Incremental Sampling Methodology, Growing into an Everyday Tool

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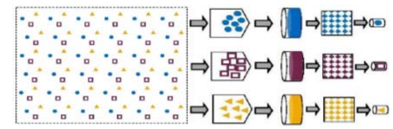
Managing Uncertainty



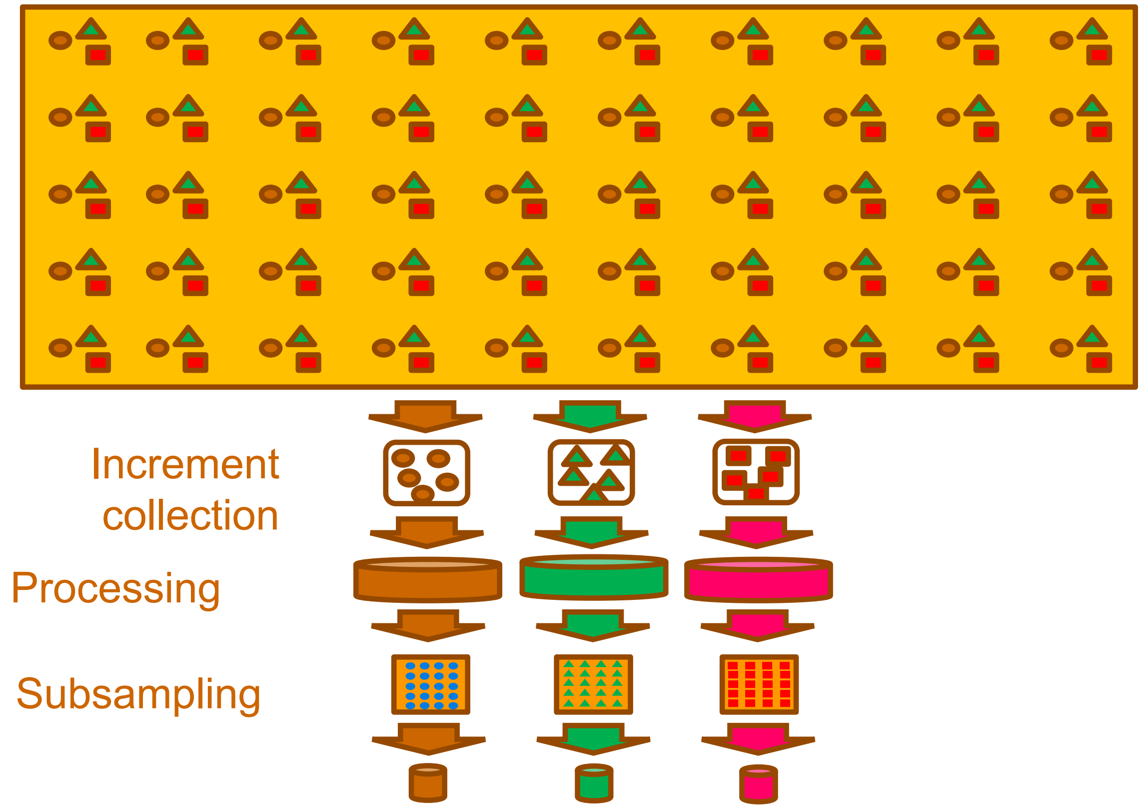
ISM is

designed to

reduce uncertainty

in the

knowable unknowns



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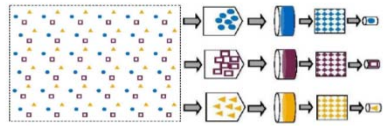
Representative by Design



Incremental Sampling Methodology (ISM)

Sampling (and sample processing) method used to

provide representative site data to inform environmental characterization and cleanup decisions.

Assess the mean concentration of the contaminants of concern within a defined portion of the site by managing heterogeneity

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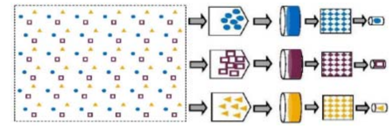
Heterogeneity at all scales



