Sampling for Lead in Drinking Water

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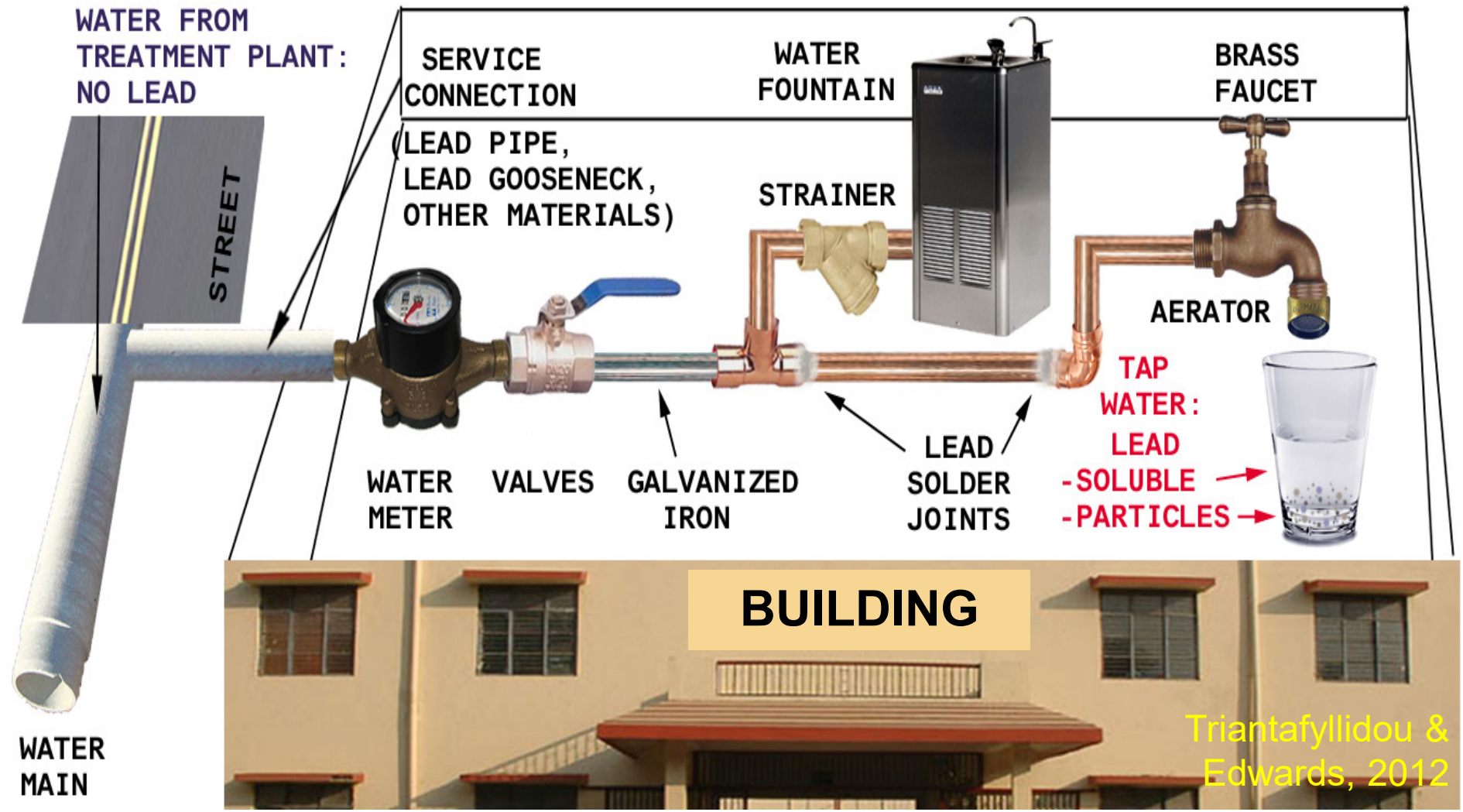
11/09/2017



Pb not present in drinking water right after treatment:

- Lead Service Lines (LSLs)
- Lead Goosenecks
- Leaded Solder
- Galvanized pipe downstream of leaded plumbing
- Leaded Brass (valves, fittings, faucets, water fountains)

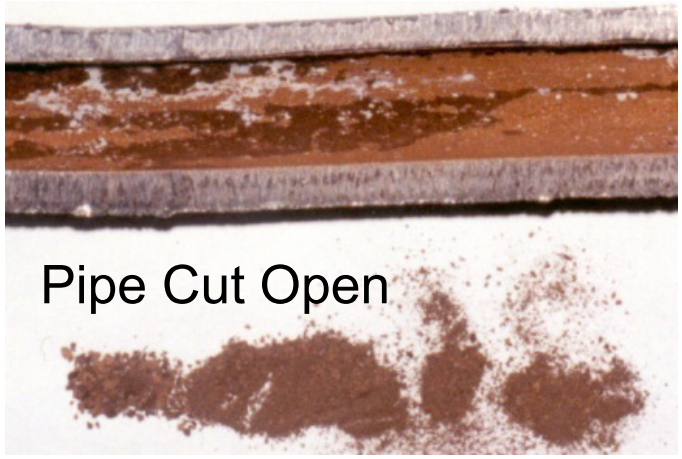
Many factors affect lead release

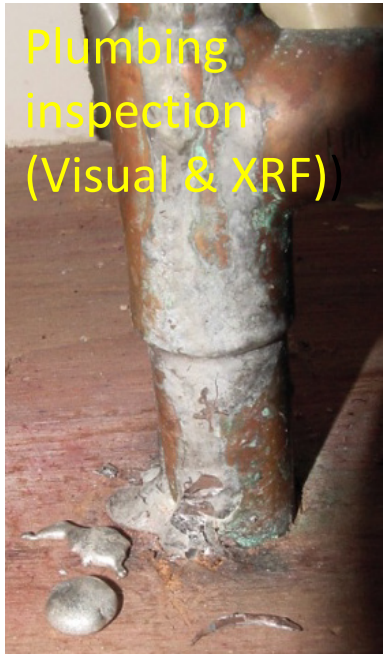
- Plumbing materials, dimensions, configurations
- Water chemistry (corrosivity)
- Chemical and hydraulic changes/disturbances
- Water use patterns

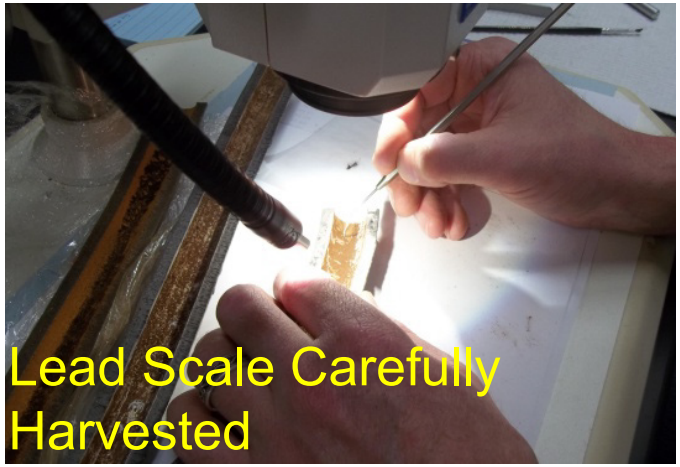
- Spatial variability
- Temporal variability
- Particulate vs Dissolved lead

