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Case Study 2, Illinois

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United States Environmental Protection Agency

Site 2, Illinois, Public Water System

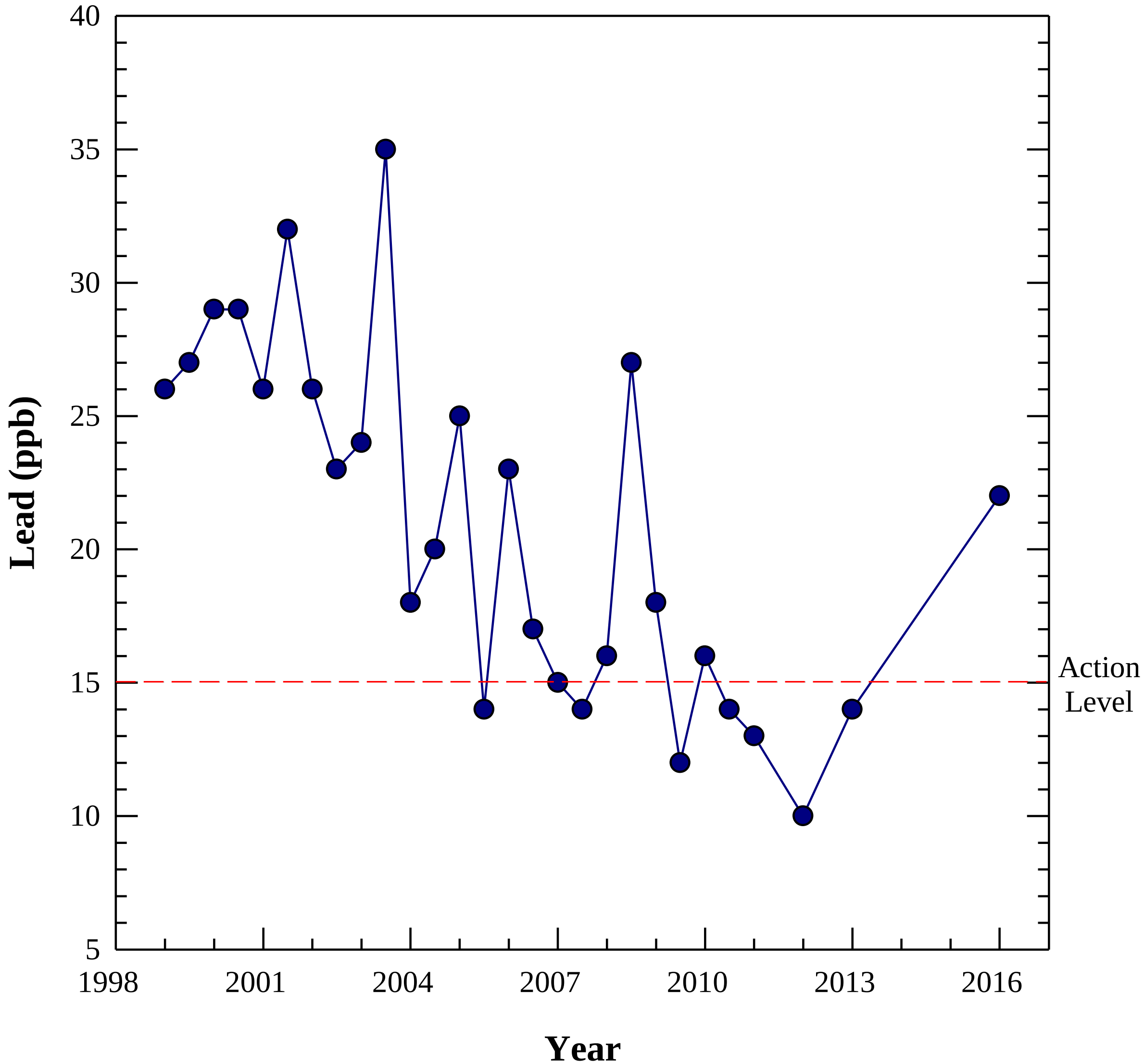
- Medium-Sized CWS
- 12,550 Service connections serving 32,195 people.
  - Estimated 4,000 LSLs
  - Entire service line owned by homeowner
- Produces 700,000 gpd
- Source: Groundwater (3 wells)

Treatment Train

- Source: Groundwater
  - Aquifer
- Filtration
- Chlorine
- Fluoride
- Blended-phosphate inhibitor

LCR Lead Action Level History
90th Percentile Lead

- History of lead action level exceedances
- Typically 60 homes are sampled per round
- Special exception permit
- Nationally known expert consultant



Corrosion Control Treatment

- August 1996-June 2000: 100% orthophosphate
- 2010 until recently: 40%/60% or 60%/40% ortho-/poly-phosphate blend
- 2007 to 2015: Orthophosphate portion 1 mg PO_4/L
- 2016: Orthophosphate portion 1.3 mg PO_4/L and polyphosphate portion 0.9 mg PO_4/L
- Lead levels have seen a general decrease with time

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Average Water Quality 2016

Parameter	Value
pH	7.5
Alkalinity, as $CaCO_3$, mg/L	199
Calcium, as $CaCO_3$, mg/L	155
Magnesium, as $CaCO_3$	79
Total Hardness, as $CaCO_3$	234
Dissolved Inorganic Carbon, DIC, mg/L	50
Total Organic Carbon, TOC, mg/L	1.5
Orthophosphate, as PO_4, mg/L	1.3
Polyphosphate, as PO_4, mg/L	0.9

