MICHIGAN DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY

15 years of Lessons Learned using Multi Increment Sampling in MICHIGAN

Chris Christensen, CPG
EGLE-RRD-Technical Support Section
Grand Rapids Office
616-446-7582 | christensenc@michigan.gov

Paul Knoerr
EGLE-RRD-IS TAPS Co-Leader
Grand Rapids District Office
616-840-2131 | knoerrp@michigan.gov

Bottom Line Up Front – What Matters

Data Quality Objectives matter

Decision Unit selection Matters

Full Spatial Coverage (Increments Matter)

Mass of field sample (Mass Matters)

Lab interaction on processing steps. Extraction/Digestion mass matters.

All leads to **Representative** and **Reproducible** Data

Objectives

- Partnership: RRD Program Team is your "phone a friend"
- Fundamentals of Multi-Increment Sampling
- DQOs for ***all*** projects
- DU Design 1)Assess Risk with Exposure Area DUs
  2)Optimize Remediation with Source Area DUs
- Soil Sampling Guidance Update
- Field Examples and Q/A

Risk and why is this important

Our criteria are based on the mean concentration of the contaminant for a specified “exposure area” and by default “exposure volume” of soil as a whole, such as a residential lot, greenspace around multifamily housing, or exposed soil at a school playground.

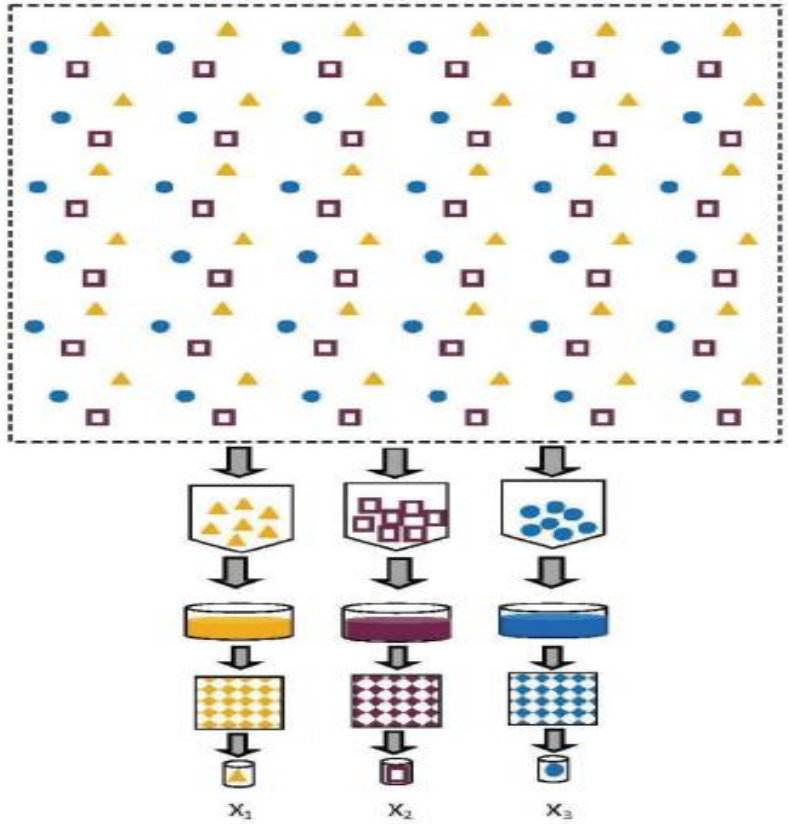
The concentration of the contaminant associated with any given small mass of soil within this area is irrelevant in terms of assessment of risk.

Risk and why is this important

- If that's true and you believe it, then how do you collect a sample that represents the volume of soil you are interested in to compare to Risk-Based Criteria?

Technical/Regulatory Guidance

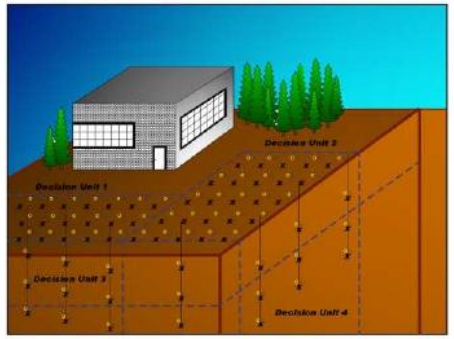
INCREMENTAL SAMPLING METHODOLOGY (ISM) UPDATE



Decision Unit - Multi Increment Sampling (DU-MIS)

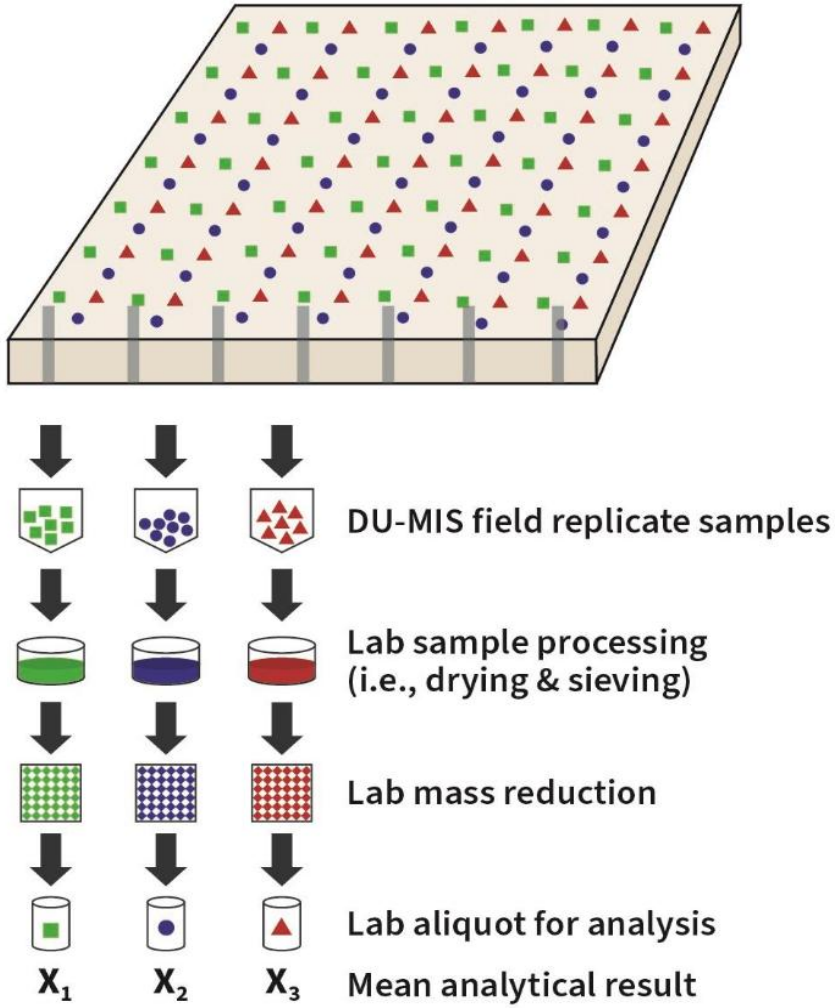
INCREMENTAL SAMPLING METHODOLOGY AND APPLICATIONS

REMEDIATION AND REDEVELOPMENT DIVISION
RESOURCE MATERIALS



Prepared by:
Michigan Department of Environmental Quality
Remediation and Redevelopment Division
525 West Allegan Street
Lansing, Michigan 48933