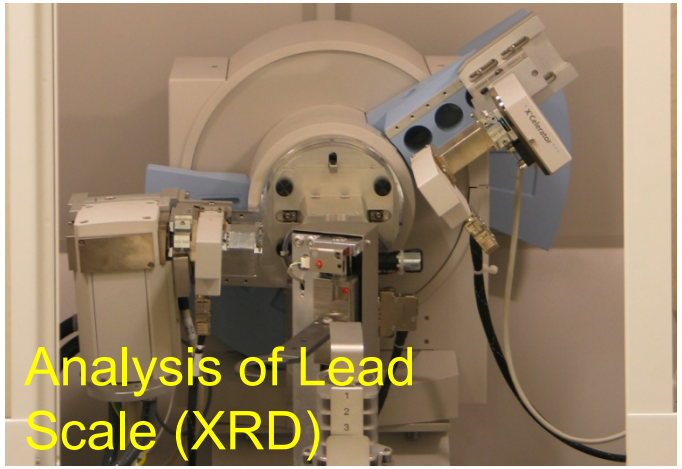
Research tools


Lead Service Line (LSL) Removal


Pipe Cut Open


Plumbing inspection (Visual & XRF)

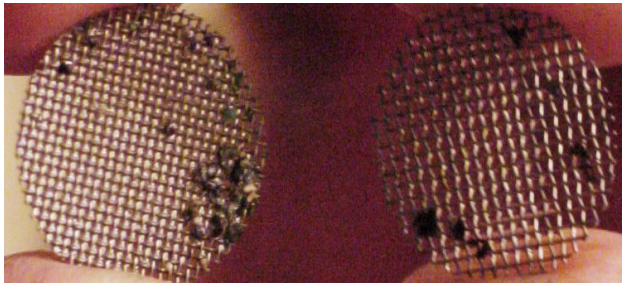

Lead Scale Carefully Harvested


Analysis of Lead Scale (XRD)

Research tools

Tap water collection

Analysis for lead and other metals (ICP-MS)



Morphology and elemental mapping of particles in faucet aerator (SEM/EDS)

Research tools

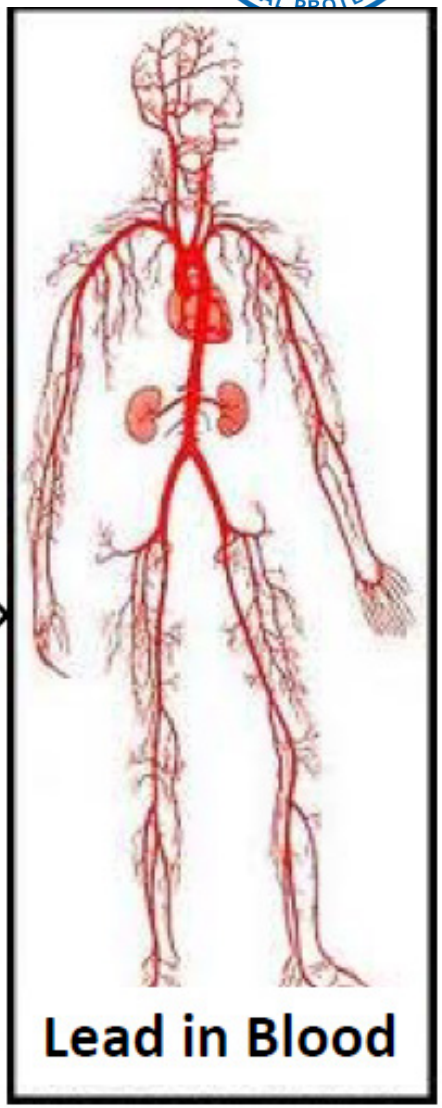
Lead in Tap Water

Integrated Exposure Uptake Biokinetic Model for Lead in Children
Windows® version 1.1 Build9

IEUBK

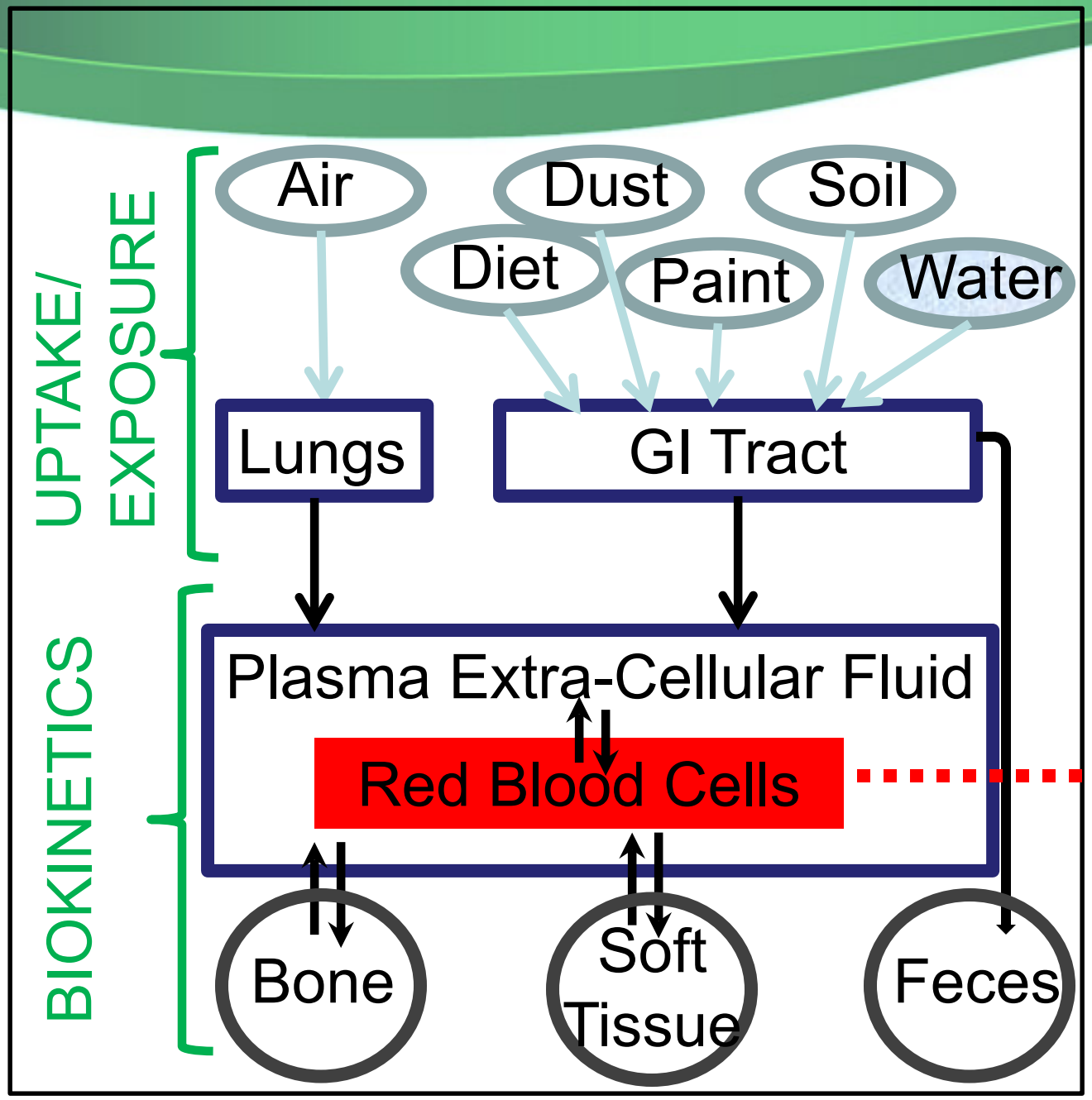
LEAD AND IEUBK TECHNICAL REVIEW WORKGROUP