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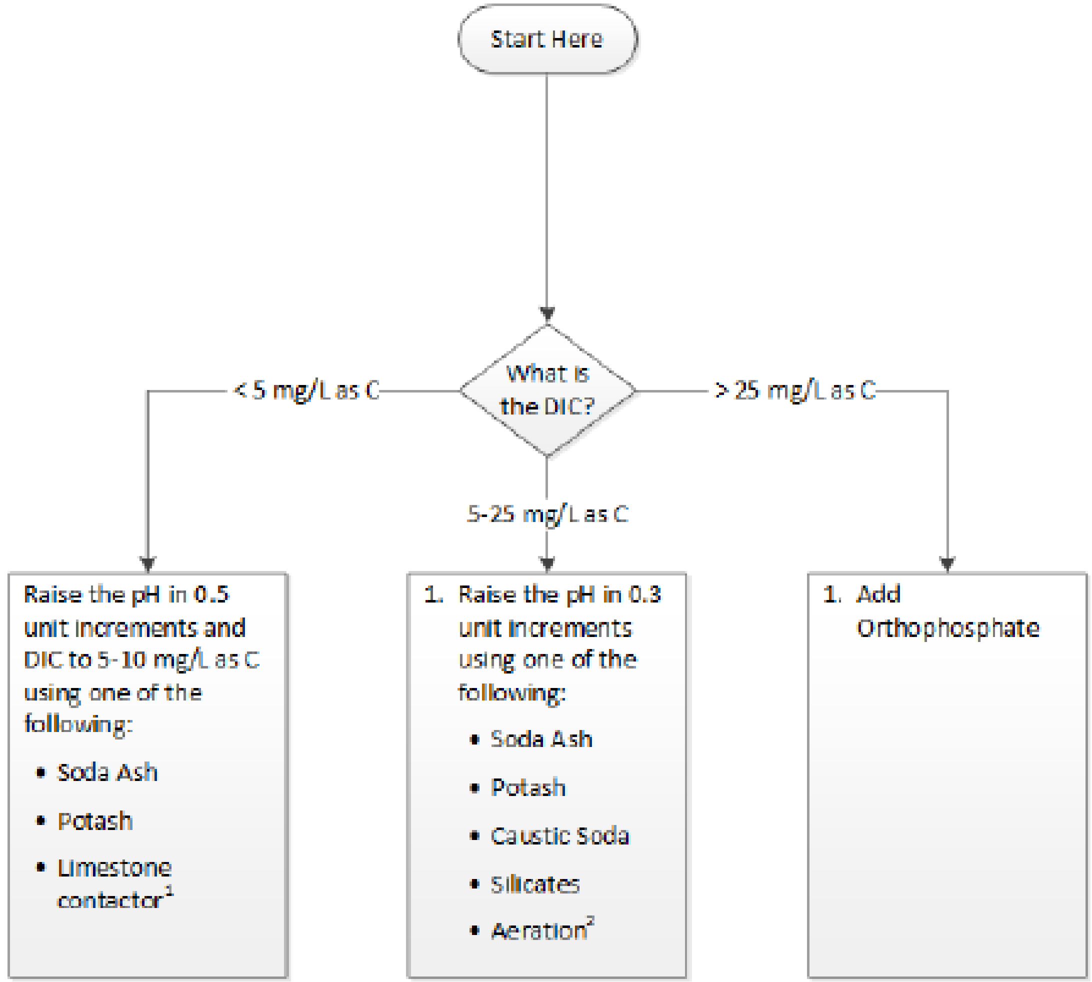
Flowchart 2b: Selecting Treatment for Copper Only with pH from 7.2 to 7.8



KEY:
AL = Action Level
Caustic soda = sodium hydroxide (NaOH)
DIC = Dissolved Inorganic Carbon
mg/L as C = milligrams per liter as carbon
Potash = potassium carbonate (K_2CO_3)
Soda ash = sodium carbonate (Na_2CO_3)

Footnotes:

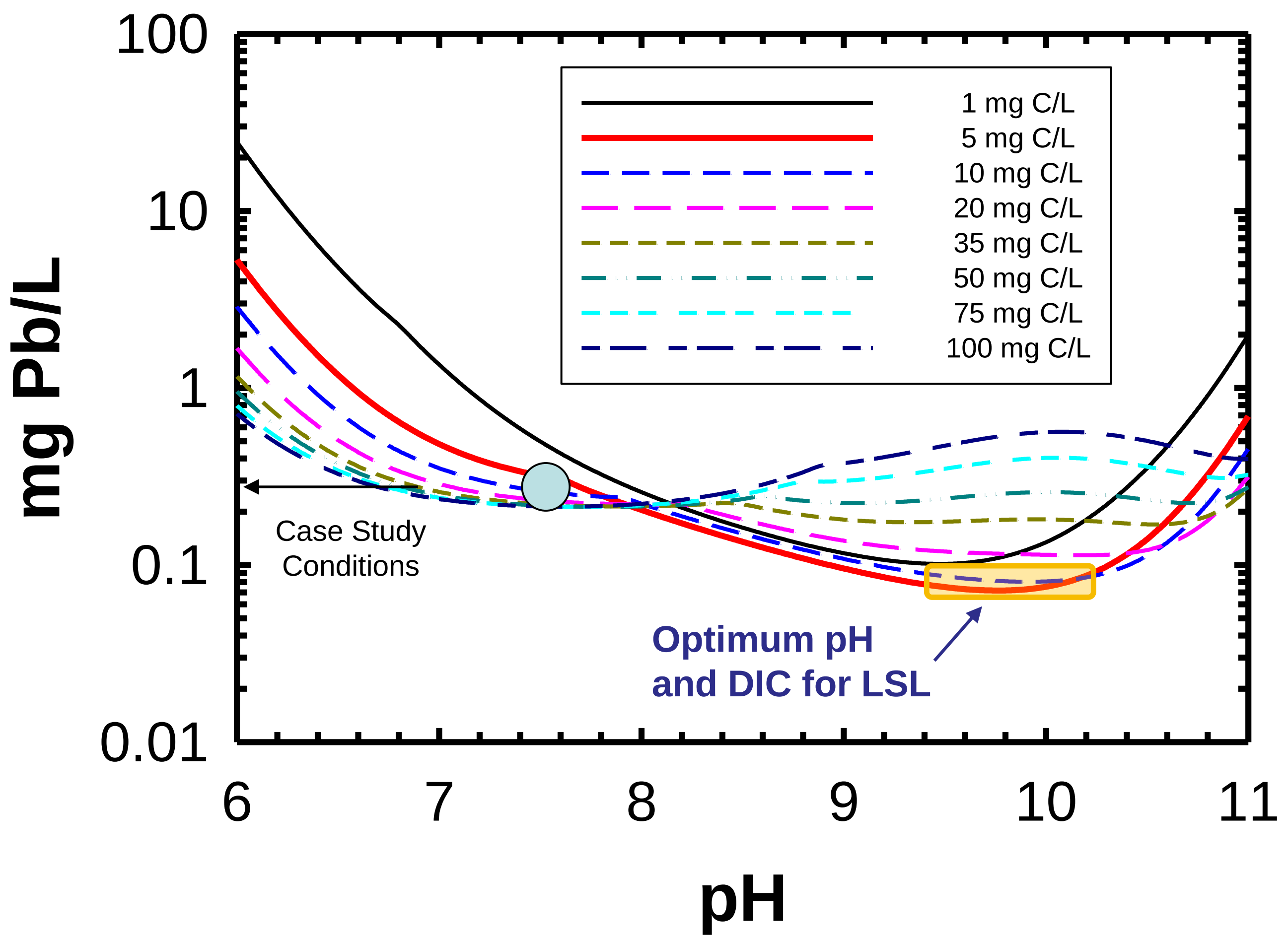
1. Carbon dioxide feed before the limestone contactor may be necessary.

