Applications of XRF Technology for Waste Remediation

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Field Applications

- analyzing dust wipes from a risk assessment while still at the project site
- prioritizing sample collection
- ensuring that final samples after abatement will pass clearance at an accredited laboratory

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Field Applications

Contaminated Site Remediation

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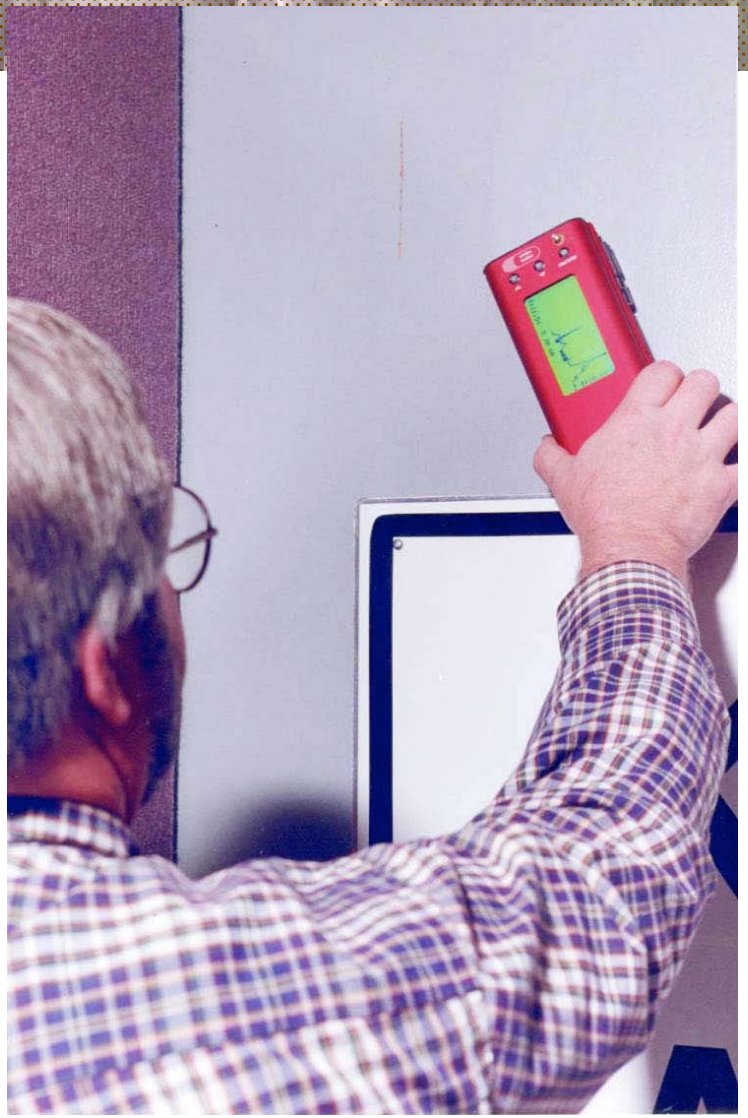
Field Applications

In-Situ Testing of Surfaces for Lead



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