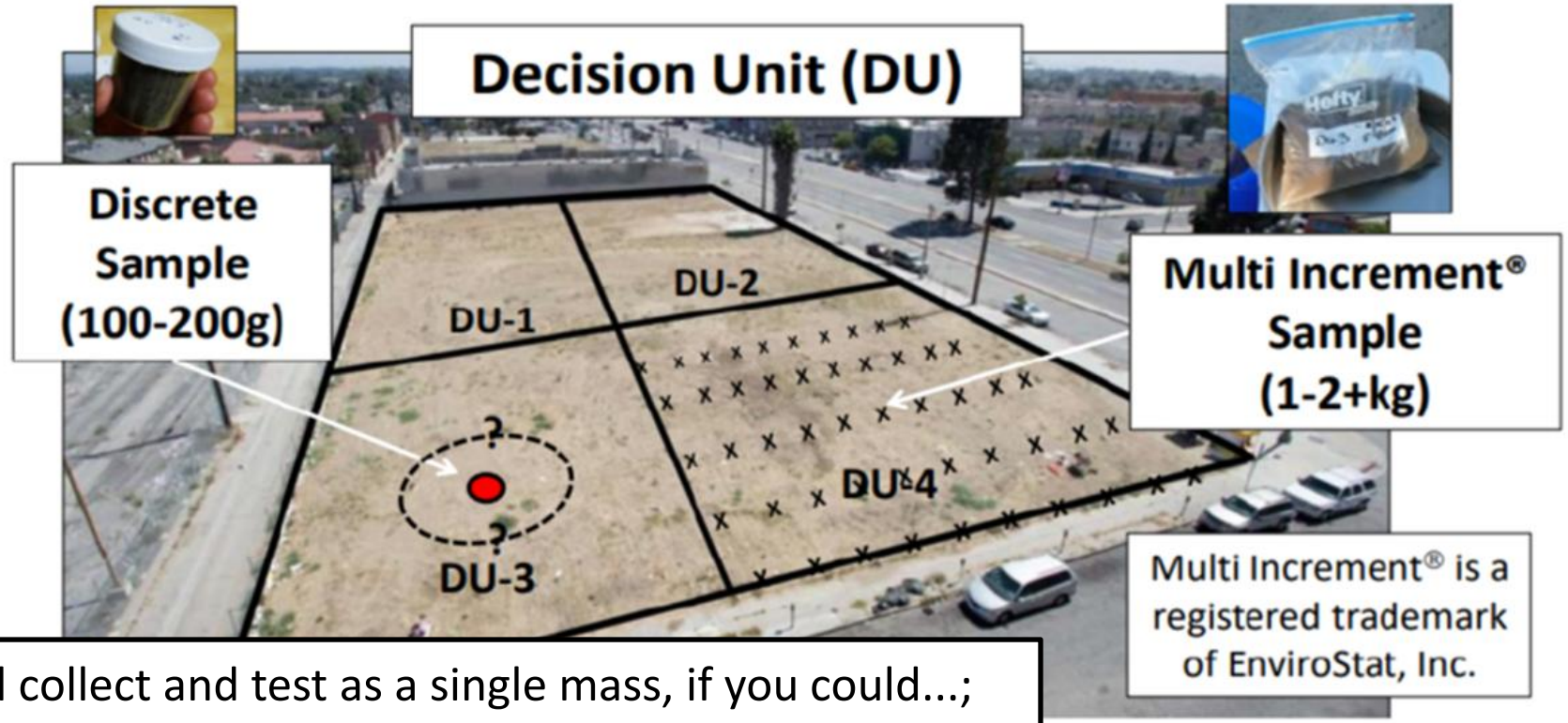
RRD-RESOURCE MATERIALS
January 2018



DO MIS

DU-MIS

TERMINOLOGY



DU: Area/volume of soil you would collect and test as a single mass, if you could...;

Discrete Sample: (USEPA 1980s)

- Collected from a single point within a targeted area ("single increment sample");
- Mass collected based on laboratory needs (typically 100-Z00 grams).

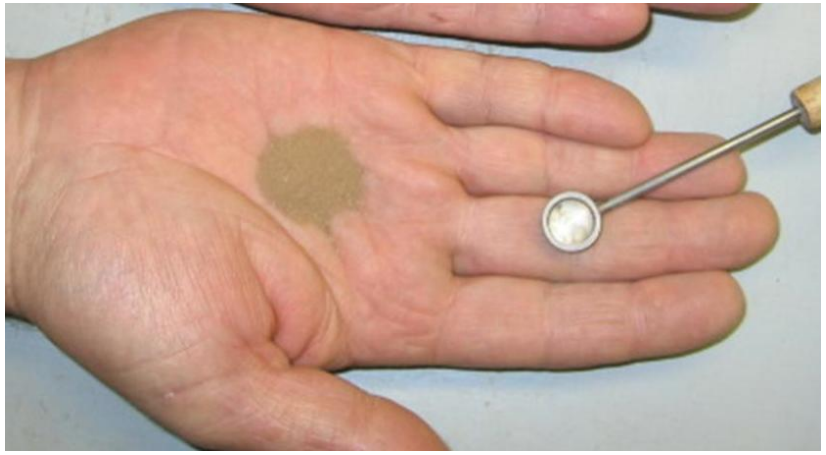
Multi Increment Sample: (relatively "new" idea)

- Collected from multiple points ("increments") within a targeted area;
- Mass and # of "increments" included in sample based on Gy's Theory of Sampling.

(Slide Courtesy of Roger Brewer)