2. May be most appropriate at higher end of DIC range

Theoretical Lead Solubility

Carbonate Passivation

Low DIC/High pH Strategy More Difficult with LSLs than Leaded Solder or Brass



Corrosion Control Treatment
Continued

- **pH/Alkalinity (DIC) adjustment:** cerussite ($PbCO_3$) and hydrocerussite ($Pb_3(CO_3)_2)(OH)_2$. Amorphous lead carbonates may also form. orthophosphate to form crystalline
- **Orthophosphate addition**: Lead phosphate ($Pb_9(PO_4)_6$) and hydroxypyromorphite ($Pb_5(PO_4)_3OH$), as well as amorphous lead orthophosphate.
- At a pH of ~ 7.5, lead phosphate solids are much less soluble than the lead carbonates; thus orthophosphate is generally used in systems in this pH range to form the lead phosphate scales

Point of Diminishing Returns for Orthophosphate Addition

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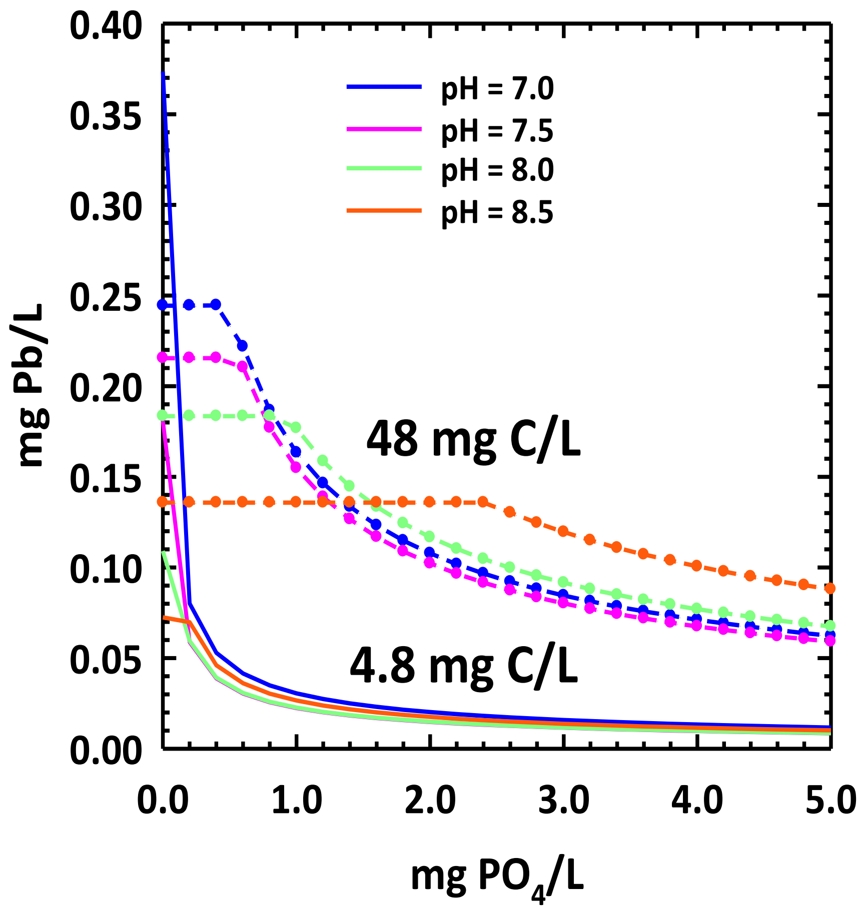
Effectiveness Depends on Dose, DIC, pH and "Cleanliness" of Pipe Surface



Most PWSs with LSLs currently do not have optimized corrosion control treatment *in terms of minimizing Pb release and exposure*.

- **pH less critical at low TIC**
- **pH less critical at high PO_4**
- **Point of diminishing returns higher with high TIC**
- **Faster Pb reduction at high PO_4**

