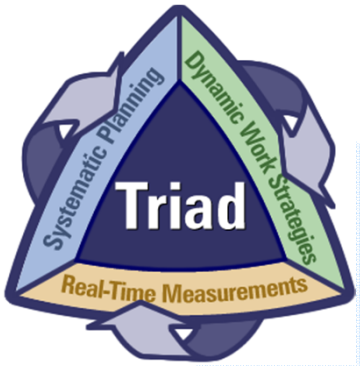
Module 8

Composite/Incremental Sampling:

Case Study - Paducah Site



Case Study Highlights

- Use of Gamma Walkover Surveys
- Use of regression analysis
- Use of dynamic work strategies
- Incremental soil sampling
- 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

September 11, 2012

Pc

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:

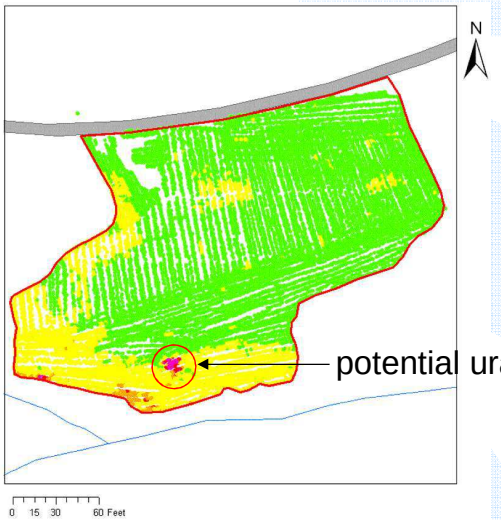
	Area-Averaged	**Hot Spot (25 m^2)**
Uranium:	10 ppm	90 ppm
Total PCB:	3.6 ppm	33 ppm

Analytical Options

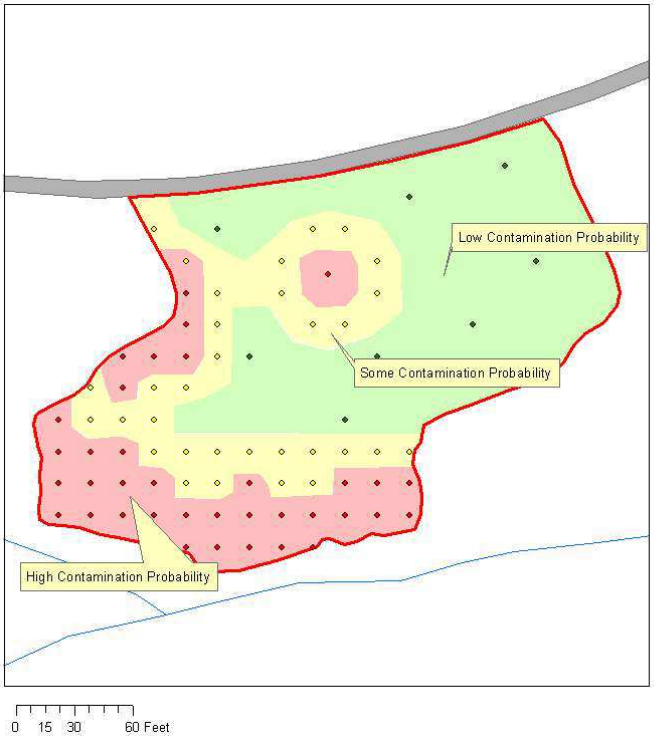
- Uranium (background ~ 3 ppm)
  - Gamma walkover surveys (qualitative)
  - XRF (quantitative, MDC ~ 10 ppm)
  - Alpha spectroscopy (“definitive”)
- Total PCBs (not in background)
  - Test kits (semi-quantitative, MDC ~ 0.5 ppm)
  - GC (“definitive”)