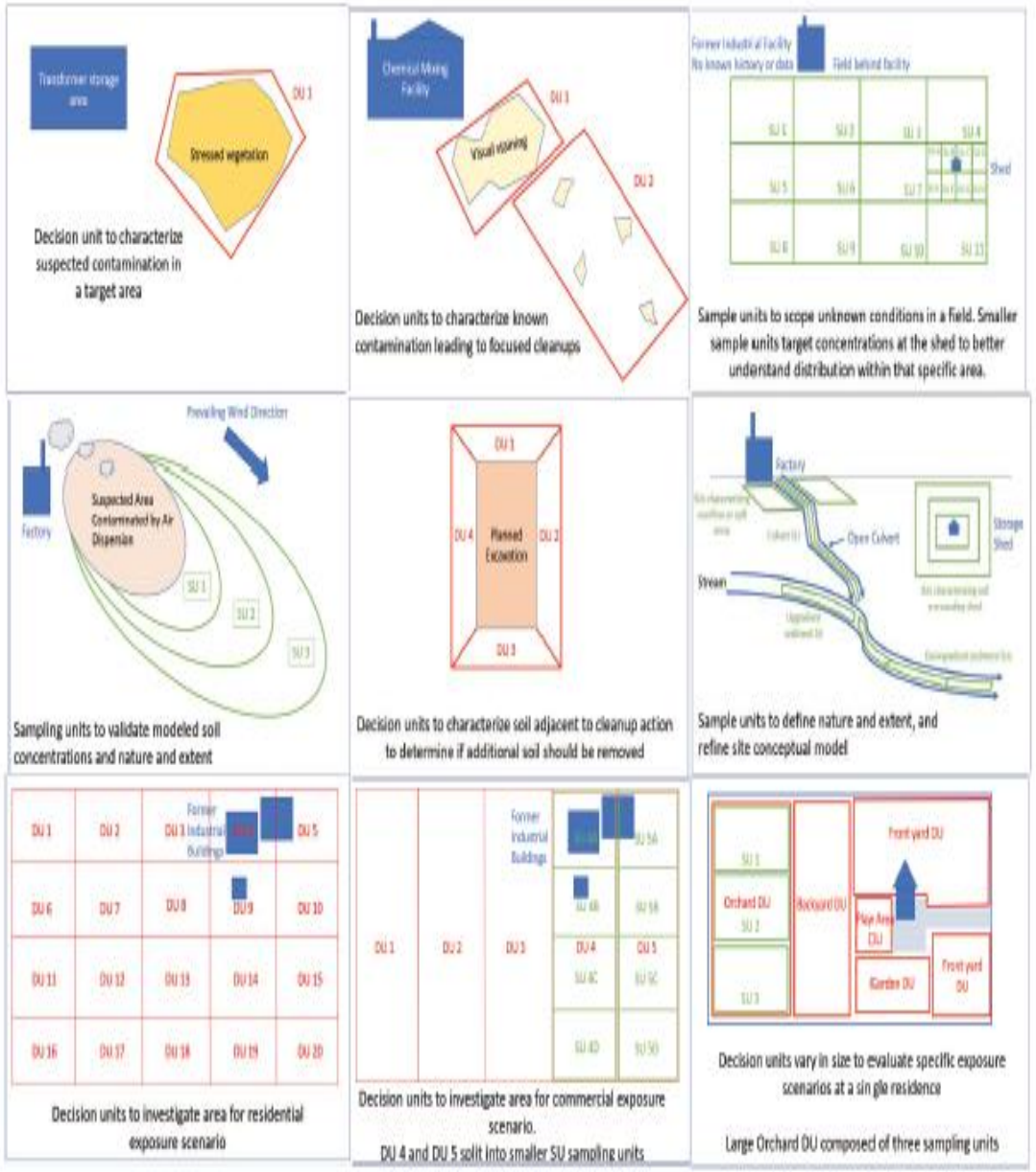
Representativeness

Think of the size of the samples you take…



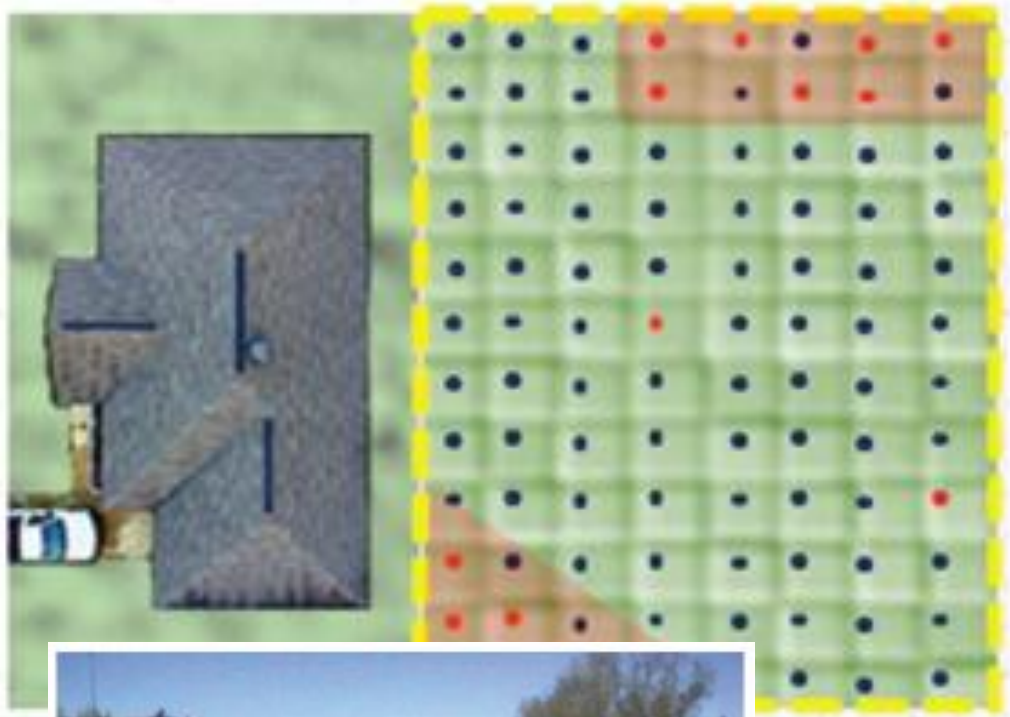
Think of the mass of the samples you take…

What are your samples representative of? 1g, 10g,
Example ¼ acre sandy front yard to 6” (277tons)



What is DU-MIS?

- Robust composite sampling technique
- Designed to provide Representative, reproducible and defendable results
- Maximizes confidence in decisions to **Assess Risk** or **Optimize Remediation**

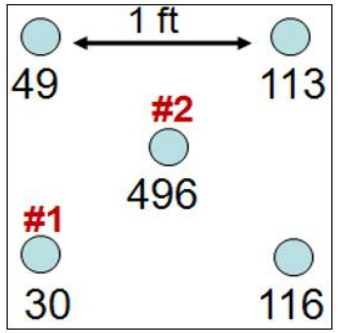


How Does DU-MIS Increase Our Confidence?

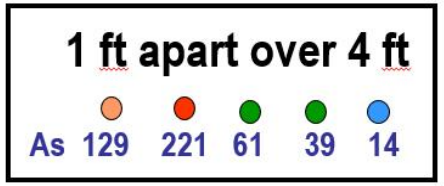
1. Greater spatial coverage
2. Use of Replicates to measure Reproducibility

Confidence is based on decisions being defendable

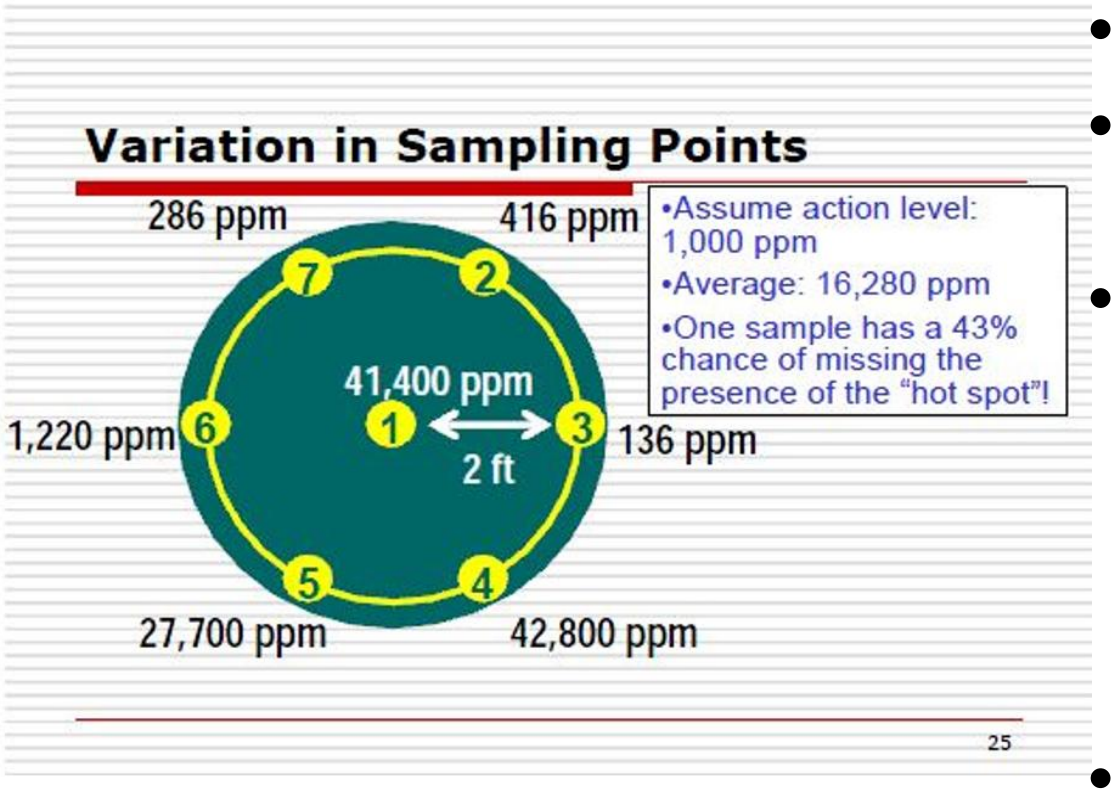
Why is this Critical?



Set of co-located samples for uranium (mg/kg)



Arsenic in residential yard transect (mg/kg)



- Heterogeneity!!!!!!
- Known challenges to soil characterization
- Must avoid unnecessary resources spent on areas which do not cleanup and focus on those which do
- Need high confidence in decisions

DQO Process Template/Checklist

This document should be completed and supplied to the Brownfield Coordinator/MSHDA Coordinator for discussion with supporting reports, figures, tables, etc. prior to execution of sample collection.

PURPOSE (Check only one per form) ☐ Risk Assessment ☐ Remediation Efficiency		
STEP 1	DEFINE THE PROBLEM	
	Type of Facility, Historic Use, Current Use and Proposed Use	
	Pathway(s) to be Evaluated (Direct Contact, Drinking Water, Volatilization to Indoor Air, etc.)	
	Known or potential sources (Primary and Secondary)	
	1. Soil	
	2. Groundwater	
	3. Surface Water	
	4. Vapor	
	Identification of team members, stakeholders, decision makers	
	Identification of available resources and deadlines.	
STEP 2	IDENTIFY THE DECISION	
	What question are you trying to answer? What do you want to accomplish with the data? What is the goal?	
	What are the outcomes and alternative actions?	
STEP 3	IDENTIFY THE INPUTS TO THE DECISION	
	What are the appropriate analytes for each REC?	
	What depth intervals will you collect and why? NOTE: This is based on source, delineation, due care, future use, ongoing operations and maintenance, soil management during construction, etc.	
	How many increments are required based on the analytes you identify?	