Typical UK Dosages: 4-6 mg/L

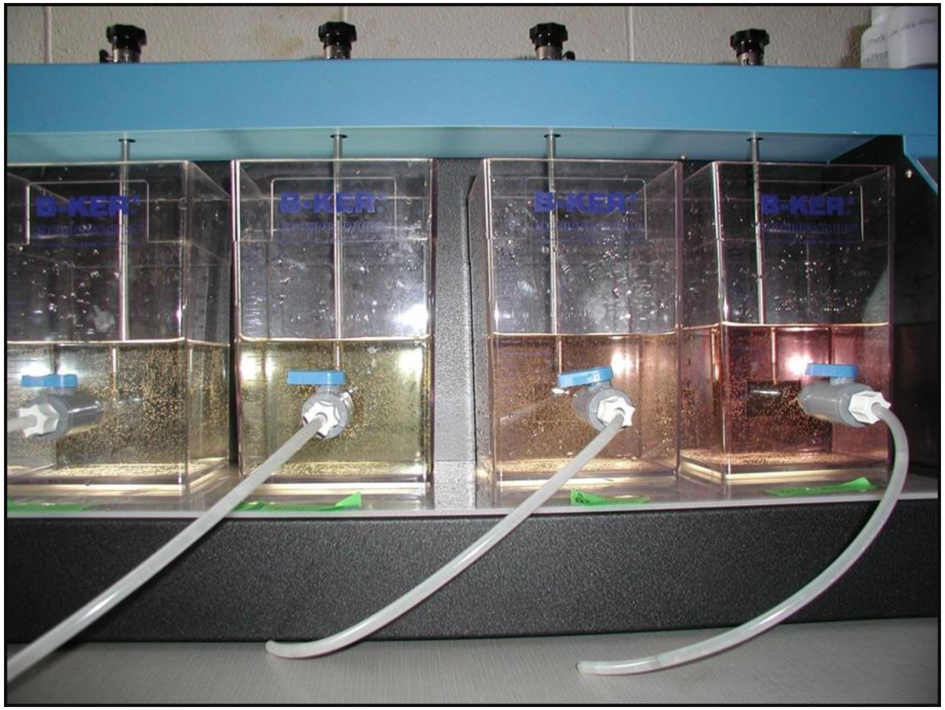
Polyphosphates/Blended Phosphates

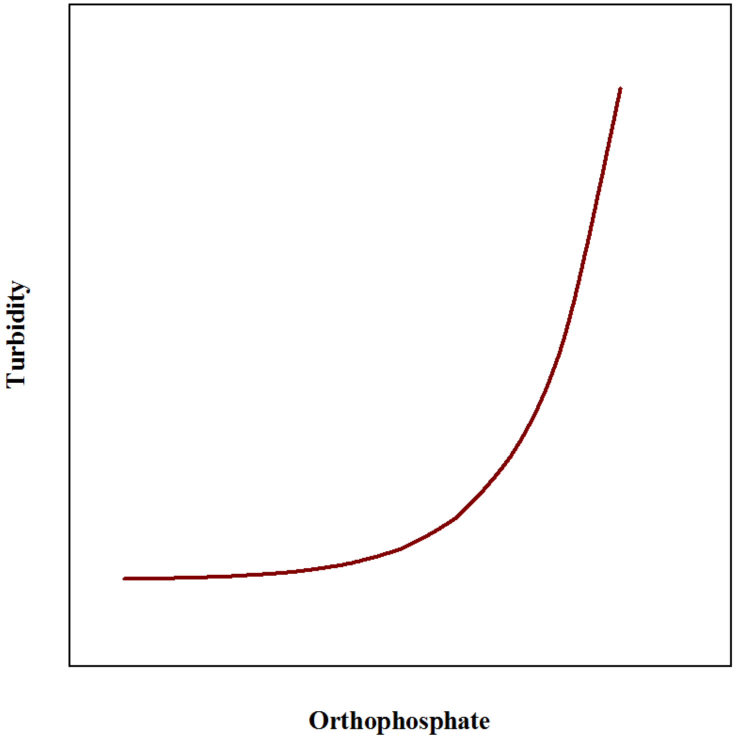
- Polyphosphates are tetrahedral PO_4 units linked together by sharing oxygen centers
- Historically be used to “sequester” or prevent the precipitation of inorganic solids (e.g., Ca, Mn, Fe, …)
  - How might they impact LI, CCPP calculations?
- They disperse particles by giving them large negative charge
  - How might the impact lead or copper?
- They break down to orthophosphate with time
- Effectiveness depends on WQ
- Have been *reported* to “chemically-clean” iron mains while others have reported opposite
- Polyphosphates do not reduce lead or copper solubility
- Blends are mixes of ortho- and poly-phosphates
- Is there value to using polyphosphates?
- Can you discontinue adding polyphosphates?

Consultant Recommendations

- Remove lead service lines
- Increase orthophosphate dose and reduce PP dose
  - 3 mg PO_4/L orthophosphate (up from 1.3 PO_4/L)
  - 90% ortho-:10% poly- phosphate blend
  - 0.3 mg PO_4/L polyphosphate (down from 0.9 mg PO_4/L)
- Polyphosphates were added to minimize excessive calcium and iron precipitation in the DS
  - Increase DS monitoring for signs of precipitation issues
- Perform regular sequential sampling at 5 homes with LSLs to track progress more closely
- Perform pipe scale analyses