Biokinetic ModelPrediction



Lead in Blood

IEUBK Model For Lead in Children

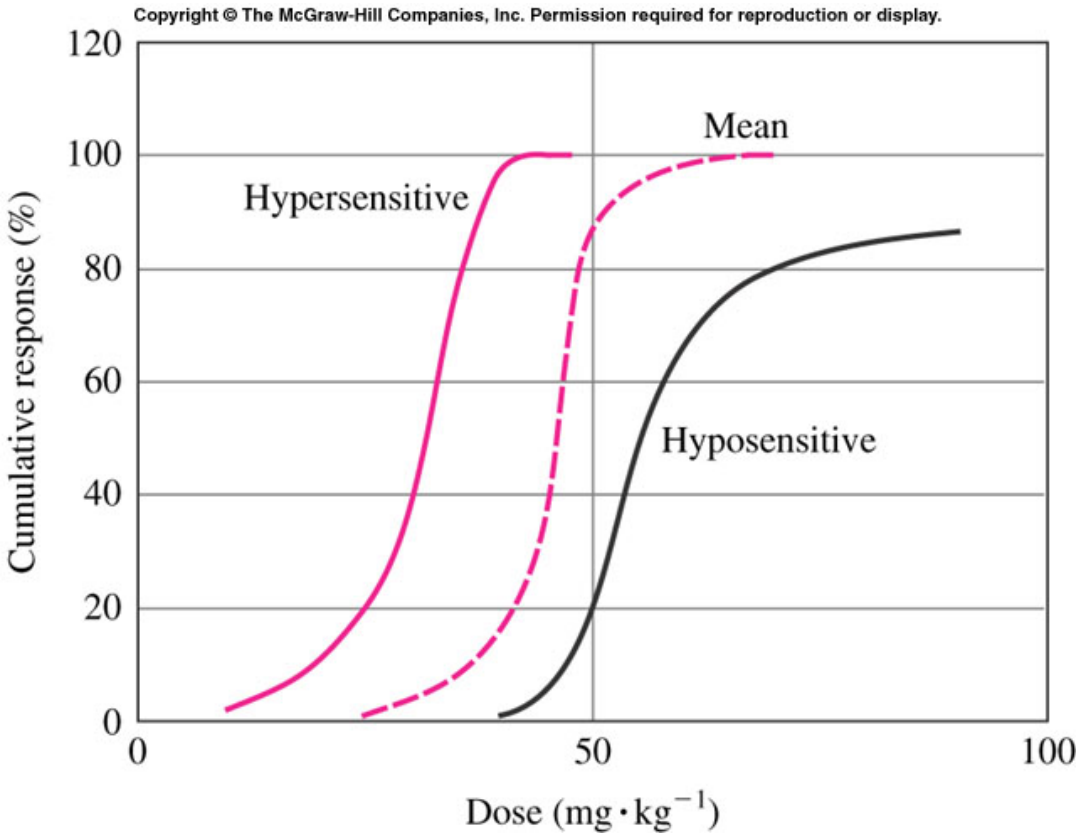


Modified from US EPA, 2002

Predict Blood Lead Levels (BLLs)

Model Considerations

- Most sensitive children:
  - BLL variability in response to same lead dose due to genetics/diet
  - IEUBK predicts **distribution** of BLLs (including hypersensitive)
- Most exposed children:
  - Formula fed children consuming much higher water volumes



0-1 year old infant consuming baby formula

- *IEUBK model predictions, hypothetical water lead levels*
- *800 mL/day, Average water consumption*
- *Default exposures from other lead sources*

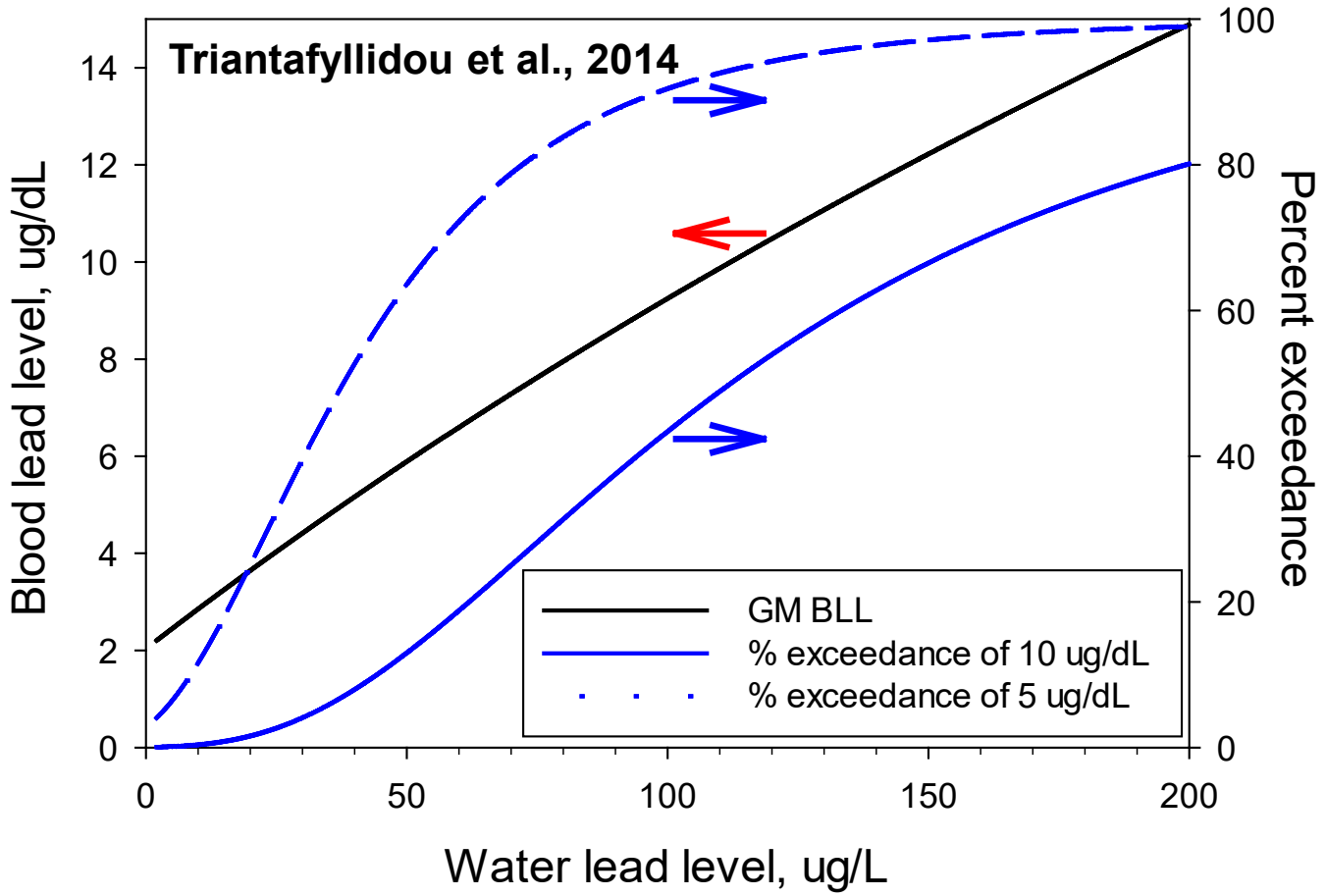
BLL Threshold (µg/dL)	Predicted Water Lead Required to Exceed BLL Threshold for		
	50%th Percentile	*75%th Percentile*	*95%th Percentile*
10	60 µg/L	40 µg/L	22 µg/L
5	18 µg/L	11 µg/L	4 µg/L

Triantafyllidou et al., 2012

For illustrative purposes. Different modeling assumptions would yield different results