EGLE MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

PCB-Infused Tar Balls and "Distributional Heterogeneity"

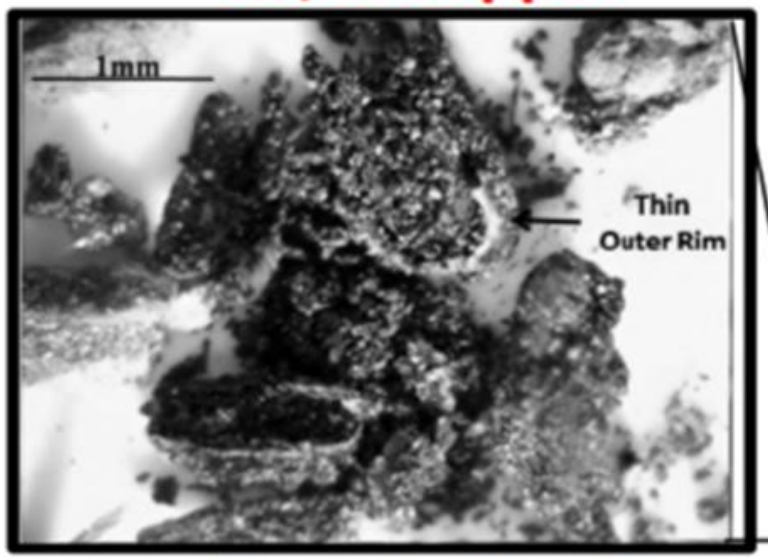
The Myth of "Maximum" Contaminant Concentrations in Soil

(Slide Courtesy of Roger Brewer)

- **Soil samples *cannot be "homogenized"* to the scale of a laboratory subsample;**
- **Reported concentration *varies with volume/mass* of soil tested;**
- **Maximum concentration *always* either 0 % (absent) or 100% (present);**

Risk-based objective is *always the mean/true concentration* for a specified area & volume of soil.

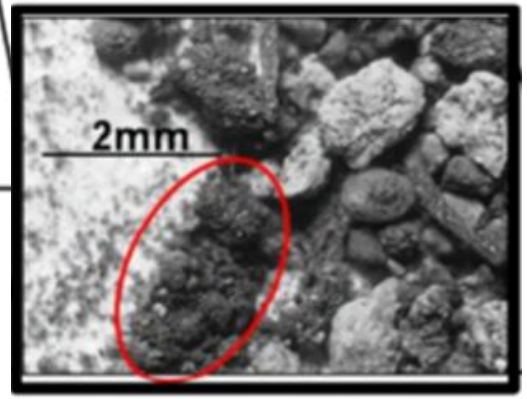
1mm **10,000s ppm**



Concentration #3
(PCB matrix)

1,000s ppm

2mm

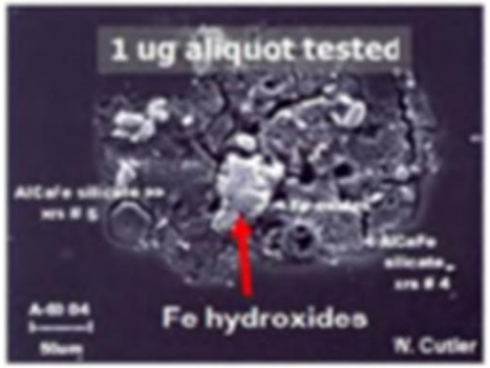


Concentration #2
(single nugget)

1cm **10s ppm**

Concentration #1
(whole sample)

Arsenic Nuggets



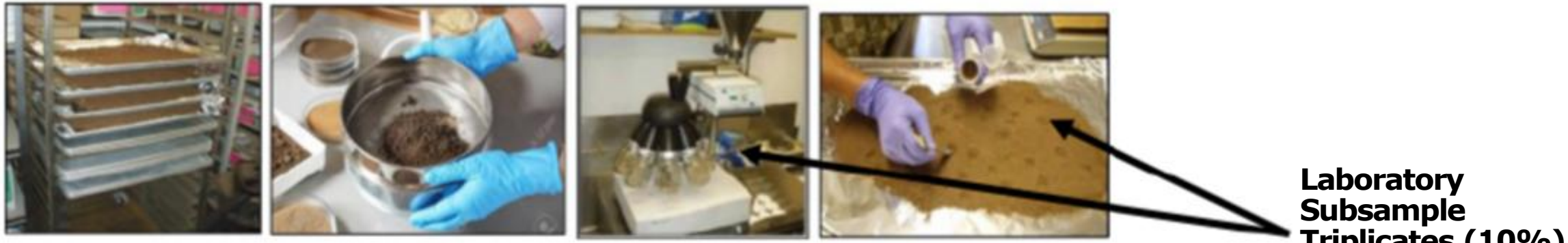
Collection of a Representative Sample

- Site preparation
- DU demarcation
- Soil type vs sampling tools
- Surface soils
- Subsurface soils
- Excavations
- Stockpiles
- Sediment
- Sampling for VOCs
- Equipment decontamination

(Slide Courtesy of Roger Brewer)

Laboratory Sample Processing and Analysis

Air Dry, Sieve Subsample



- **Recommended subsample masses based on discussions with sampling statisticians trained and experienced in Gy's Theory of Sampling.**
- ***Minimum of 1.0g currently allowed for unground soil if necessary but include laboratory replicates (increases error in data).**

Ideal Minimum Subsample Mass

Sample Preparation Method	*Subsample Collection Method	
	Sectoral Splitter	Manual
Unground (<2mm)	10g	*30g
Ground (≤100 um)	5g	10g

Why change?

Good science will win in the end and in lawsuits

Fairness to regulated public (time, money, clear endpoint)

Unforeseen liability of stakeholders and consultants (and regulators)

Competition with other consultants (Get In. Get Out. Get it Right)

Regulatory requirement:

- Laboratory data must be representative of the sample provided
- Sample provided must be representative of area of collection

What good are discrete samples?

- For indirect pathway evaluations and screening to determine if the media of concern should be sampled…

Paved UST sites, point source (piping elbow leak) presence or absence that leads to GW or VI sampling for risk and compliance (Soil protective of…) may not even need to be analytical…visual, odor

Why use DQOs

From EGLE's Quality Management Plan:

- EGLE's quality assurance activities: All data generated will be scientifically valid, of known precision and accuracy, of acceptable completeness, **representative**, comparable, and legally defensible.

Representativeness

- Description of the degree to which an estimate agrees with the true value of the parameter of interest. (ITRC Incremental Sampling Methodology 2012)
- A representative sample is one that answers a question about a population with a certain confidence. (Ramsey, C. A., and A. D. Hewitt. 2005. "A Methodology for Assessing Sample Representativeness," *Environmental Forensics* **6**: 71–75.)
- Representative, reproducible, and defensible (RRD)

Draft Soil Sampling Guidance Development

- Planned Updates DU-MIS Document replacing 2018 resource material

- Planned development of a Soil Sampling Guidance Document to replace the 2002 S3TM.