Unintended Consequences of Orthophosphate Addition

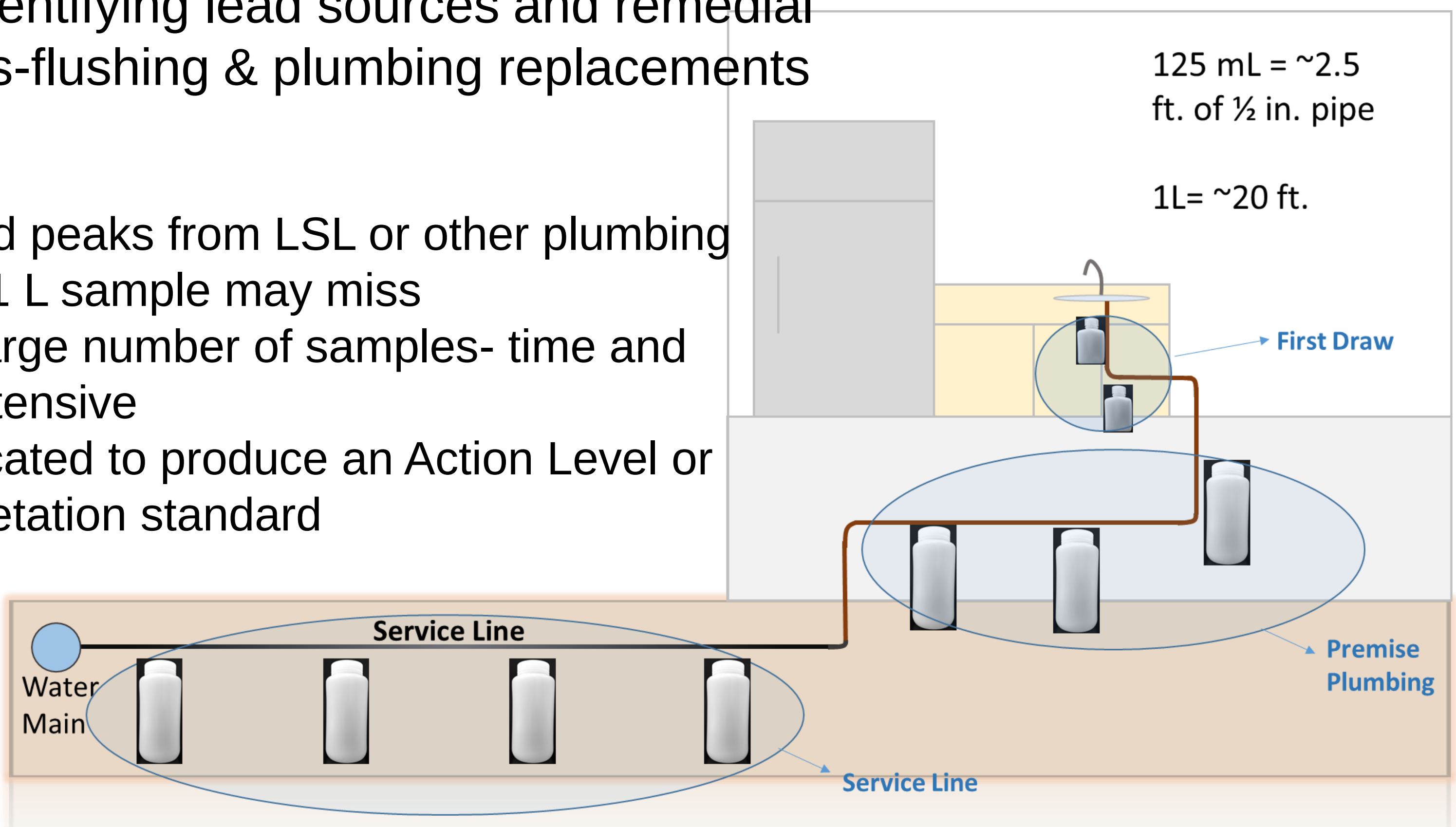




Sequential Sampling

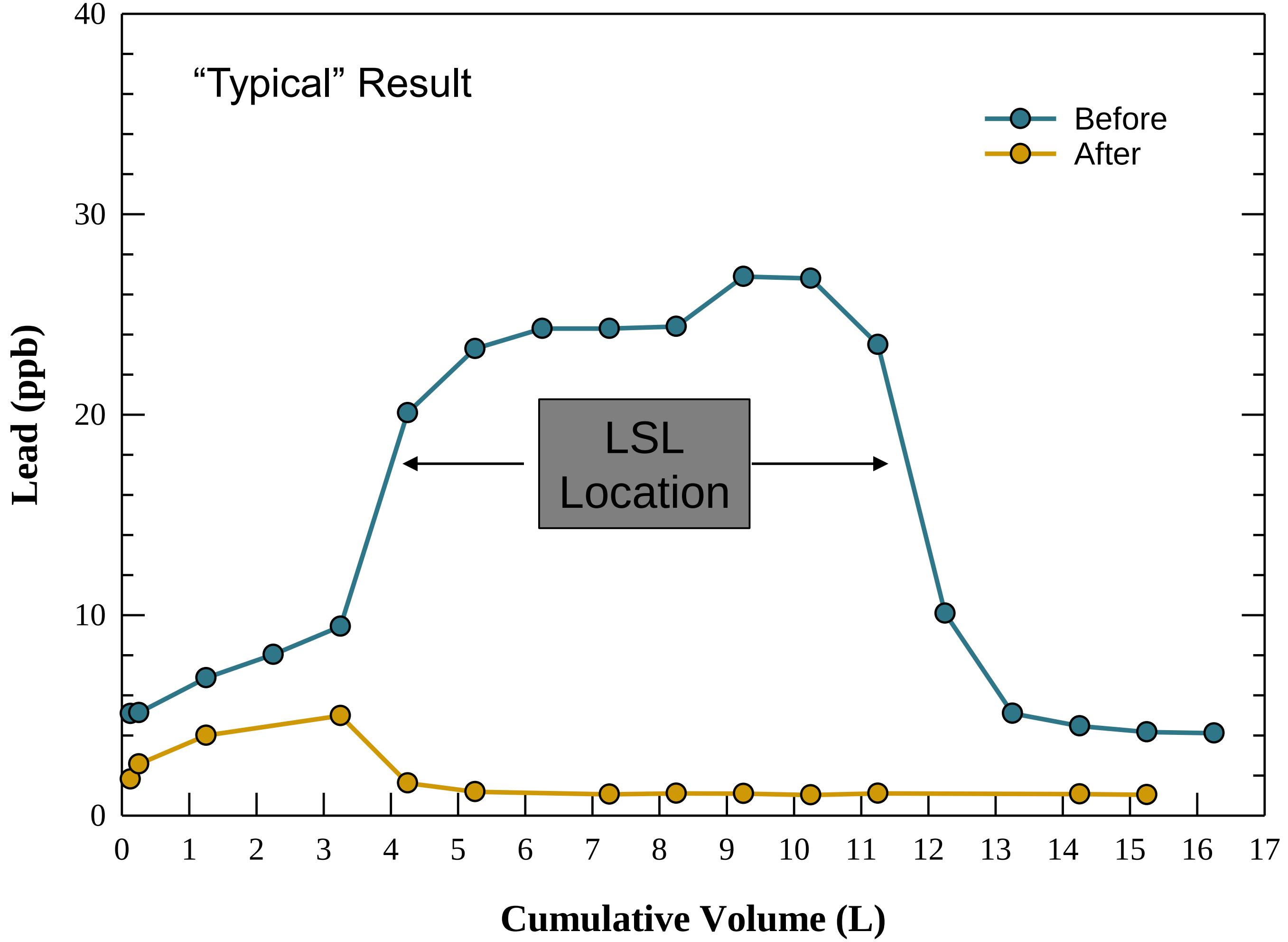
- Series of samples taken after stagnation
- First samples typically 125-250 mL
- Later samples 1 L (uniform plumbing)
- Correlate sample volumes to plumbing sections
- Useful for identifying lead sources and remedial actions-flushing & plumbing replacements