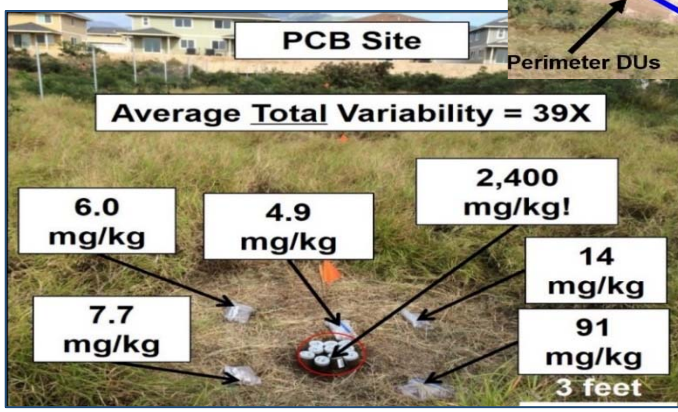
Landscape

signal

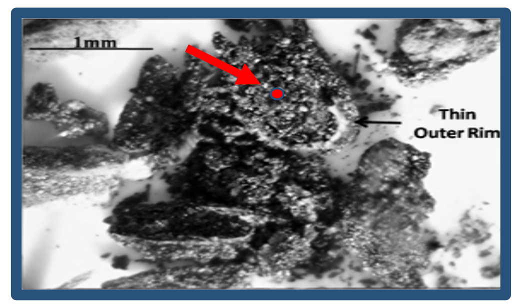
Decision

noise

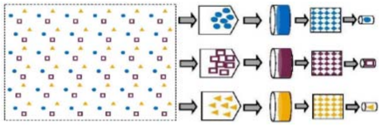
Microscopic



Hawaii DOH



Key Terms



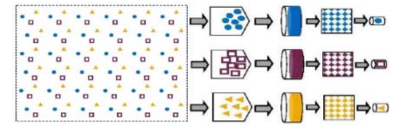
signal

Decision Unit (DU) is the smallest volume of soil for which a decision will be made based on ISM sampling. It is the area and depth of soil from which mean analyte concentrations are obtained and is representative of a specifically defined population.

noise

An increment is a specified volume of soil collected from a specific point within a DU. Multiple increments (typically 30 or more) are collected from a specified DU and combined into a single sample that is typically designed to represent the entire DU.

Regulatory Acceptance



> 60% of States reporting use of ISM

Many states have official ISM guidance

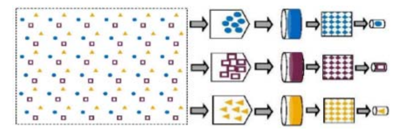
~ 50,000 participants in ITRC ISM training since 2012

ITRC ISM-1 2012 guidance being updated for 2020

state regulators, federal, community, academic, industry

Look for ISM-2 in Fall 2020

ISM Applications



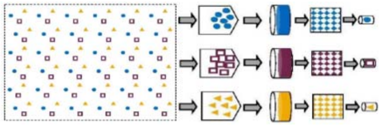
Media:

Surface soil, subsurface, sediment and piles

Contaminants:

Metals, SVOCs, PCBs, pesticides, VOCs, TPH, dioxins, explosives, cyanide, perchlorate and PFAS

ISM Applications



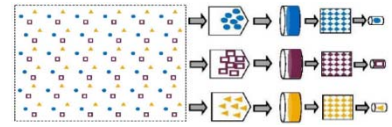
Assessments:

Site screening, nature and extent, confirmation sampling, risk assessment, waste characterization, background characterizations

Decisions: by comparison to:

Regulatory cleanup levels, screening levels, human and ecological risk-based criteria, background concentrations.

Nature of Soil Sampling



ISM addresses the two weak links common in soil studies:

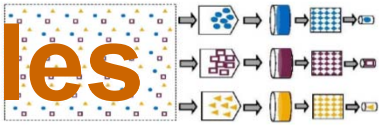
Field sampling

Lab subsampling

Small Scale Heterogeneity

Spills flow around bumps unevenly depositing liquids

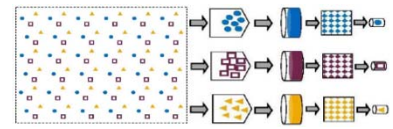
Representativeness Principles



Representation always relates to a specific question about a population with a given level of confidence.

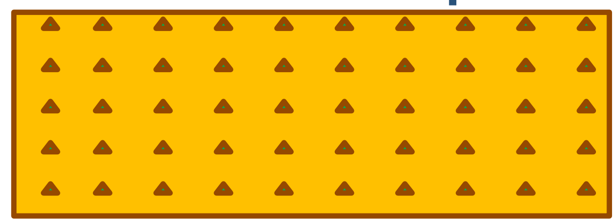
A sample that is representative for one question might not be representative for a different question.

Managing Heterogeneity



Small-scale heterogeneity in the field

use many increments within a decision unit to provide good spatial coverage



Micro scale heterogeneity at the laboratory

variety of sample processing techniques to produce more consistent subsamples.