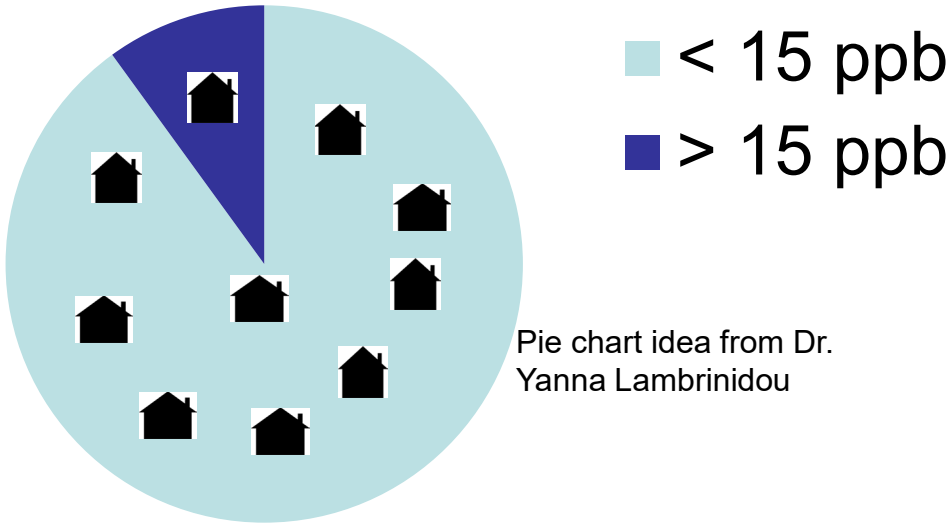
5-6 year old child drinking tap water

- *IEUBK model predictions, hypothetical water lead levels*
- *Default exposures from other lead sources*



Lead and Copper Rule Sampling, US

- Lead Action Level is not an MCL (Maximum Contaminant Level)
- Aimed at identifying system-wide problems rather than problems at outlets in individual buildings
- 90th percentile 15 µg/L action level is a trigger for corrosion control treatment rather than an exposure level



Pie chart idea from Dr. Yanna Lambrinidou

ALWAYS SAMPLE WATER IN ENVIRONMENTAL ASSESSMENTS OF LEAD-POISONED CHILDREN, EVEN IN CITIES COMPLYING WITH LCR

Is my water safe to drink?

How do I know if my tap water is contaminated with lead?

The only way to know whether your tap water contains lead is to have it tested. **You cannot see, taste, or smell lead in water.** Therefore, you must ask your water provider whether your water has lead in it. For homes served by public water systems, information on lead in tap water may be available from your local water authority. If your water provider does not post this information, you should call and find out.

You should be particularly suspicious if:

- **Your home has lead pipes** (lead is a dull gray metal that is soft enough to be easily scratched with a house key)
- **You see signs of decay** (frequent leaks, rust colored water, stained dishes or laundry, or if your nonplastic plumbing is less than five years old)

* Taken from www.healthychildren.org

- Results on the spot
- No Lab Required
- No Mixing or Measure
- Calibrated the EPA standard for lead

Small price to pay for piece of mind

By R Young on May 6, 2016

Verified Purchase

After hearing of several local schools that discovered high levels of lead in their water, I really started to worry about lead in the water at my workplace as the building is fairly old. I didn't want to spend a lot on an expensive test since it's my workplace and not my home, but I just wanted some piece of mind. This test did the trick.

The test itself was simple to use, fill the included dropper with water, put it in the provided vial, drop in the test stick and 10 minutes later you're done. It's really a breeze. I wish they mentioned in the instructions how little water is actually in the vial. I was second guessing myself that I didn't put enough, but one dropper did the trick.

After the 10 minutes, my test came back and my water tested negative for lead. Now I don't have to worry about it anymore.

The only thing I wish is that the test gave an amount of lead detected rather than just a TRUE or FALSE response, but tests that did that were way more expensive. For this price, it did the trick.

Testing your home's water

Start with your local water supplier -- some will come to your home and test for free. If that's not an option, you can buy a lead testing kit from home improvement stores to collect the testing samples.

If you do it yourself, be sure to follow directions carefully and only use "first-draw water," the very first water coming out of your pipes after sitting overnight. If your pipes are contaminated, that water will have the most accumulation of toxins.

Oct 13

The only way to tell if your water is safe is to test it at the tap. Let us give you peace of mind. .com/leadsmart #BusinessOwners

- How well we can answer that question hinges on many variables:
  - Premise plumbing (volume, composition, configuration, age)
  - LSL present?
  - Individual household usage patterns

- Need to ask more specific questions
  - What is the general public's exposure to lead in drinking water in this residence/neighborhood/town/distribution system?
  - How effective is the current corrosion control treatment?
  - What forms of lead are present in the drinking water (soluble vs. particulate)?
  - Where is the lead coming from?
  - Does the water meet regulatory standards for lead?

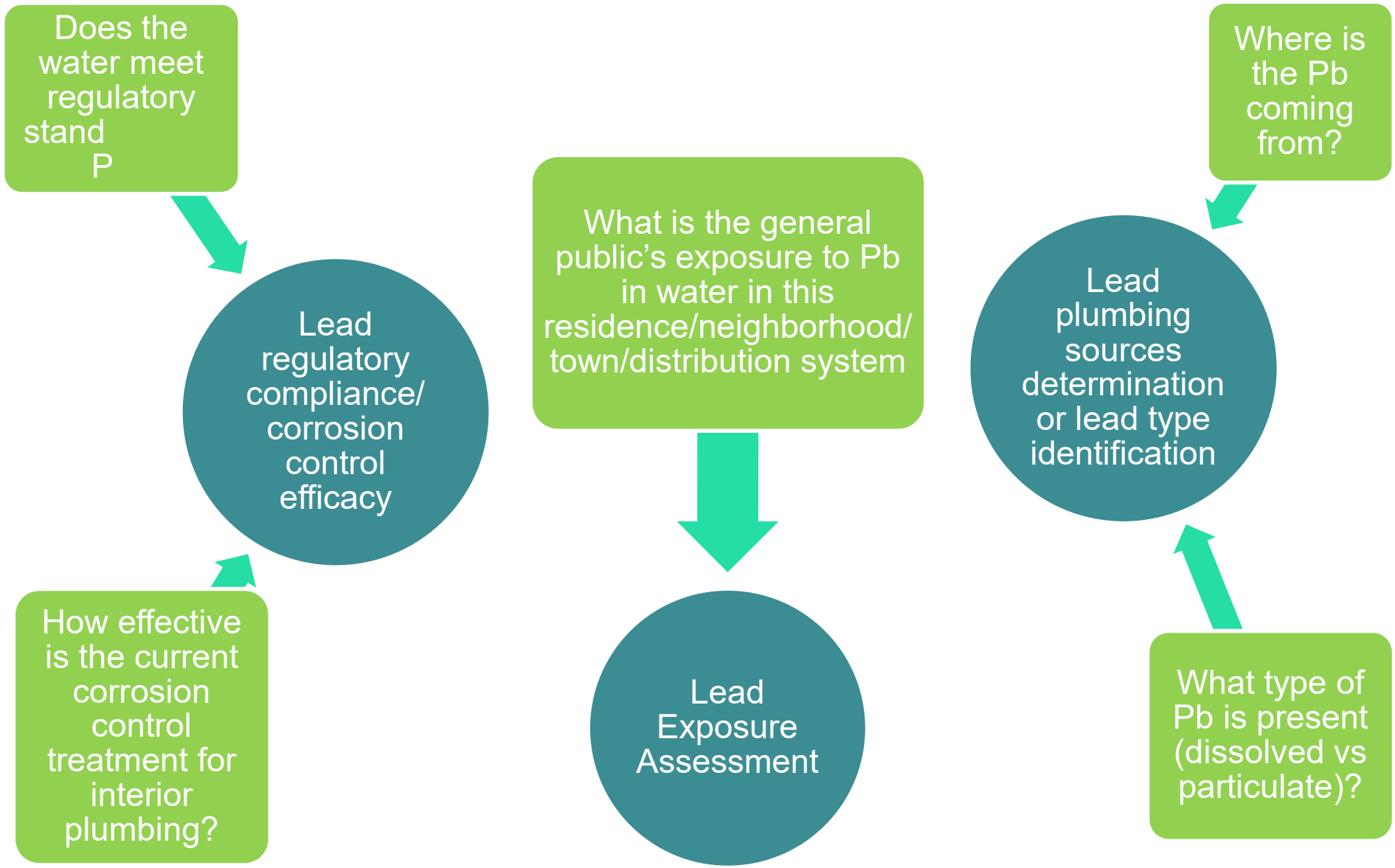
Current Sampling Approaches

- Regulatory/Compliance/Treatment Sampling
- Exposure Assessment Sampling
- Sampling for Lead Sources

No single universally applicable sampling approach for lead in drinking water exists

There are many protocols, but each has a specific use answering one of those many questions

What questions are you trying to answer?