- Planned Guidesheets on unique but common applications:

  Soil Piles, Characterization of Clean Fill, Excavations

Field Concerns

1. How is mass reduction of the sample to be done? Plugs, Wedge, Full Vertical Core(Densteadt tool)

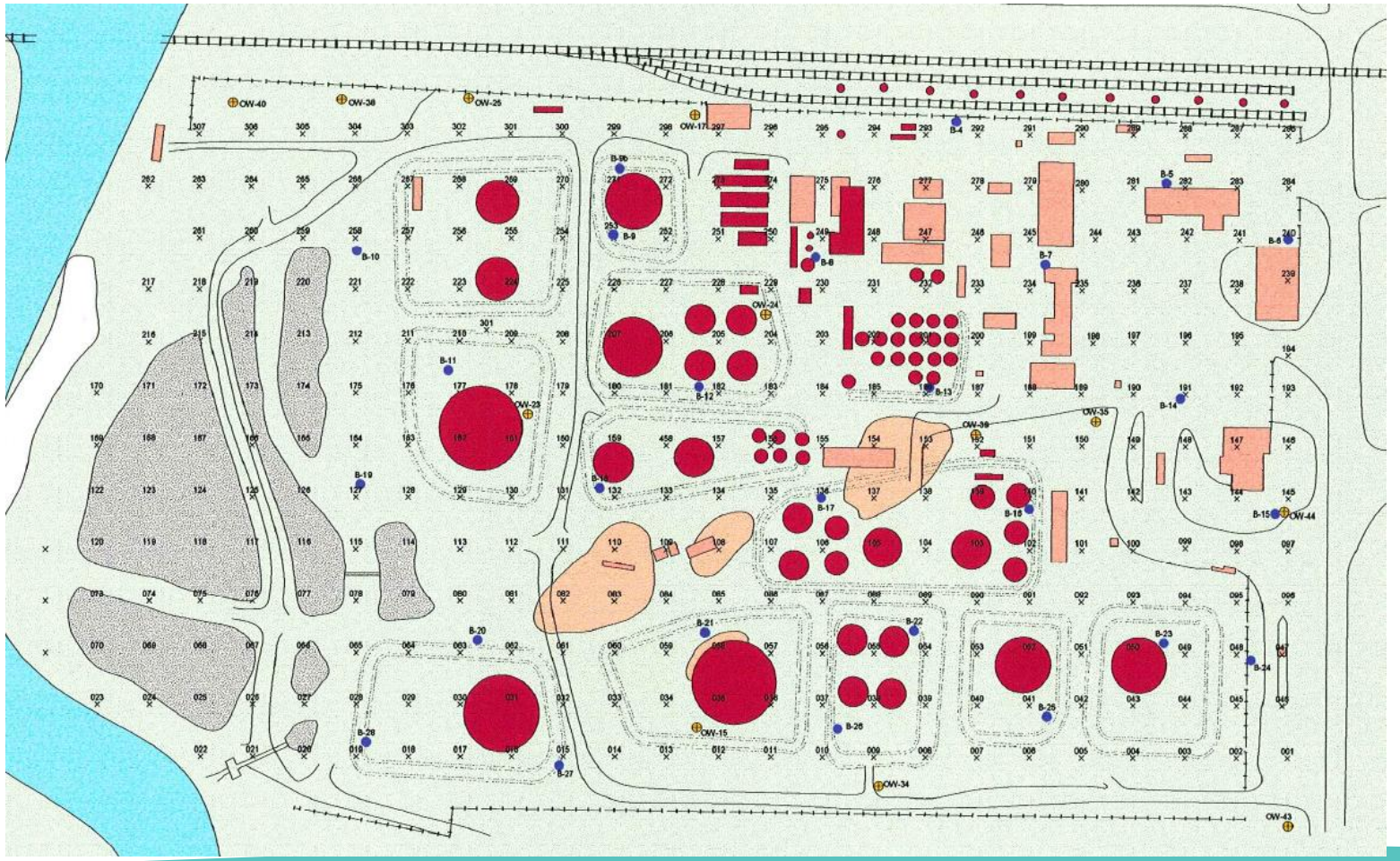
2. What is the protocol if core is less than 100% recovery?

3. Staining, visible asphalt nuggets or paint flakes noted in field notes or pivot with PM in the field to boundary or source area sub-DUs.

Hawaii TGM Appendix M (Field Doc) App F (Tools and Methods)

