Module 6

Composite/Incremental Sampling:
Case Study - Paducah Site

Triad

Systematic Planning  Dynamic Work

Real-Time Measurements
Case Study Highlights

• Use of gamma walkover surveys
• Use of dynamic work strategies
• Use of soil sample compositing strategies:
  – Incremental soil sampling for estimating average concentrations
  – Composite search methods for hot spot identification
• Application of real-time analytical methods
Case Study Background

- The Paducah site is an active uranium enrichment facility
- Historical processes resulted in release of PCBs and uranium to the environment
- Ditch and creek with contaminated sediments were dredged, and the spoils were placed along the banks almost 30 years ago
- Present concern is PCB and uranium contamination in soils where dredged materials were placed
- Assumption is that uranium and PCBs are commingled
Area of Concern

- Approximately 1 acre
- Mostly grassland
- Bordered by waste ditch on west and creek to the south
- Concern is sediment spoils from ditch and creek
- Spoils placement probably 20 to 30 years ago
Applicable Criteria

- MARSSIM applies due to radionuclide (uranium) presence
  - Multi-Agency Radiation Survey and Site Investigation Manual
- MARSSIM assumes two criteria:
  - Wide-area averaged criterion applied to an exposure unit (EU)
  - Hot spot criterion applied to much smaller areas
- For this site, those criteria were:

<table>
<thead>
<tr>
<th></th>
<th>Area-Averaged</th>
<th>Hot Spot (25 m²)</th>
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</thead>
<tbody>
<tr>
<td><strong>Uranium:</strong></td>
<td>10 ppm</td>
<td>90 ppm</td>
</tr>
<tr>
<td><strong>Total PCB:</strong></td>
<td>3.6 ppm</td>
<td>33 ppm</td>
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Analytical Options

• Uranium (background \( \sim 3 \) ppm)
  – Gamma walkover surveys (qualitative)
  – XRF (quantitative, MDC \( \sim 10 \) ppm)
  – Alpha spectroscopy (“definitive”)

• Total PCBs (not in background)
  – Test kits (semi-quantitative, MDC \( \sim 0.5 \) ppm)
  – GC (“definitive”)
Gamma Walkover Surveys Provided Unique Data Set

More than 20,000 measurements provided high-density spatial resolution regarding the presence/absence of uranium contamination.
Decision Unit Layout Based on CSM

- Total area = 0.98 acre
- 3 exposure (decision) units, each reflecting a different level of concern about whether contamination present above criteria
- DUs formed to avoid diluting contamination, if present
- CSM based on assumption of contaminant release mechanism, and on gamma walkover survey results
- Hot spots considered a potential issue for the 2 units with higher probability of contamination
Contamination Heterogeneity was a Recognized Problem

Total U (XRF) for example 1-ft$^2$ surface area

- 49 ppm
- 113 ppm
- 496 ppm
- 30 ppm
- 116 ppm

September 11, 2012

Portsmouth Training

Loc 13-1-10 Depth (in) vs Total U (ppm)
Sampling Strategy Requirements

• Show compliance with wide area-averaged criteria for uranium and PCBs for each EU (95%UCL comparison)
• Demonstrate that hot spot concerns are not present for the 2 EUs with a higher likelihood of contamination
• Provide data to support surgical soil removal if necessary
Strategy
Combine Incremental-Averaging with Composite-Searching

- Gamma-walkover data already indicated at least one uranium hot spot was likely present
- Generally elevated uranium present in one EU that might pose a concern
- Composite-searching to cost-effectively address PCB hot spot concerns
- Incremental-averaging across EUs to show wide-area-average compliance
Sample Compositing Took Place Over Two Different Spatial Scales

- One 5-increment composite sample per 25 m$^2$
  - Each bottom-tier composite sample homogenized and split
  - One half archived, the other half used to form top-tier composites
- # of samples contributing to the top-tier composites depended on possibility of contamination
  - 5 for EU with the greatest chance of contamination
  - 8 for the EU with a medium chance of contamination
- Composites analyzed by XRF and PCB immunoassay kits
- Results compared to decision criterion
  - Decision criterion = (hot spot criterion)/(# of samples in composite)
  - Composite results averaged across EU
  - Average compared to the wide-area-average criteria
Compositing Strategy…

Area to be checked for hotspots = yellow & pink with a total area of 1700 m² (68 25-m² areas)
Results…

• As expected, one composite failed for U, requiring analysis of the archived primary samples
• Its EU as a whole also failed its average comparison (95%UCL > action level)
• Split analysis identified one 25 m² “hot spot”
  – Corresponded to hot spot identified by gamma walkover survey (GWS)
• Hot spot remediated, exposed soil re-sampled
• Re-sampled results pooled with original data, EU now passed 95%UCL comparison
This DU was a "decision unit" in your original slides.

jody.edwards, 10/8/2009
Summary of Increment & Composite Numbers

- 385 total soil increments
  - 190 from 1\textsuperscript{st} exposure unit (EU) – High contamination probability
  - 155 from 2\textsuperscript{nd} EU – Some contamination probability
  - 40 from 3\textsuperscript{rd} EU – Low contamination probability
- Resulting in 77 bottom-tier increment-average samples
  - 38 from 1\textsuperscript{st} EU
  - 31 from 2\textsuperscript{nd} EU
  - 8 from 3\textsuperscript{rd} EU
- Producing 11 top-tier search-composites for analysis
  - 7 from 1\textsuperscript{st} EU
  - 4 from 2\textsuperscript{nd} EU
- 8 increment-average (single tier) composites from 3\textsuperscript{rd} EU
- A total of 23 sample analyses
  - Cleared 68 25-m\textsupersquare areas of hot spot concerns
  - Demonstrated wide-area average compliance for 3 EU's
Overall Performance

- GWS provided insights into spatial distribution of contamination
- XRF extremely accurate for uranium and provided quick turn-around results
- Compositing strategies provided significant cost savings
- Analytical costs for 1st EU reduced by 68%
- Analytical costs for 2nd EU reduced by 88%
Any Questions?