- Captures lead peaks from LSL or other plumbing that a 1 L sample may miss
- Requires a large number of samples- time and cost intensive
- More complicated to produce an Action Level or interpretation standard



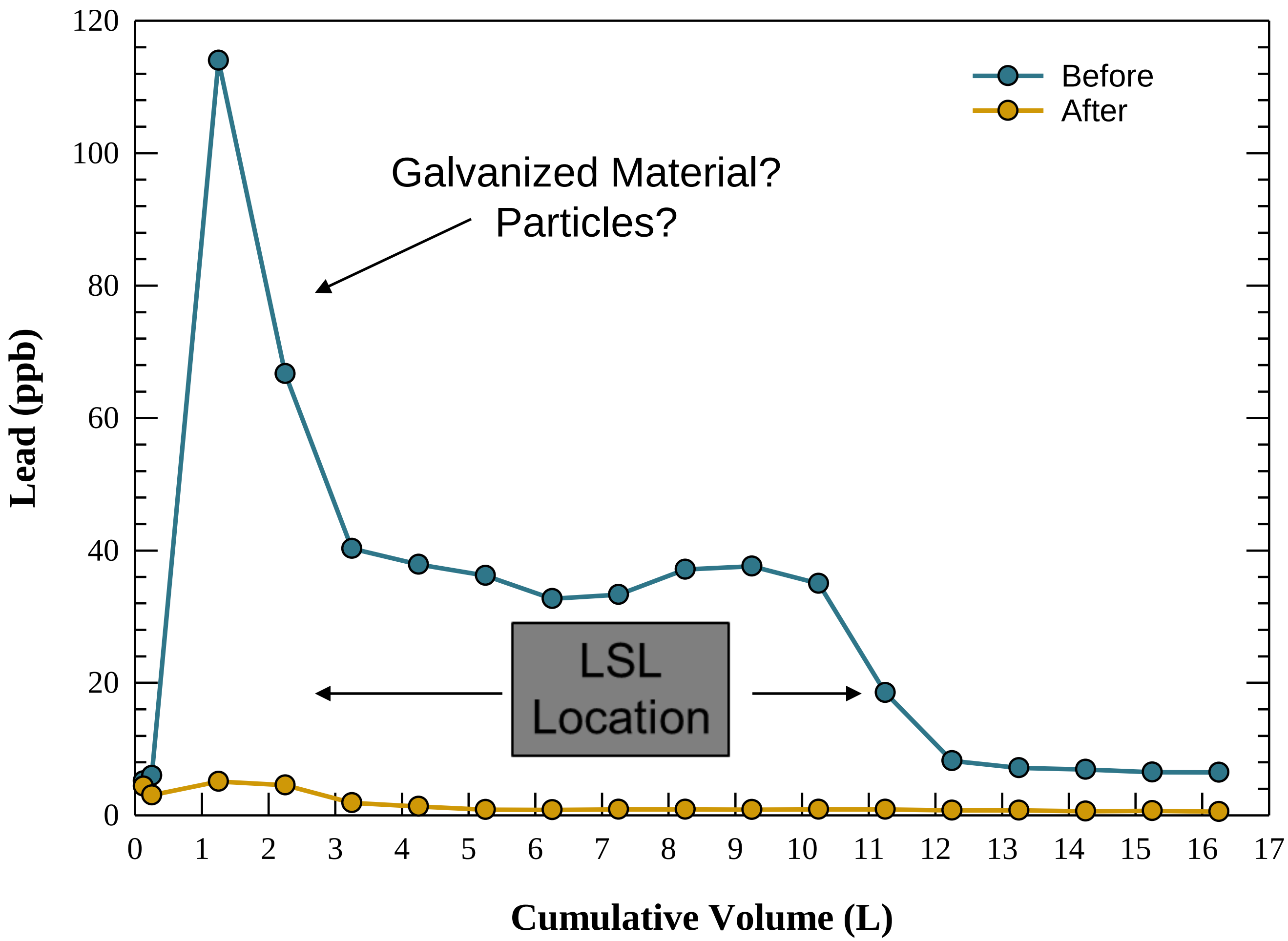
Sequential Profiles of Home 8

Before (Sept., 2017) and After LSL Removal



Sequential Profiles of Home 1

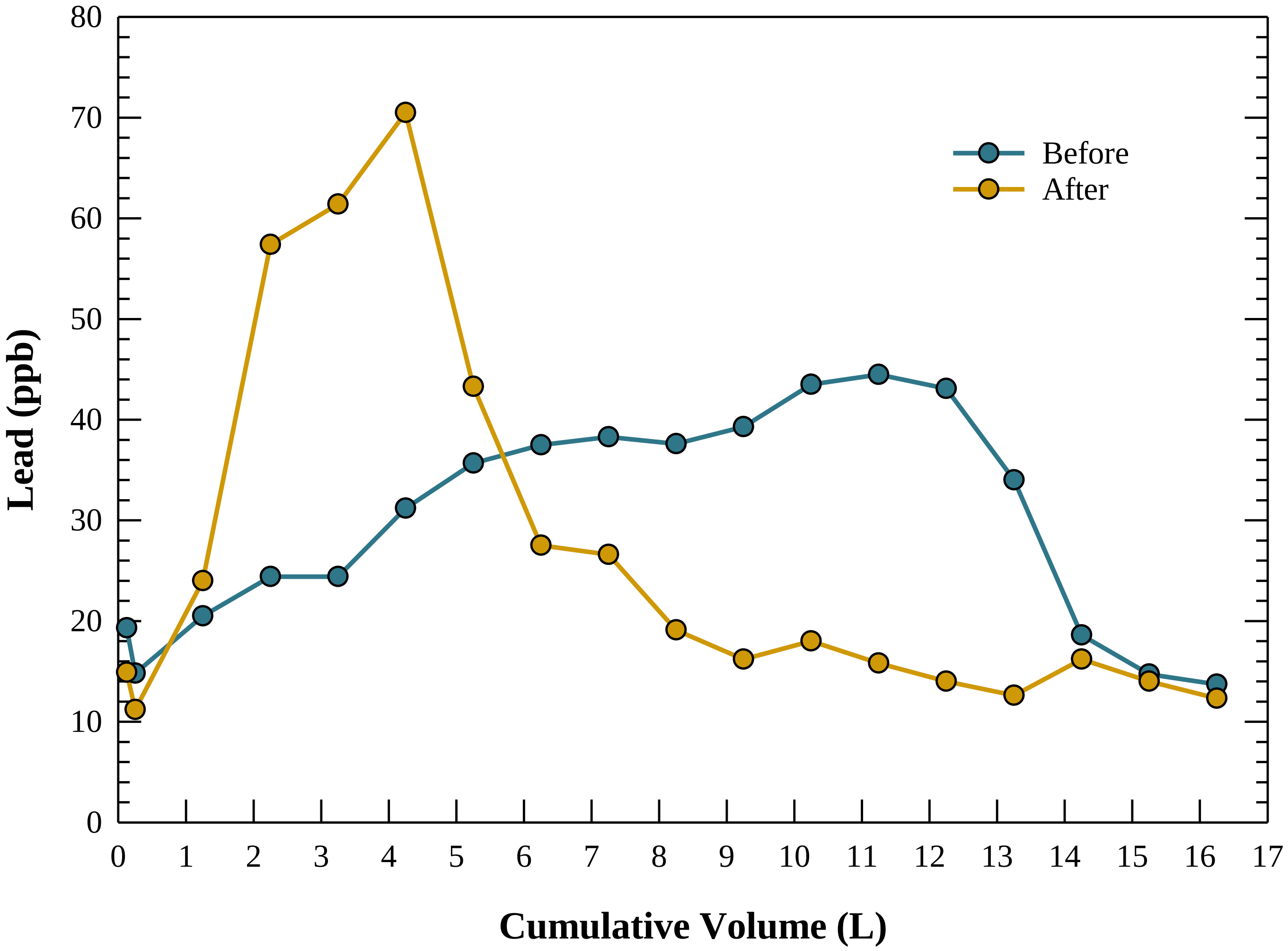
Before (Sept., 2017) and After LSL Removal