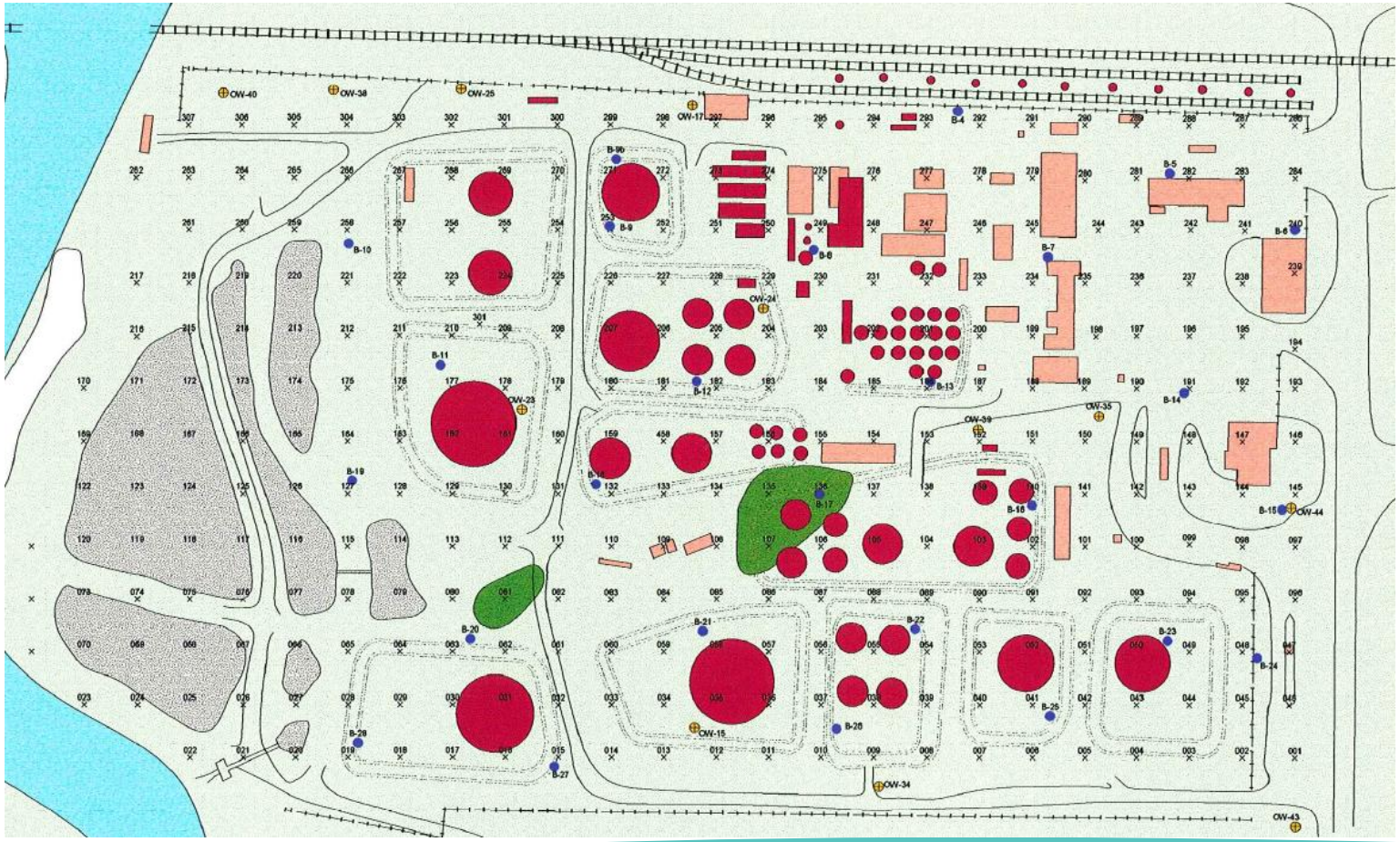
Refinery DU-MIS Example

Discrete Lead Samples exceeding Direct Contact Criteria 0-2 feet



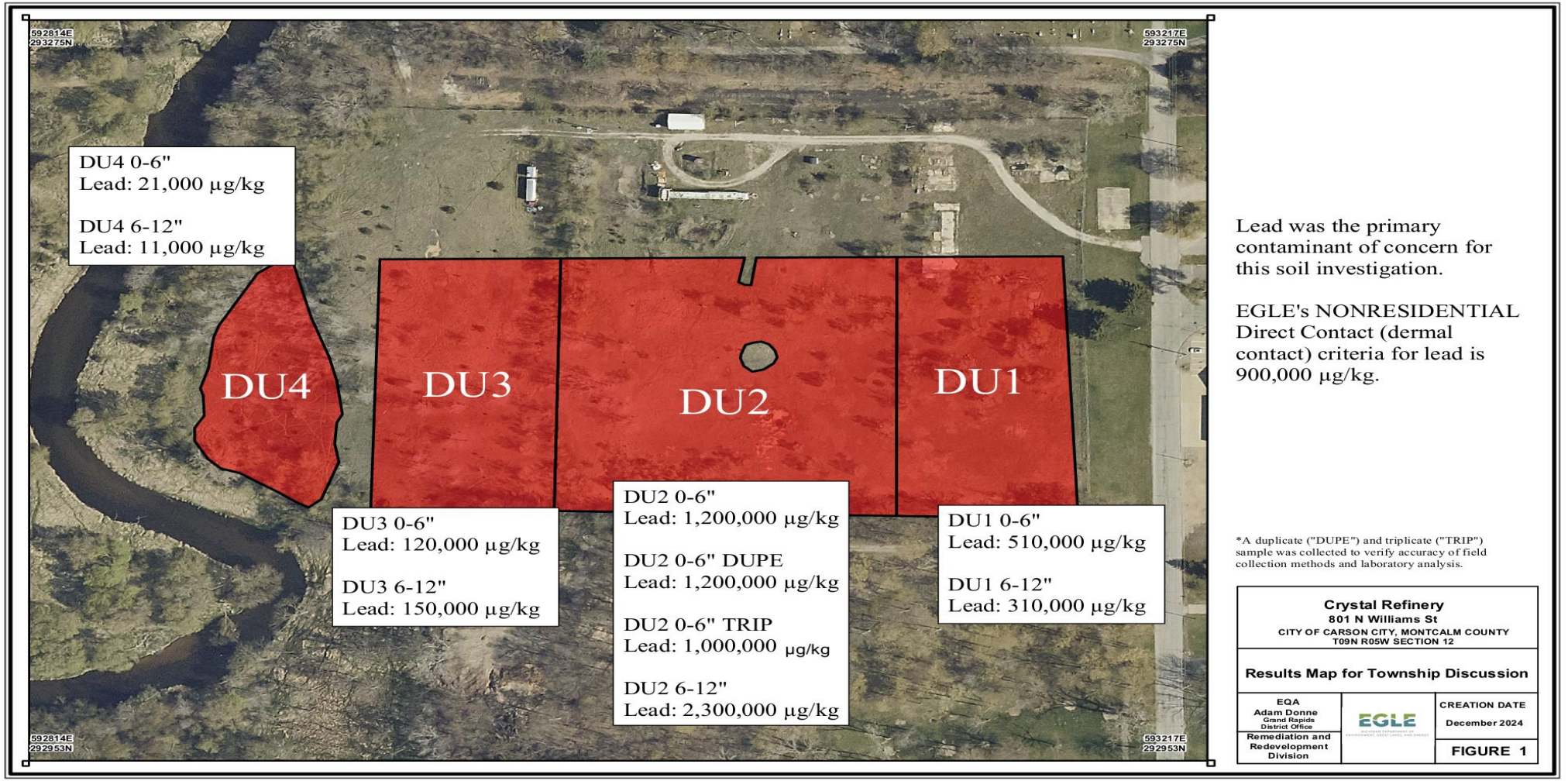
Refinery DU-MIS Example

Discrete Lead Samples exceeding Direct Contact Criteria Below 2 feet



Refinery DU-MIS Example

Refinery DU-MIS Example



Refinery DU-MIS Example

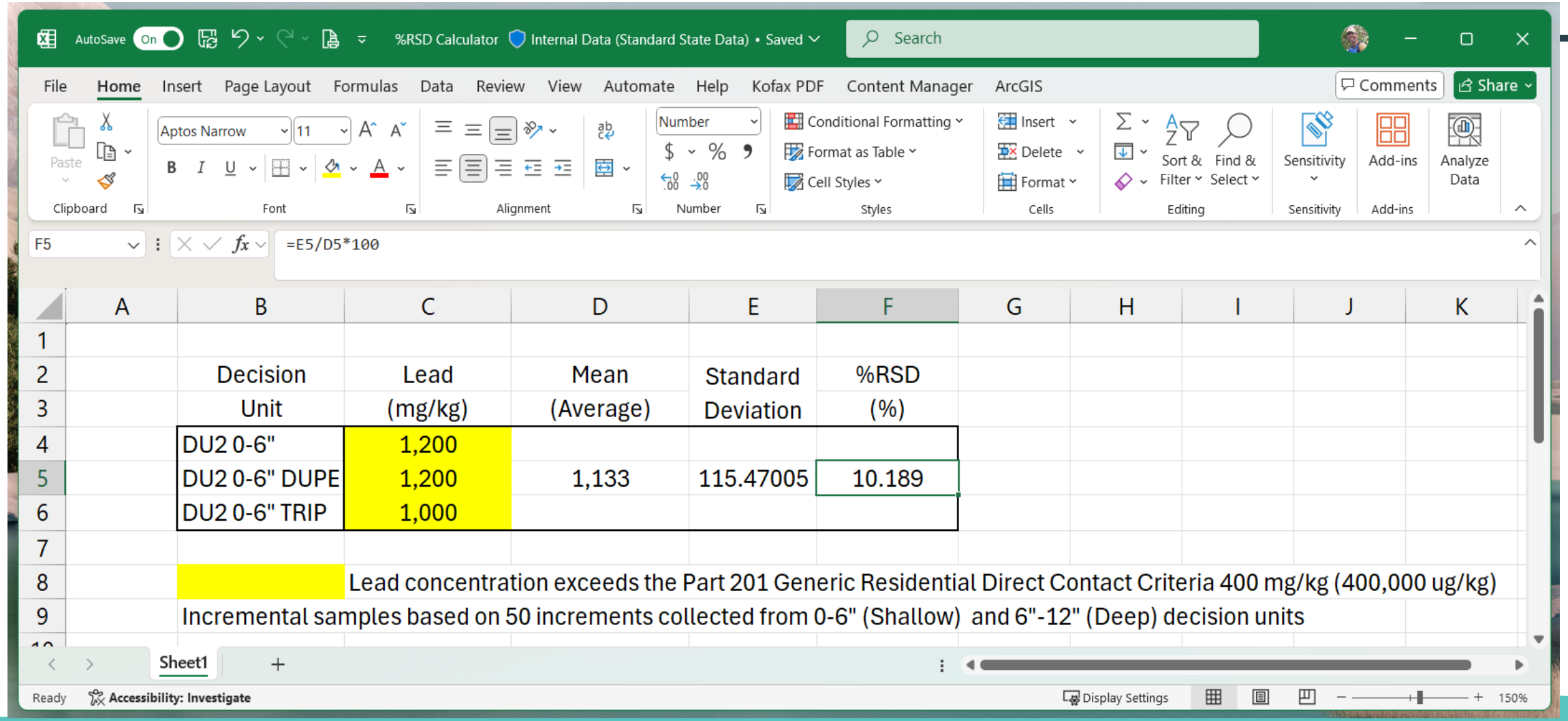
What is Percent Relative Standard Deviation (%RSD)?