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

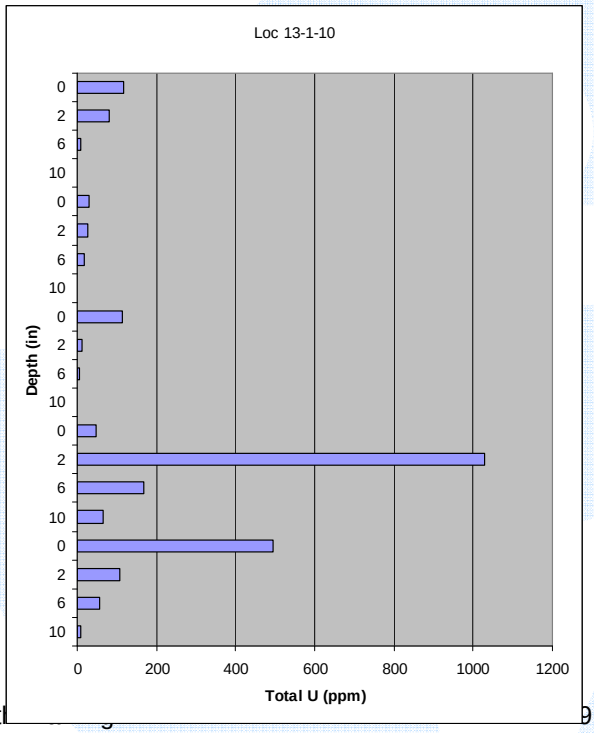
49 ppm

113 ppm

496 ppm

30 ppm

116 ppm



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

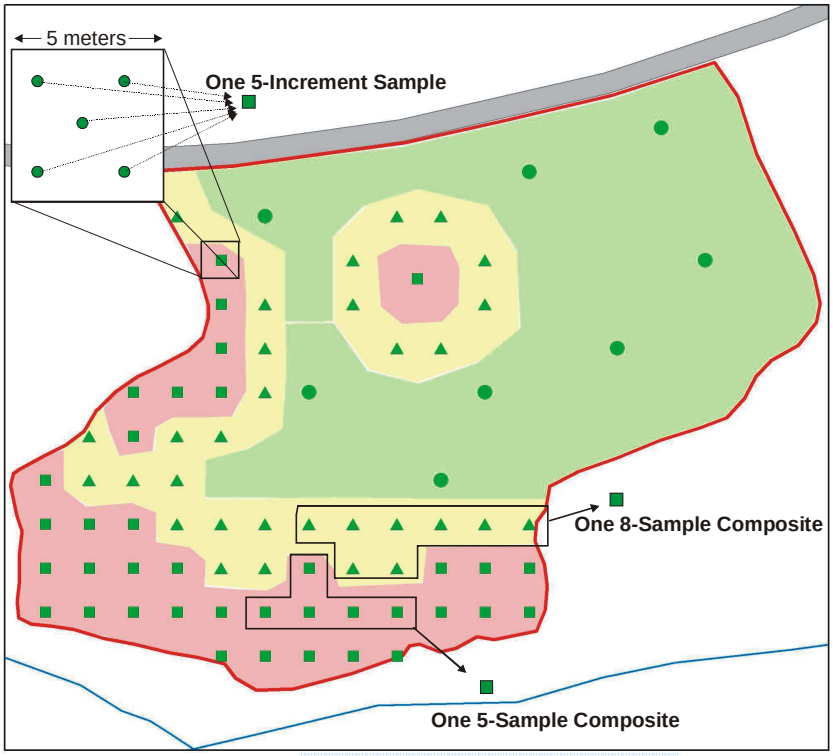
- Gamma-walkover data already indicated at least one uranium hot spot was likely present
- Generally elevated uranium present in one EU that might pose a concern
- Composite-searching cost-effectively addressed PCB hot spot concerns
- Incremental-averaging across EUs used to show wide-area-average compliance

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 1,700 m^2 (68 25-m^2 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 m^2 “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

Slide 14

JE4 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 1st exposure unit (EU) – High contamination probability
  - 155 from 2nd EU – Some contamination probability
  - 40 from 3rd EU – Low contamination probability
- Resulting in 77 bottom-tier increment-average samples
  - 38 from 1st EU
  - 31 from 2nd EU
  - 8 from 3rd EU
- Producing 11 top-tier search-composites for analysis
  - 7 from 1st EU
  - 4 from 2nd EU
- 8 increment-average (single tier) composites from 3rd EU
- A total of 23 sample analyses
  - Cleared 68 25-m^2 areas of hot spot concerns
  - Demonstrated wide-area average compliance for 3 EUs