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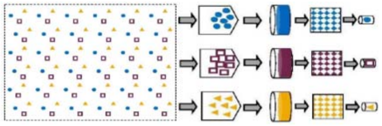
Statistical Concepts



Central Limit Theorem (CLT), distribution of the average is approximately normally distributed, regardless of the distribution of the concentration in the increments

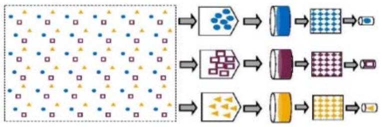
95% upper confidence limit (UCL) is typically used as a conservative estimate of the mean

Positively skewed environmental data

- More samples with smaller concentrations
- Fewer samples with larger concentrations

Compensate with more samples/increments to avoid under estimate

Planning Use of ISM Data



Specify how data will be analyzed in sampling design

- Examples
  - Compare UCL to screening level
  - Compare site concentration to background

Define tolerable decision error rate

- Helps define
  - number of samples and increments
  - size and location of decision units
  - QA/QC criteria (and response if not met)

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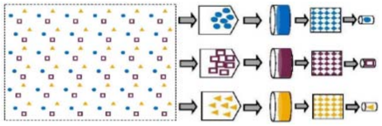
Cost Analysis



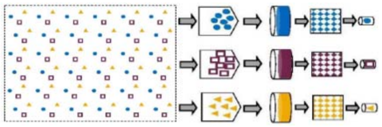
Cost-benefit ratio favors ISM.

- It results in fewer decision errors
- ISM provides higher confidence in cleanup decisions
- Effective use of funds to address actual environmental impacts

ISM also reduces overly conservative decisions

- Lead to multiple investigations
- Project delays
- Expense to implement the wrong remedial action
- Increased liability for the responsible party

Factors Affecting ISM Cost



Size of the property

Nature and extent of the contamination

Site characteristics

- Soil type
- Vegetation
- Depth of sample collection

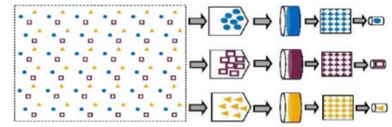
Number of decision units, replicates, increments

Use of field analytical methods for specific contaminants

Sampling processing techniques

Individual analyte analysis costs

Cost Comparison



ITRC ISM-2 worksheet

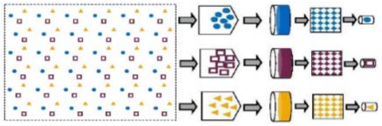
“Ball Park” cost estimates costs

- **ISM samples vs discrete samples**

Common scenarios

- **Screening assessment**
- **Nature and extent of surface spill**
- **Confirmation sampling from an excavation**
- **Stockpile characterization**

Systematic Planning and Decision Unit Design



Understanding of the data quality objectives (DQOs)

Source area investigation

Evaluation of contaminant fate and transport

Assessment of potential exposure and risks

Use DQOs and CSM to drive

selection of size, shape,

location, depth and # of DUs

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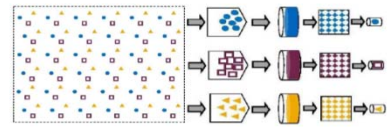
Decision Unit Design



Exposure area DUs for risk assessments and risk-based decisions

Residential lot (e.g. 1/4 acre)

Industrial receptors (e.g. 1 acre)

DUs for a frog smaller than for waterfowl

If multiple species of interest

- **DU sizes based on the smallest home range then aggregated for analysis for larger home ranges**

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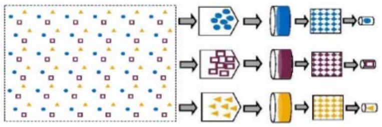
Decision Unit Design



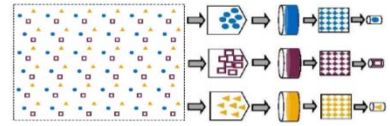
Determine the nature and extent of contamination

DUs may be in rings or layers from the source area

Portable x-ray fluorescence (XRF) or gas chromatograph help define DU boundaries

Example: XRF lead results help define front yard DUs

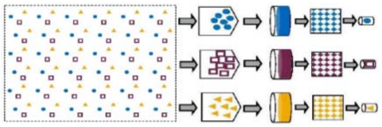
Field Implementation & Sample Collection



Special considerations

- **Field personnel training**
  - **understanding sampling objectives & procedures**
- **Preexisting site conditions**
- **Surface features**
- **Soil characteristics**
- **Determine number and location of increments**

Estimate Sample Mass



Sufficient for tests

Facilitate DU representativeness

Mass of sample (1-2 kg most common size)