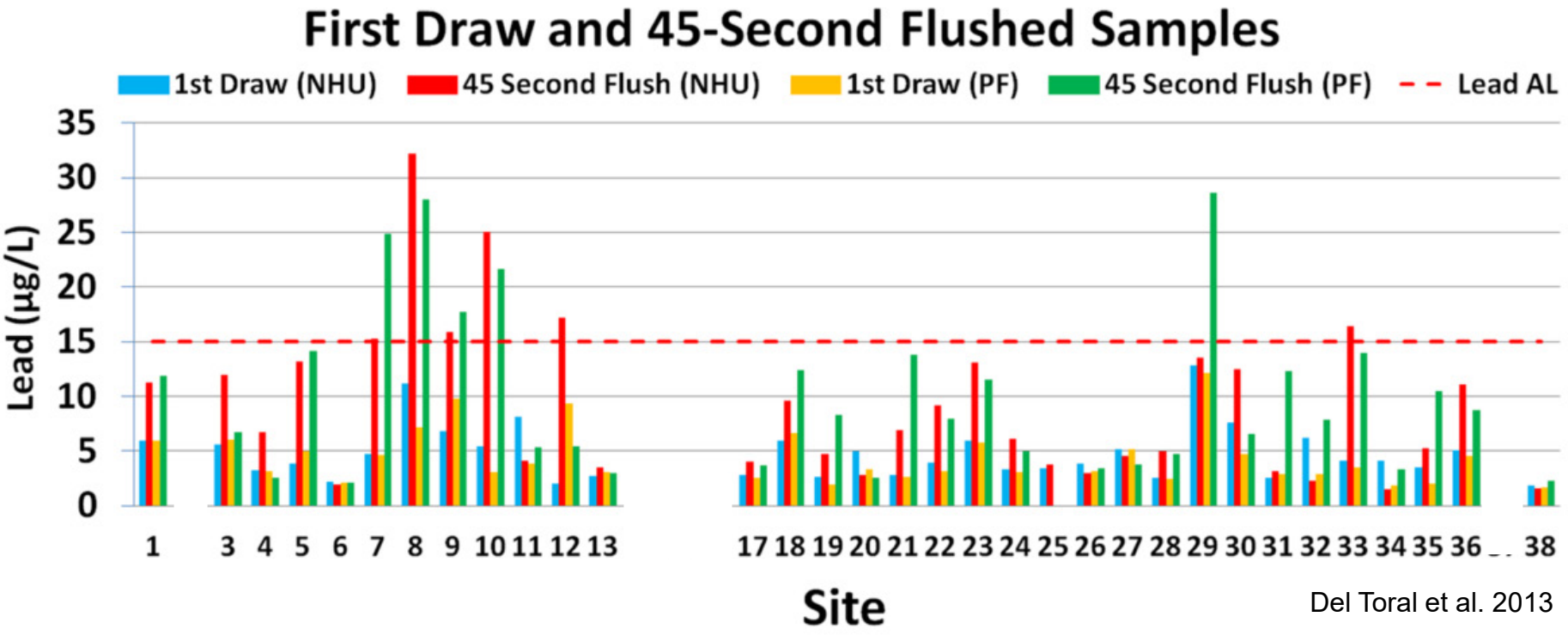
Multiple Options Exist for Lead Sampling

OBJECTIVE	SAMPLE TYPE	PROTOCOL
Lead regulatory compliance/ corrosion control efficacy	First Draw, US	6+ hr stagnation Collect 1 L
	Random Daytime (RDT), UK	Random sample collection (variable stagnation) Collect 1 L
	30 Min. Stagnation (30MS), Ontario Canada	2-5 min. flush 30 min. stagnation Collect first two liters

OBJECTIVE	SAMPLE TYPE	PROTOCOL
Lead plumbing sources determination or lead type identification	Profile (or sequential) sampling (traditional)	Defined stagnation time 10-20 sequential samples of defined volume (125 mL, 250 mL, 1 L, etc.)
	Profile sampling that stimulates particle release	Traditional profile sampling at increasingly high water flow rate (low, medium and high)
	3T's for schools guidance, US	Overnight stagnation Collect first 250 mL from all taps and fountains If sample> 20 ppb, take follow up samples

OBJECTIVE	SAMPLE TYPE	PROTOCOL
Exposure Assessment	Voluntary monitoring Or Environmental assessments in homes of at-risk children	"Ad hoc"
	Composite proportional	- Captures actual water use - A device collects 5% of every draw from the tap for consumption - Used for 1 week

Risk = Hazard x Exposure



Del Toral et al. 2013

NHU= normal household use prior to stagnation
PF= flush of at least 5 minutes prior to stagnation
32 sites with LSLs (built between 1890-1960)

Regulatory Compliance Sampling

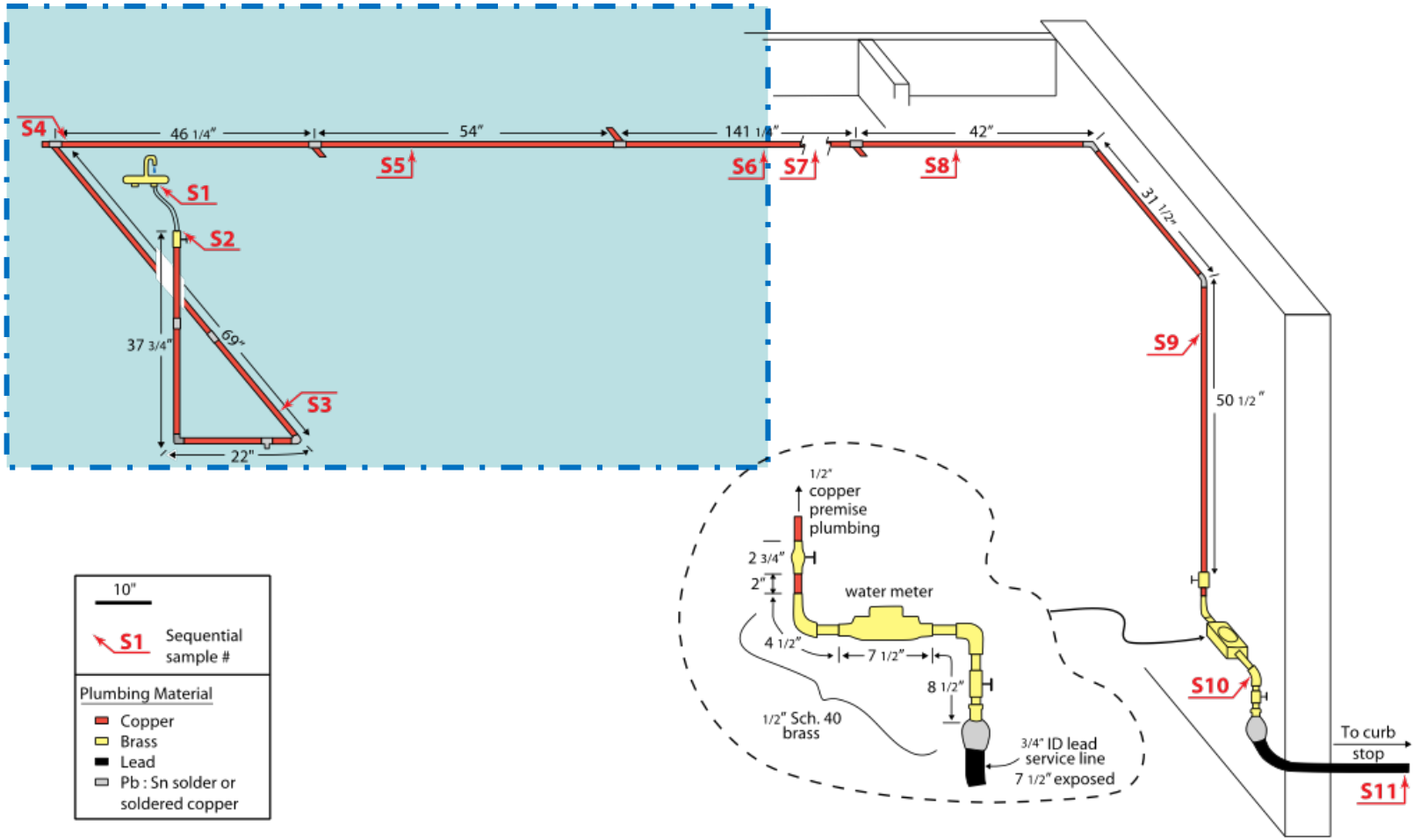
Does the water meet regulatory standards?