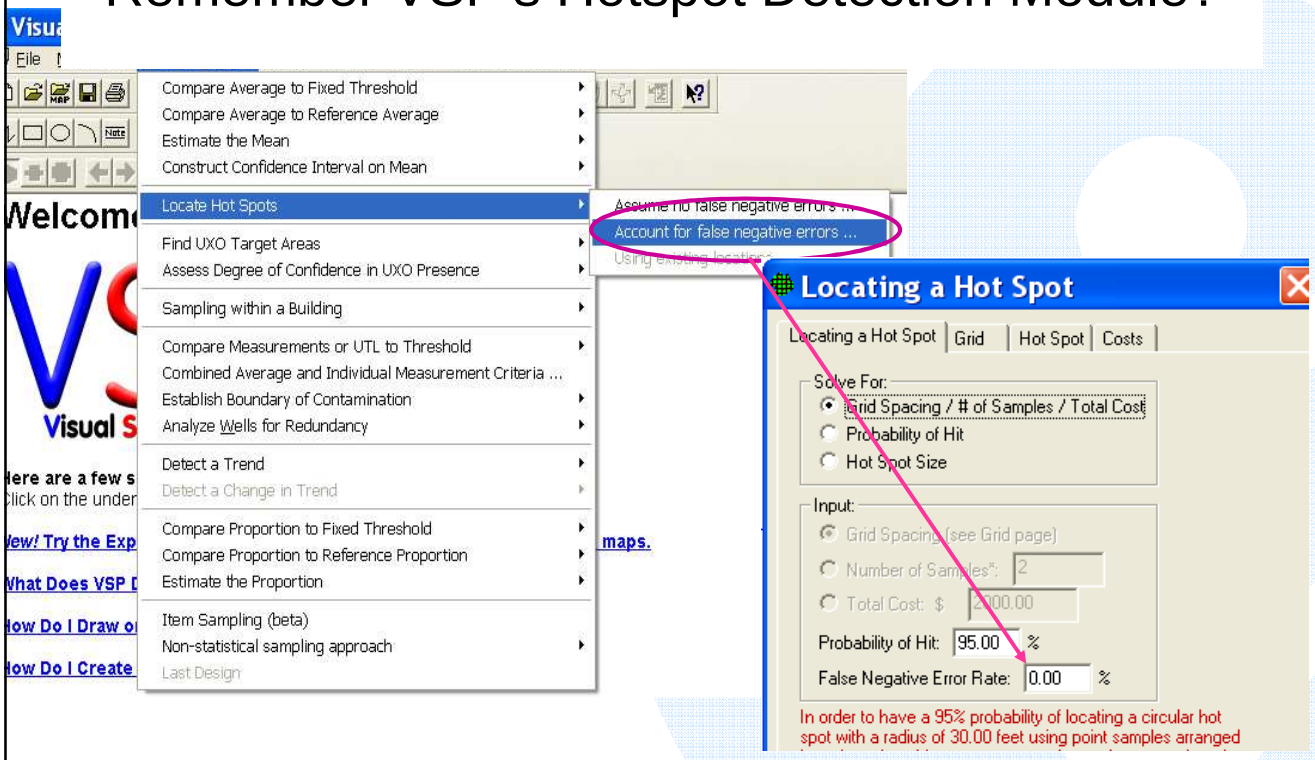
Hot Spot Detection Performance: Why 5 Increments per 25 m^2?

