Incremental Sampling Methodology (ISM)

State of the Art of Incremental Sampling Methodology
Science and Application

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Discussion Topics

- Applicability
- ISM Overview
  - Systematic planning
  - DUs
  - Field Sampling and Processing
  - Laboratory Processing and Analysis
- Challenges/Limitations
- Tech-Reg Document (web-based)
General Application

- Media
  - ISM Team focus on soils
- Type of Contaminants
  - Energetics (Explosives)
  - Metals
  - Semi-Volatiles
  - Volatiles
## Site Applicability

- Superfund
- Dry Cleaners
- Petroleum
- Agricultural Lands
- Schools
- Federal Facilities
- Natural background studies
- Other Program Sites
ISM Overview

- Limited number of discrete samples
- Sampling variability >> Analytical Variability
- Quality control and reproducibility are lacking
- Scientifically defensible?

Q: How can we get representative and defensible data that meet DQOs, including use in a risk assessment, and reduce overall analytical costs?
ISM- A Structured Composite Sampling Protocol

ISM is a sampling methodology used to obtain a representative sample having analytes in exactly the same proportions as the entire decision unit.
Does Your Sample Represent the Decision Unit?

<table>
<thead>
<tr>
<th>Discrete Sampling</th>
<th>Incremental Sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>▲ Collection point for 100 discrete samples</td>
<td>▲ Collection point for increment collection point for 3 to 5 separate IS</td>
</tr>
<tr>
<td>▲ Typically only a few discrete samples are collected</td>
<td>▲ Path of travel</td>
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</tbody>
</table>

- Incremental Sampling: Collection points for up to 5 separate IS.
Protocol Components of ISM

- **Systematic Planning**
  - Determining the Decision Unit (DU)

- **Field Sample Collection**
  - Systematic random collection of 30 – 50+ increments per DU

- **Laboratory Processing and Analysis**
  - Particle size selection (dry, sieve, grind), sub-sample, analysis

- **Data Evaluation**
Decision Unit (DU)

- An area (mass/volume of soil) where samples are to be collected and a decision made
  - Decision
    - Risk based decision
    - Need for remediation
    - Background level(s)?
    - Comparison to screening level(s)
DU Types

- **Source Area DUs** (e.g., drums, waste pits, soil around primary sources, etc.)
  - Focus on investigation of obvious or suspected contaminated areas
  - Identify contaminants of potential concern
  - Flag potential environmental problems that warrant additional attention

- **Exposure Area DUs** (e.g., exposed soil in yard)
  - Focus on risk to humans (or ecological health)
  - Used in traditional human health risk assessments
Decision Units (DUs)

- An area (volume) where samples are to be collected and decisions made based on the resulting data.
- Variability *within* the DU need to be specifically determined?

Source Areas

Exposure Areas
Investigate Obvious Source Areas Separately

waste oil pit

Release Area DU (after draining pit)
Release Area DU Transformer Pad
(Representative concentration of PCBs in DU soil?)

Coverage of DU based on three discrete samples

Coverage of DU based on one incremental sample

Will these samples give a reliable estimate of PCB concentrations in DU soil.

Is this a better estimate of representative PCB concentration in DU soil?
Exposure Area DUs

What is the representative Exposure Area ("point") concentration in my . . . ?

Size & shape of decision unit depends on the targeted receptor and the desired *resolution* of the evaluation.
Localized petroleum source area
Large Exposure area
DUs in areas in low-suspect areas
(1-2 acres = 2-3,000 yds³/ft)

Small Remediation
DUs in high-suspect areas
(5,000ft² = 200 yds³/ft)

Medium-Size, DUs in moderate-suspect areas
(0.5 acres = 1,000 yds³/ft)

Large Exposure area
DUs in areas in low-suspect areas
(1-2 acres = 2-3,000 yds³/ft)
Former Pesticide Mixing Area – DU Designation

- **Source Area DUs (3):** Heavy contamination/leaching
- **Direct Exposure DUs (41):** Maximum 5,000 ft²
Discrete Sample Investigation
(25 inner, 100 perimeter)