- US Lead and Copper Rule **(90th Percentile Action Level ≥15 ppb)**
  - 6+ hour stagnation and 1 L first draw sample

- Long stagnation time, allows sufficient lead amplification
- May also be used for corrosion control treatment evaluation
- Low flow rate, aerator removal, and pre-stagnation flushing have all been used to lower sample concentrations
- Differences in stagnation times can affect sample concentrations

1 L is often short of the volume required to reach the LSL and corresponding lead concentrations

1 L encompasses all of the plumbing components in the blue box (LSL is not reached)



Exposure Assessment Sampling

What is the general public's exposure to lead in drinking water?

- RDT & 30 Minute Stagnation (MS)
  - Representative of the approximate inter-use stagnation time
  - Requires appropriate number of samples based on population size and variability within water system

- Composite Sampling Devices
  - Exposure reference method
  - Collects proportion of all lead consumed per week

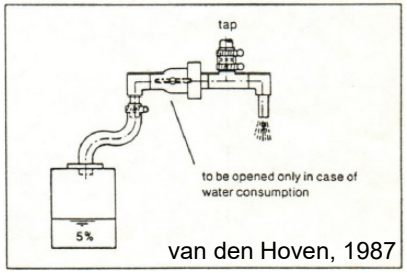
These are the applicable sampling methods to use when a customer asks "Is my water safe to drink?"

Reminder: LCR sampling does not assess exposure

Automatic vs Manual Composite Sampling

- Collects lead under normal use conditions, capturing a range of flow rates, stagnation times, flow durations, and temperatures

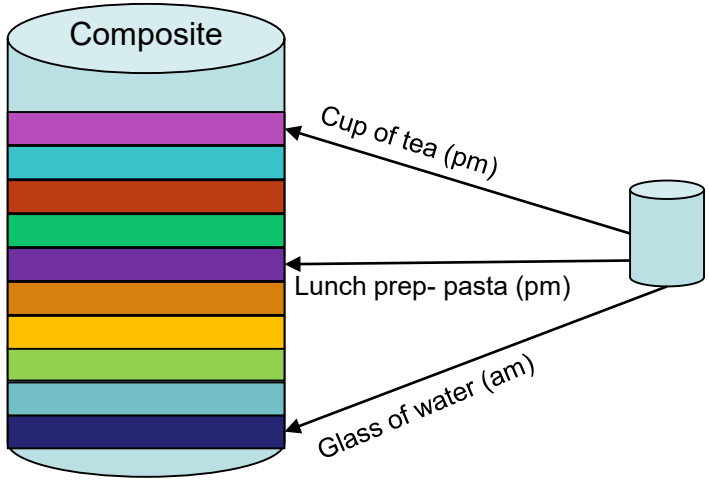
- Device is affixed to the tap & consumer operated
- 5% of every draw meant for consumption is routed into holding tank



van den Hoven, 1987

- Does not collect all lead
- Seen as inconvenient and cumbersome by residents

- Of all water drawn for consumption the consumer pours a small volume into a collecting vessel
- Creates a composite sample over a day's use, few days, week…

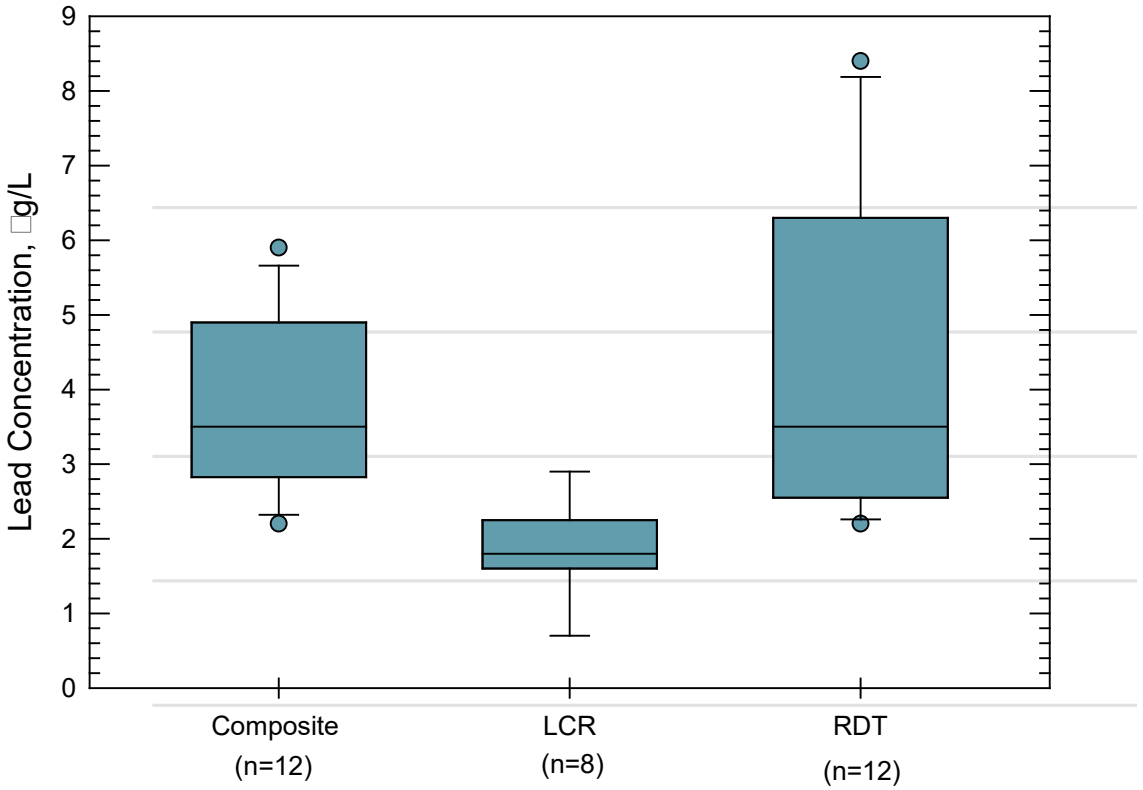


After a period of time the composite sample analyzed for lead → average lead concentration

Comparison

USEPA's Home Plumbing Simulator (HPS) compares composite proportional sampling to LCR 1st Draw and RDT

- Shorter than typical LSL (7 ft. vs. ~60 ft.)
- LSL is 1.3 L away from faucet-not captured by LCR sampling



Sources of **LEAD** in Drinking Water

Sampling for Lead Sources

Where is the lead coming from?