- **Number of increments (equal volume)**
- **Depth (length)**
- **Diameter**
- **Soil density**
- **Moisture content**

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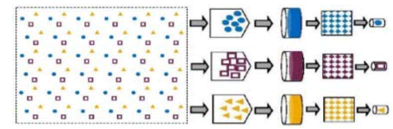
Sample Collection



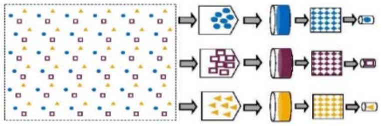
Common practice

One person collects the sample increment

Second person

- **Manages sample container(s) (triplicates?)**
- **Tracks the number of increments collected**

Sampling for VOCs



Scaled up methanol preservation option Method 5035

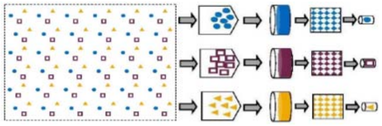
Large methanol bottle

- **1 per DU, > 30 mL methanol**
- **restricted to ground shipping**

Medium methanol bottles

- **several per DU**
- **25 mL methanol**
- **air shipment OK**

Decision Unit Designation



- Rectangular DU marked by corners
- Other shapes or uneven terrain benefit from GPS
- Not necessary to record exact increment locations

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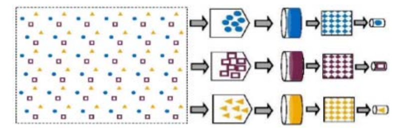
Sample Processing



Multiple sample processing options and combinations to be selected based on the site characterization objectives

Five areas:

- **Soil moisture management**
- **Disaggregation**
- **Particle size selection**
- **Particle size reduction**
- **Subsampling**

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New Lab Tools

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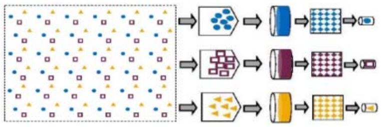
Data Quality Evaluation

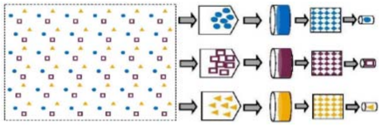


Data verification ensure the data are complete

Data validation assesses the data on a per-sample basis,

Examine qualifiers
Evaluate performance criteria
Reject data unfit for use in decision making
Reporting limits vs sensitivity needs
Reasonableness of measured values relative to CSM, note anomalies

Data Analysis



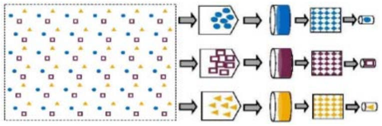
Estimate of mean
Single result
Mean of replicates
95% UCL

Can’t pool data from ISM and discrete

Can qualitatively combine as multiple lines of evidence

Compare UCL, LCL and action level

Conclusions



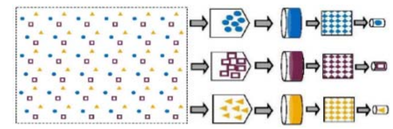
ISM improves data quality and reduces uncertainty in data-based decisions

Effective management of heterogeneity

Increased representativeness

Reduced variability

Conclusions



Keys to a successful ISM design

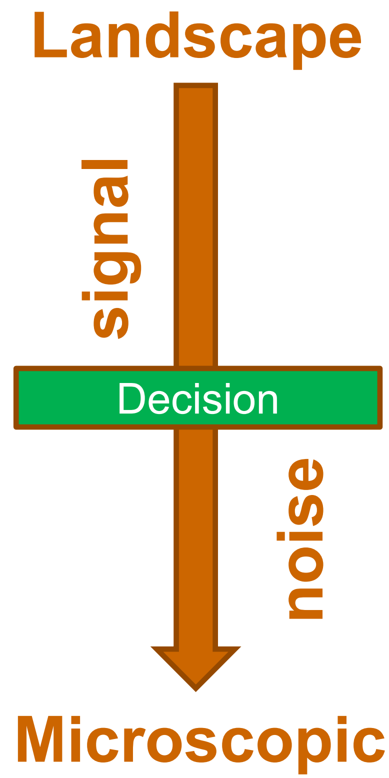
Project planning

Application of statistical concepts

Consideration of costs

Design of sampling units

Quantification of tolerable field and lab uncertainty



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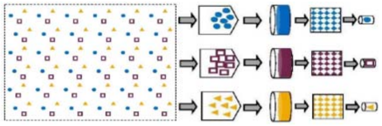
Questions & Contacts



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