Contamination 1-2’ bgs

Contamination to 10’ bgs

*All sample points not shown

Leaching or direct exposure hazards

Estimated volume of contaminated soil 3,300 yds$^3$
ISM-DU Investigation Results
(Basal samples hot, depth of contaminated soil not determined)

Estimated volume of contaminated soil >7,500 yds³

Discrete samples missed most of the contamination

Leaching or direct exposure hazards

Depth not determined

ISM samples identified additional contamination outside of fenced area
Other IS-DU Applications

- Excavations
- Stockpiles
- Sediment (eco risk)
- Dredging
Excavation Decision Units

Floor and sides tested as separate decision units
Stockpile Decision Units

*Unrestricted Use: Maximum DU volume 100-200 cubic yards

Restricted Use: Maximum DU volume up to 2,000 cubic yards

*Residential Exposure Area DU: 100 cubic yards covers a 5,000 ft² lot to a depth of six inches
ISM Sample Collection

Determine/Mark ISM increment locations
(e.g. 30-50 independent locations per DU)
ISM Sample Collection

Collect an “increment” of soil at each point (e.g., 20-50 grams)
Maximum Subsurface DU Layer Volumes 100 to 500 yds$^3$ to optimize removal

(Disposal of dioxin-contaminated soil $300$ to $3,000$/ton)
Collect Core Samples From Target Layers

Individual core samples combined to prepare an IS sample for each DU and/or for each core (e.g. to identify areas of high contamination).
Source Area Core Wedge Samples (30 borings per DU)

- Send entire core to lab for MI subsampling, OR
- Continuous wedge removed from entire length of targeted DU interval for 100% coverage.
Incremental Core Samples

Closely spaced, 5g plugs removed from targeted Sampling Unit layer and combined into single ISM VOC sample.

photo courtesy of Hewitt, Ramsey & Bigl; ACE
Laboratory Processing/Subsampling

- Air dry
- Sieve to pre-determined size (e.g. < 2mm)
- Sometimes grind
- Subsample for each analysis (30-50 ~ 1 g increments)
- Analyze 10 - 30 gram mass to minimize fundamental error
- Maintain quality of field sample in lab analysis
Puck Mill Grind
Increment Core (IC) Sample Preservation in Methanol (1:1 Soil:MeOH Ratio)

Traditional 5-gram VOC sample

Planned 50- to 150-gram VOC sample

Laboratory Analysis
• Alternate analytical technique, e.g. SIM, may be required for reporting limits to meet DQOs
# Data Evaluation

## DU1: Comparison of Sampling Methods

<table>
<thead>
<tr>
<th></th>
<th>Discrete (mg/kg)</th>
<th>30-Increment (mg/kg)</th>
<th>100-Increment (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.0</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>StDev</td>
<td>1.4</td>
<td>0.08</td>
<td>0.03</td>
</tr>
<tr>
<td>95UCL</td>
<td>3.0</td>
<td>2.0</td>
<td>1.8</td>
</tr>
</tbody>
</table>

State of Florida risk screening threshold for arsenic: 2.1 mg/kg
Data Evaluation

DU 2

Concentration

Discrete
Inc-30, Prepped
Inc-100, Prepped
Inc-30, Unprepped
Inc-100, Unprepped
Challenges

- Regulations or Policies
- Misperceptions
- Other Concerns
ITRC ISM Tech-Reg Document

Tech Reg Document
- Will web-based

Schedule
- External Peer Review
  January – February 2011
- Final Spring 2012
ITRC ISM Web-Based Tech-Reg Document

- Provide technically sound guidance to design ISM approaches for improved soil and sediment data quality
- Aid in developing consistent and technically sound ISM policies
- Point out pitfalls to avoid in designing sampling strategies
- Address misperceptions about:
  - Composite sampling
  - Lack of characterization
  - Minimizing hot spots
Special Thanks

- All ISM team members
Questions ? Comments ?