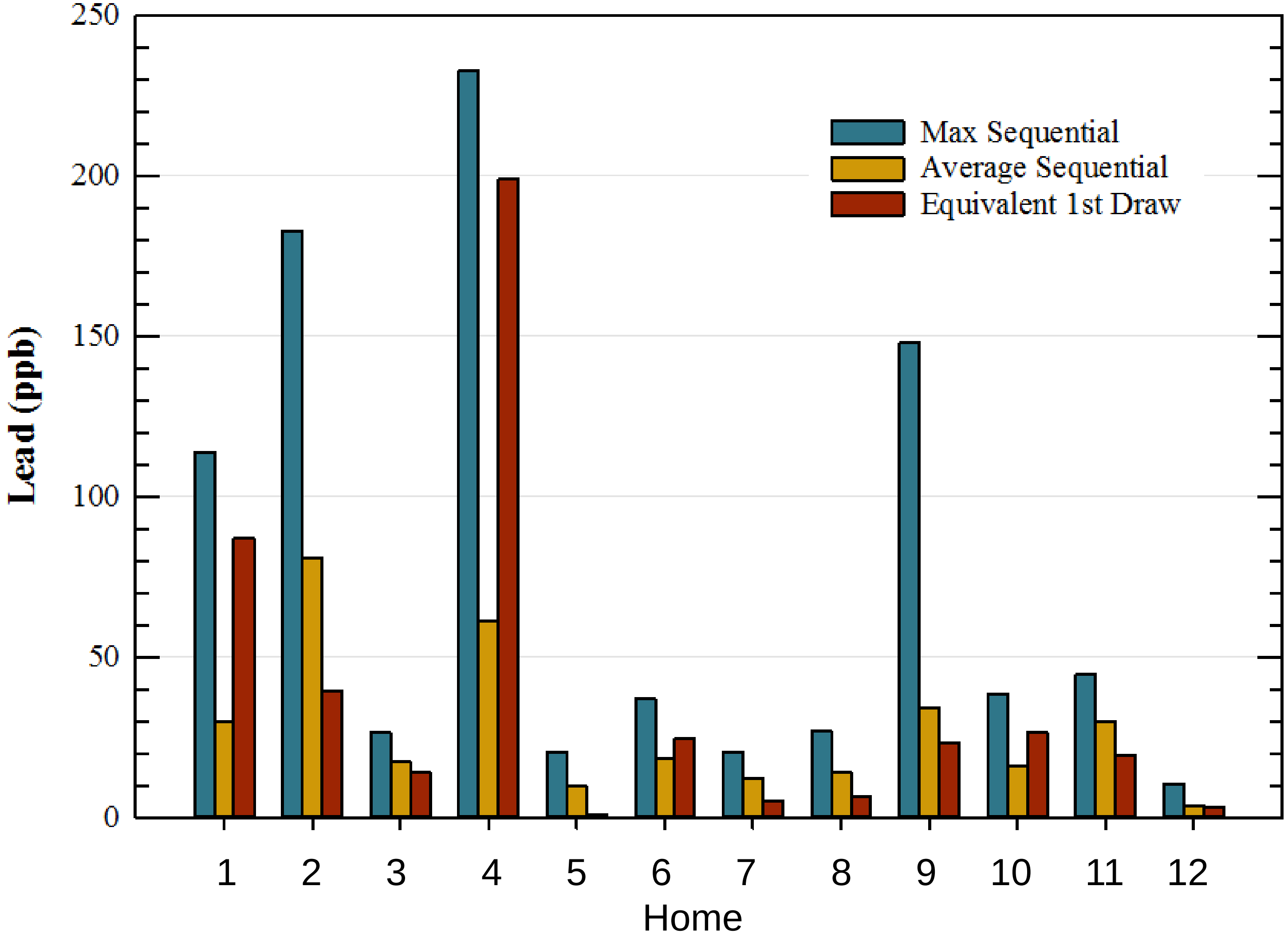
Galvanized Plumbing Components Noted

Sequential Profiles of Home 10

Before (Sept., 2017) and After LSL Removal



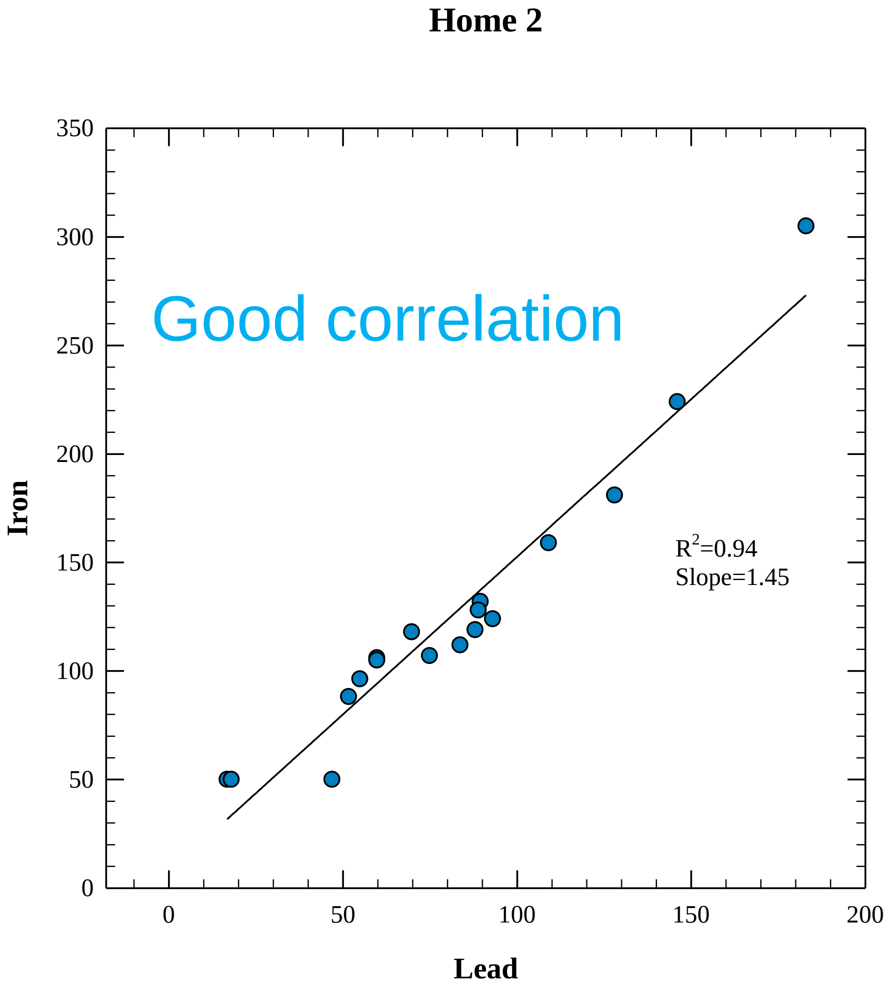