Copper Pipe with Lead Solder: Solder made or installed before 1986 contained high lead levels.

Faucets: Fixtures inside your home may contain lead.

Galvanized Pipe: Lead particles can attach to the surface of galvanized pipes. Over time, the particles can enter your drinking water, causing elevated lead levels.

Lead Service Line: The service line is the pipe that runs from the water main to the home's internal plumbing. Lead service lines can be a major source of lead contamination in water.

Lead Goose Necks: Goose necks and pigtails are shorter pipes that connect the lead service line to the main.

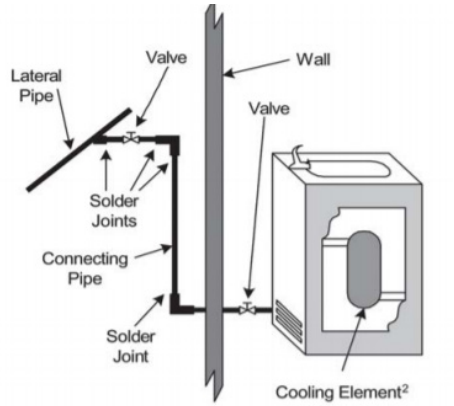
Sampling for Lead Sources

Where is the lead coming from?

- Sequential Sampling
  - Correspond high Pb and/or Zn, Cu, Sn, Fe samples to plumbing volumes
- LSL Sampling

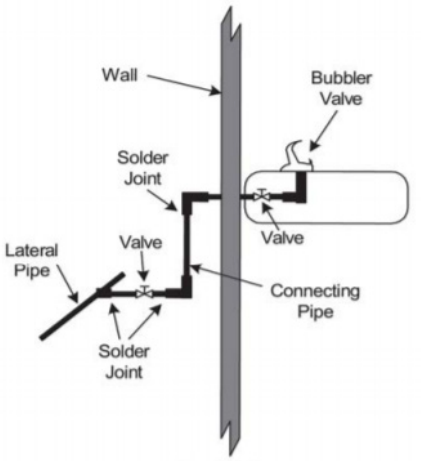
  Option 1: Fully flushed (+short stagnation, 15-30 minutes) samples above ~3 µg/L can indicate a LSL is present (threshold depends on LSL length)

  Option 2: Allow water to sit motionless in the LSL for at least 6 hours, flush premise plumbing volume to sample LSL stagnation contribution (1 L sample)
- 3T's
  - 250 mL sample above 20 ppb after overnight stagnation indicates faucet or bubbler likely contributes lead (brass)



Water Cooler

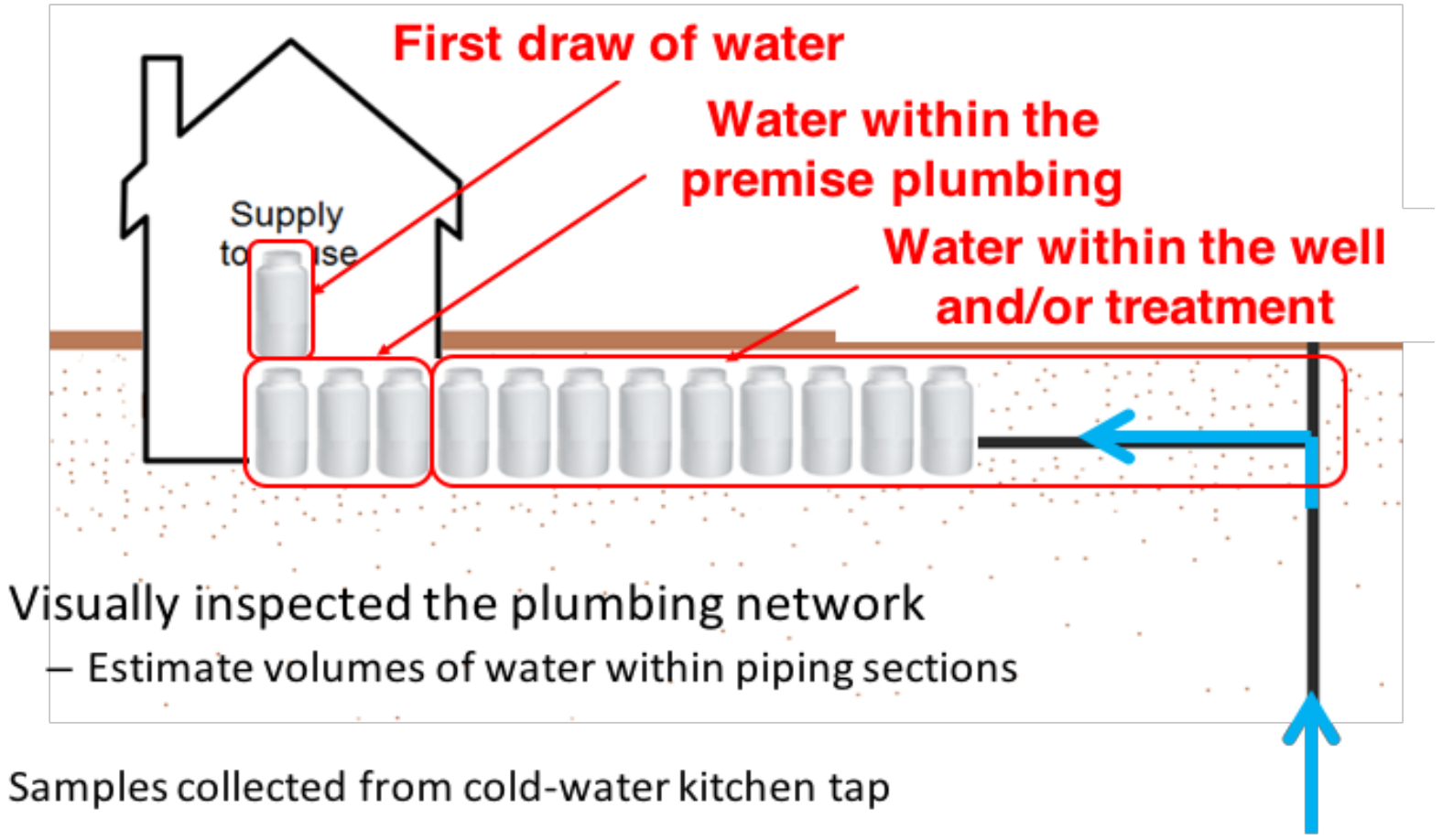
*250 mL is ~4 ft of plumbing at ½ inch ID (inside diameter)



Bubbler

Sequential Sampling

- Series of samples taken after stagnation
- Correlate sample volumes to plumbing sections
- Useful for identifying lead sources and remedial actions-flushing & plumbing replacements
- Captures lead peaks from LSL or other plumbing that a 1 L sample may miss



Courtesy: Kelsey Pieper, UNC

Sampling for Lead Type

What forms of lead are present in the drinking water?