It's a measurement of precision. It tells you whether your data has captured the heterogeneity of the Decision Unit (DU)

Standard Deviation of the triplicate data divided by the Average (Mean) of the triplicate data, multiplied by 100.

$$\%RSD = \frac{Standard\ Deviation}{Mean} X\ 100$$

Refinery DU-MIS Example



%RSD Calculator • Internal Data (Standard State Data) • Saved

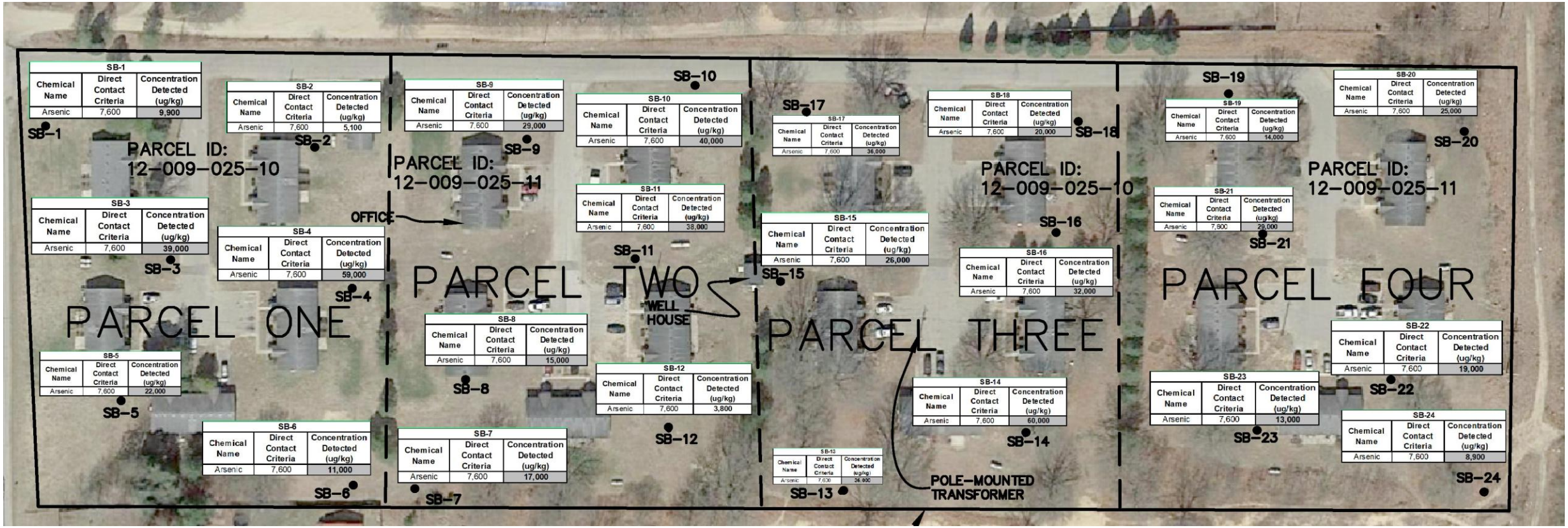
=E5/D5*100

	Decision Unit	Lead (mg/kg)	Mean (Average)	Standard Deviation	%RSD (%)
DU2 0-6"	1,200				
DU2 0-6" DUPE	1,200	1,133	115.47005	10.189	
DU2 0-6" TRIP	1,000				

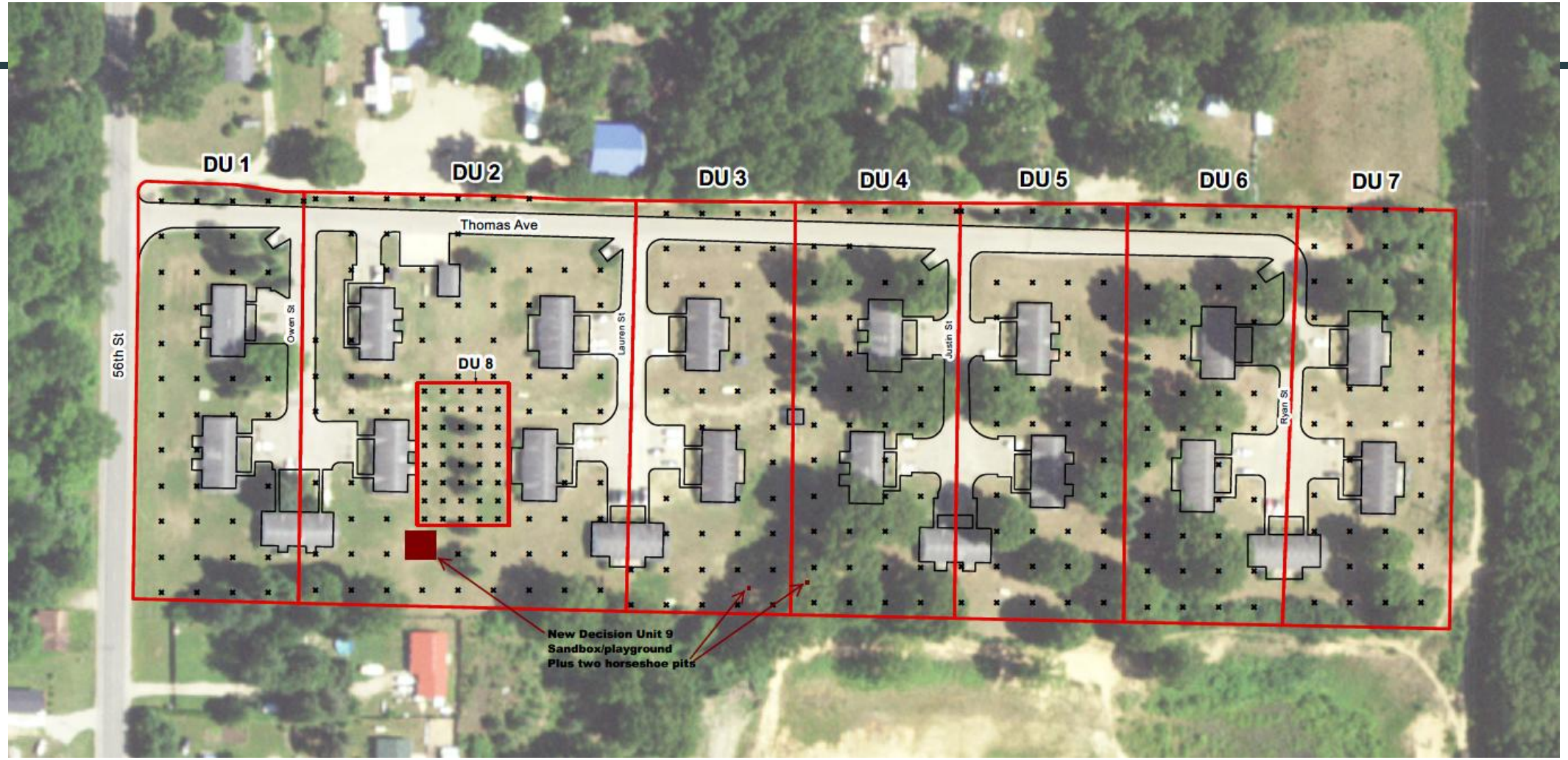
Lead concentration exceeds the Part 201 Generic Residential Direct Contact Criteria 400 mg/kg (400,000 ug/kg)

Incremental samples based on 50 increments collected from 0-6" (Shallow) and 6"-12" (Deep) decision units

Housing on Former Orchard



Housing on Former Orchard



Housing on Former Orchard

Decision Unit	Depth	ISM Total Concentration (mg/kg)	**Bioaccessible Concentration**	Mean	Standard Deviation	%RSD	Depth	ISM Total Concentration (mg/kg)	Bioaccessible Concentration	Mean	Standard Deviation	%RSD
DU-1	Shallow (0-6")	45	**10**	45.667	1.155	2.529	Deep (6"-12")	50	**10**	45.333	5.686	12.543
DU-1	Shallow (0-6")	47	**11**				Deep (6"-12")	39	**9.5**			
DU-1	Shallow (0-6")	45	**12**	**11.000**	**1.000**	**9.091**	Deep (6"-12")	47	**9.6**	**9.700**	**0.265**	**2.728**
DU-2	Shallow (0-6")	46	**11**				Deep (6"-12")	27	**7.2**			
DU-3	Shallow (0-6")	35	**10**				Deep (6"-12")	21	**7.1**			
DU-4	Shallow (0-6")	51	**12**				Deep (6"-12")	39	**8.6**			
DU-5	Shallow (0-6")	42	**9.4**				Deep (6"-12")	22	**5.3**			
DU-6	Shallow (0-6")	39	**10**				Deep (6"-12")	26	**6.5**			
DU-7	Shallow (0-6")	40	**9.6**	35.667	4.041	11.331	Deep (6"-12")	22	**6.2**	23.000	1.000	4.348
DU-7	Shallow (0-6")	35	**9.4**				Deep (6"-12")	23	**5.6**			
DU-7	Shallow (0-6")	32	**7.8**	**8.933**	**0.987**	**11.044**	Deep (6"-12")	24	**6.2**	**6.000**	**0.346**	**5.774**
DU-8	Shallow (0-6")	48	**13**	48.000	5.000	10.417	Deep (6"-12")	22	**6.3**	24.667	3.055	12.385
DU-8	Shallow (0-6")	53	**15**				Deep (6"-12")	28	**8.2**			
DU-8	Shallow (0-6")	43	**12**	**13.333**	**1.528**	**11.456**	Deep (6"-12")	24	**7.3**	**7.267**	**0.950**	**13.079**
DU-9	Shallow (0-6")	21	**5.5**				Deep (6"-12")	21	**<4.4**			

Arsenic concentration (or Bioaccessible arsenic concentration) exceeds the Part 201 Generic Residential Direct Contact Criteria 7.600 mg/kg (7600 ug/kg)

Incremental samples based on 50 increments collected from 0-6" (Shallow) and 6"-12" (Deep) decision units

Former Orchard in 1955

Housing on Former Orchard

Housing on Former Orchard

DHHS and EGLE Publication

Lead and Arsenic in Soil in Former Fruit Orchards

Many of us live on land that was once used for farming. This fact sheet provides basic information about lead and arsenic soil contamination in areas that were formally used as fruit orchards. If you live, work or play in an area that used to be an orchard, the information in this fact sheet can provide guidance about actions you can take to learn more about possible soil contamination and how to protect your health.