- Assume that within a hotspot (defined as ≥ 25 m^2), chance of any single increment > criterion is 50%
- Assume that if composite contains even one increment above the criterion, composite result will be > criterion
- Theoretical chances of a composite identifying a hot spot:
  - Discrete sample: 50% (possible outcome = **>** or **<** = 1 of 2)
  - 2-increment composite: 75% (**<<**, **<>**,**><**,**>>** = 3 out of 4)
  - 3-increment composite: 87.5% (**<<<**, **<<>**, **<>>**, **<><**, **><>**, **>><**, **><<**, **>>>** = 7 out of 8)
  - 4-sample composite: 93.75% (**<<<<**, etc. for 15 out of 16)
  - ***5-sample composite: ~97%*** (**<<<<<**, etc. for 31 out of 32)

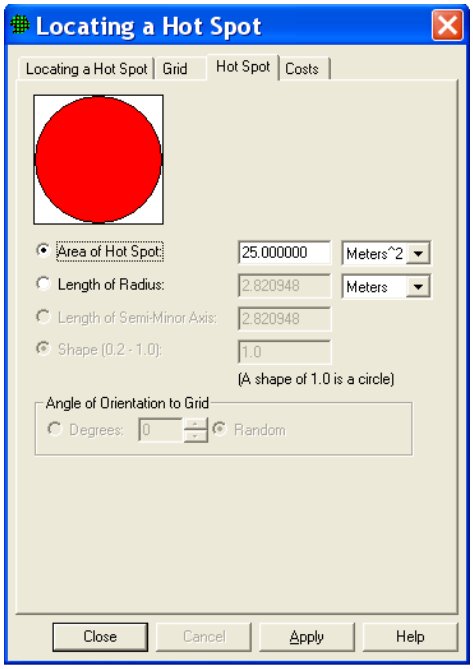
Actual Hotspot Search Performance

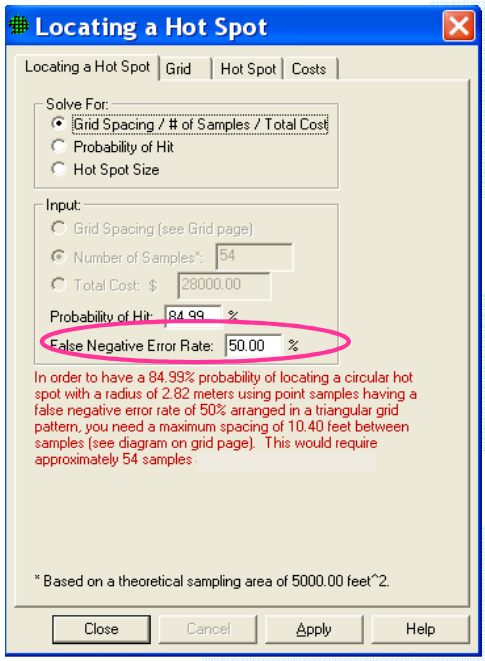
- Hotspot identified by GWS also caught by soil sampling
- 10 discrete samples collected from within hotspot footprint
  - Analyzed by XRF
  - Results ranged from 4 to 649 ppm, with average of 174 ppm
    - Well above hotspot criterion of 90 ppm
  - 5 > 90 ppm; 5 < 90 ppm (= 50% hotspot detection rate)
  - Probability (via Monte Carlo) of hotspot detection if the 10 discrete samples were considered increments & randomly combined into composites using actual concentration values:
    - 1 increment (1 of the 10 randomly selected) – 50% detection rate
    - 2 increments (2 selected & "composited") – 66% detection rate
    - 3 increments (3 selected & "composited") – 74% detection rate
    - 4 increments (4 selected & "composited") – 78% detection rate
    - ***5 increments – 85% detection rate (actual performance)***

Remember VSP's Hotspot Detection Module?



To clear a 1,700 m^2 area – by locating 25-m^2 hotspots with 95% chance of detection and 50% error rate constraint





- VSP recommends 307 samples, all analyzed
- A dual composite averaging/searching design accomplished the same with 345 increments and 11 analyses

Overall Performance

Compositing strategies provided significant cost savings

- Analytical burden for 1st EU reduced by 68%
- Analytical burden for 2nd EU reduced by 88%

Achieved 85% probability of 25-m^2 area hotspot detection for only a fraction of the analytical cost of a traditional hotspot search strategy

Any Questions?