- Particulate
  - Easy to miss with standard sampling protocols
  - High flow rate, hydraulic disturbances, & certain materials (brass especially) spur release
  - Harder to quantify with acidification
- Soluble
  - ~0.1-0.2 µm
- Sampling Protocol to disturb scale/generate particulate and protocol to filter samples for dissolved lead content

Lead Pipe Scales

smallest intervals= mm

Choosing the correct protocol for the question being asked is extremely important

Protocol Considerations:

- Sample volume
- Number of samples per site
- Number of sites
- Stagnation time
- First draw or flush
- Site choice
- Frequency of sampling

Sampling Variabilities:

- Flow rate
- Water temperature
- Time of year
- Pre-flushing
- Aerator removal
- Particulate release
- Accurate quantification
- Stagnation time differences

Summary

- Lead in water can be highly variable
- Different sampling protocols produce different lead concentrations and sample different sources/forms of lead
- The efficacy of a single protocol varies from building to building due to plumbing differences and other site variabilities
- Choosing the correct protocol for the sampling purpose is crucial to producing meaningful data

Contact Information

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Notice

The findings and conclusions in this presentation have not been formally disseminated by the U.S. Environmental Protection Agency and should not be construed to represent any Agency determination or policy. Any mention of trade names or commercial products does not constitute endorsement or recommendation for use.

References

Cartier, C., et al. (2011). "Investigating Dissolved Lead at the Tap Using Various Sampling Protocols." Journal - American Water Works Association **103**(3): 55-67.

Clement, M., et al. (2000). "A Practical Model for Estimating Total Lead Intake from Drinking Water." Water Res **34**(5): 1533-1542.

Del Toral, M. A., et al. (2013). "Detection and evaluation of elevated lead release from service lines: a field study." Environ Sci Technol **47**(16): 9300-9307.

Grayman, W. M. and S. G. Buchberger (2006). Fixture-Level Human Exposure Calculation Model. 8th Annual Water Distribution Systems Analysis Symp. Cincinnati.

Hayes, C. R. and T. N. Croft (2014). Optimization of Plumbosolvency Control using Computational Modelling Techniques: A Demonstration Project for the Government of Alberta, Working with the City of Calgary and EPCOR (Edmonton).

Sandvig, A., et al. (2008). Contribution of Service Line and Plumbing Fixtures to Lead and Copper Rule Compliance Issues, AWWA Research Foundation.

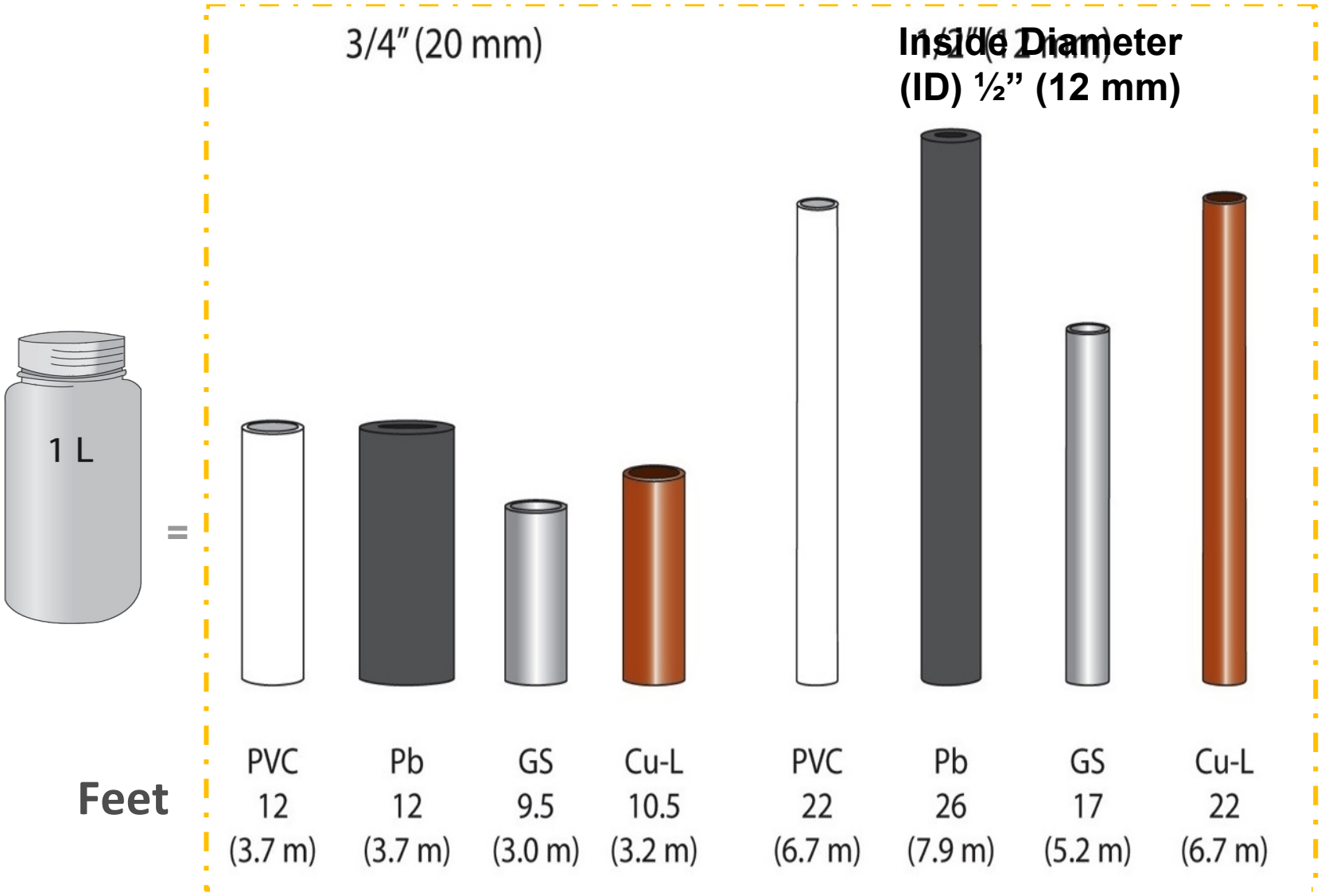
Schock, M. R.; Lytle, D. A. Internal Corrosion and Deposition Control; In Water Quality and Treatment: A Handbook of Community Water Supplies; Sixth ed. 2011.

van den Hoven, T. (1987). "New Method to Determine and Control Lead Levels in Tap Water." Aqua AQUAAA **6**.

Multiple Options Exist for Lead Sampling

Sample Type	Sampling Purpose	Protocol
First Draw	-Regulatory (US) -Treatment Assessment	-6+ hr stagnation -Collect first liter
Random Daytime Sampling (RDT)	-Regulatory (UK) -Treatment Assessment	-Random sample collection (variable stagnation times) -Collect first liter
Fixed Stagnation Time (30MS)	-Regulatory (Ontario) -Treatment Assessment	-2-5 min. flush -30 min stagnation -Collect first two liters
Fully Flushed	-Lead Source Assessment -Treatment Assessment	-Several piping volumes flushed -Collect first liter
Sequential Sampling (Profile Sampling)	Lead Source Assessment	-Defined stagnation time -Collect 10-20 samples of defined volume (125 mL, 250 mL, 1 L, etc.)
Composite Proportional	Exposure Assessment	-Normal water use patterns -A device collects 5% of every draw from the tap for consumption -Used for 1 week
Particle Stimulation Sampling	-Lead Type Assessment -Exposure Assessment	-5 min stagnation -Collect first liter and maximum flow rate, open and close tap five times, fill rest of bottle at normal flow rate. -Collect second liter at a normal flow rate -Collect third liter the same way as the first
Service Line Sampling (Second Draw)	-Lead Source Assessment	-6+ hr stagnation -Volume between tap and LSL flushed -Collect 1 L
3T's Sampling for Schools	-Lead Source Assessment	-Overnight stagnation -Collect first 250 mL from all taps and fountains -Take follow up sample of overnight stagnation and 30 second flush if first sample> 20 ppb

Sample Volumes Represent Where in the Plumbing You are Sampling From



After: Schock, M. R.; Lytle, D. A. Internal Corrosion and Deposition Control; In *Water Quality and Treatment: A Handbook of Community Water Supplies*; Sixth ed. 2011.