How does soil become contaminated with high levels of lead and arsenic?

Arsenic and lead in soil can be naturally occurring or may be there as a result of human activity. Arsenic and lead may also end up in soil from past agricultural activities.

From the late 1890s through the 1960s, pesticides that contained arsenic and lead were commonly used throughout the United States to control insects in fruit orchards. Arsenic and lead used a long time ago can stay in the soil if the affected soil has not been removed.

How do I know if I live somewhere that used to be an orchard?

A resident or property owner can search historic air photos available from your local county GIS office or from mapping applications, Google Maps or historicaerials.com (to access maps at the Historic Aerials website, you will need to create a free account). Neighbors, previous owners, your Michigan County Conservation District (macd.org/find-your-district) or Michigan State University Extension (canr.msu.edu/outreach/ask-an-expert) may also be able to provide helpful historical information.

Historical aerial picture of an orchard.

What are the health effects of arsenic and lead?

Health effects can vary based on how much and how long you were exposed to lead and arsenic.

Arsenic

Health effects of arsenic can include:

- Darkening of skin and development of small growths on palms, soles of feet and other parts of the body.
- Cardiovascular disease.
- A higher risk of skin, liver, bladder and lung cancer.

Lead

Exposure to lead can cause a wide variety of health effects because lead affects almost every organ in the body. Swallowing lead can be a serious issue for children because of lead's effect on developing nervous systems. When lead affects the nervous system, children can experience problems with learning, behavior, speech and hearing. The more lead children are exposed to, the more serious the health effects can be.

Learn more about the ways you can be exposed to lead and possible health effects at bit.ly/lead-and-health.

How can I be exposed to arsenic and lead in soil?

People can be exposed to arsenic and lead by breathing it in or accidentally swallowing it. This can happen if you have soil on your hands and eat or touch your mouth.

What should I do to protect myself and my family?

You can reduce possible exposure to lead and arsenic by:

Limiting contact with soil, especially in areas not covered by grass or other vegetation. Discourage children from playing in soil that is not covered by grass, vegetation or mulch.

If you do have contact with the soil or if you garden:

- Consider wearing gloves.
- Wash hands frequently, especially after contact with the soil and before eating.

Avoid tracking soil into your home.

- Consider leaving shoes at the door, especially if you have walked in the soil.
- Wipe your pet's feet off before bringing them into the house.

Should I test my soil or groundwater?

Soil and groundwater testing on your property is optional and you will be responsible for the cost. If you choose to test soil or groundwater, contact an environmental consultant. Because costs can vary, consider getting several bids. Some ways to find an environmental consultant include:

- Searching the EGLE Environmental Consultant Directory at bit.ly/EGLE-Consultants.
- Asking for a referral from financial institutions, real estate agencies or trade associations.
- Contacting your EGLE county representative at 800-662-9278.

How can I garden in areas where arsenic and lead may be in the soil?

Vegetables may take in arsenic and lead as they grow, but the bigger concern is soil that sticks to the outside of vegetables. You can limit exposure by washing vegetables before eating them. You can also mulch garden beds to reduce dust and soil from getting on fruits and vegetables.

You can further limit exposure to arsenic and lead while gardening by:

- Covering walkways with grass, mulch, landscape fabric, stones or bricks to help keep soil off shoes so that you do not accidentally bring soil into your house or car.
- Wearing gloves while gardening. Wash hands after gardening and before eating and drinking.
- Building raised beds or container gardens and fill them with soil from a non-contaminated source. If you make a raised bed, use a liner to separate the existing soil from the new soil that you put into the bed.
- Building raised beds can be expensive, but you can use inexpensive materials. Use untreated wood, stone, concrete blocks or bricks. You can even use smaller containers like plastic pots and make a container garden.

Please call 1-800-648-6942 to talk with a toxicologist if you have other questions about lead or arsenic in soil.

Por favor llame al 1-800-648-6942 para hablar con un toxicólogo si tiene otras preguntas sobre el plomo o el arsénico en la tierra. Hay interpretación al español.

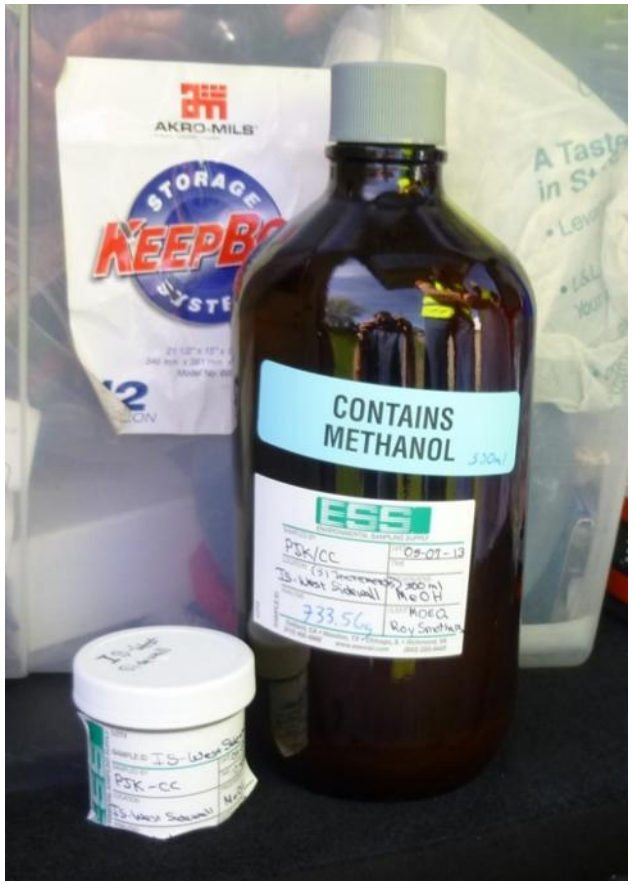
إذا كان لديكم أسئلة أخرى حول نواجد الرصاص أو الزرنيخ في التربة، فالرجو منكم الاتصال هاتفياً بالرقم 1-800-648-6942 للتحدّثوا مع أحد الاختصاصيين في علم السموم حول هذا الأمر. وإذا كنتم بحاجة إلى مترجم شفهي في اللغة العربية، فهناك مترجمون شفهيون موجودون لمساعدتكم.

EGLE MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

MDHHS Michigan Department of Health & Human Services

MDHHS-Pub-2036 (10-24)

Can I Incrementally Sample VOCs? Yes



Summary of What Matters **Defensible Decisions**

Data Quality Objectives matter

Decision Unit Selection Matters

Full Spatial Coverage (Increments Matter)

Mass of field sample (Mass Matters)

Lab interaction on processing steps. Extraction/Digestion mass matters.

All leads to **Representative** and **Reproducible** Data

Follow us at: Michigan.gov/egleConnect

Chris Christensen, CPG
EGLE-RRD-Technical Support Unit
Grand Rapids Office
616-446-7582 | christensenc@michigan.gov

Paul Knoerr
EGLE-RRD-IS TAPS Co-Leader
Grand Rapids District Office
616-840-2131 | knoerrp@michigan.gov