Sequential Sample Results
Summary

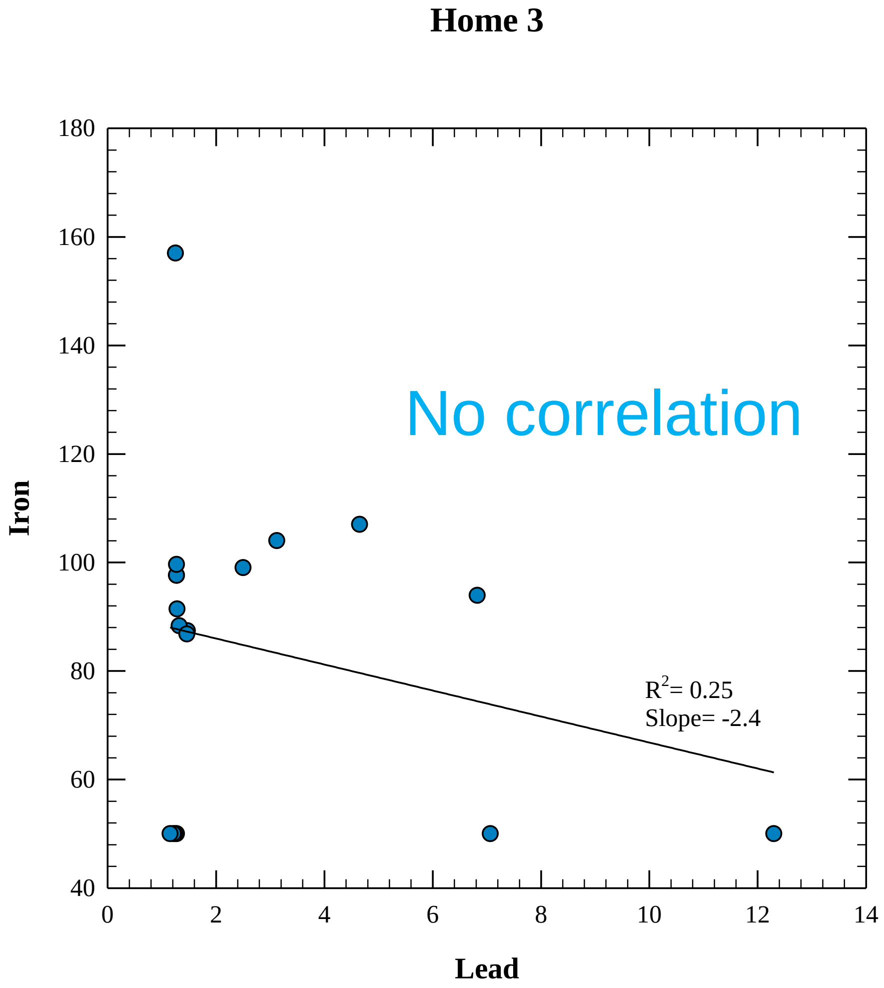


$$Equivalent\ 1st\ Draw = (conc1 + conc2 + conc3) \times \frac{1250\ mL}{1000\ mL}$$

Relationship Between Pb and Fe

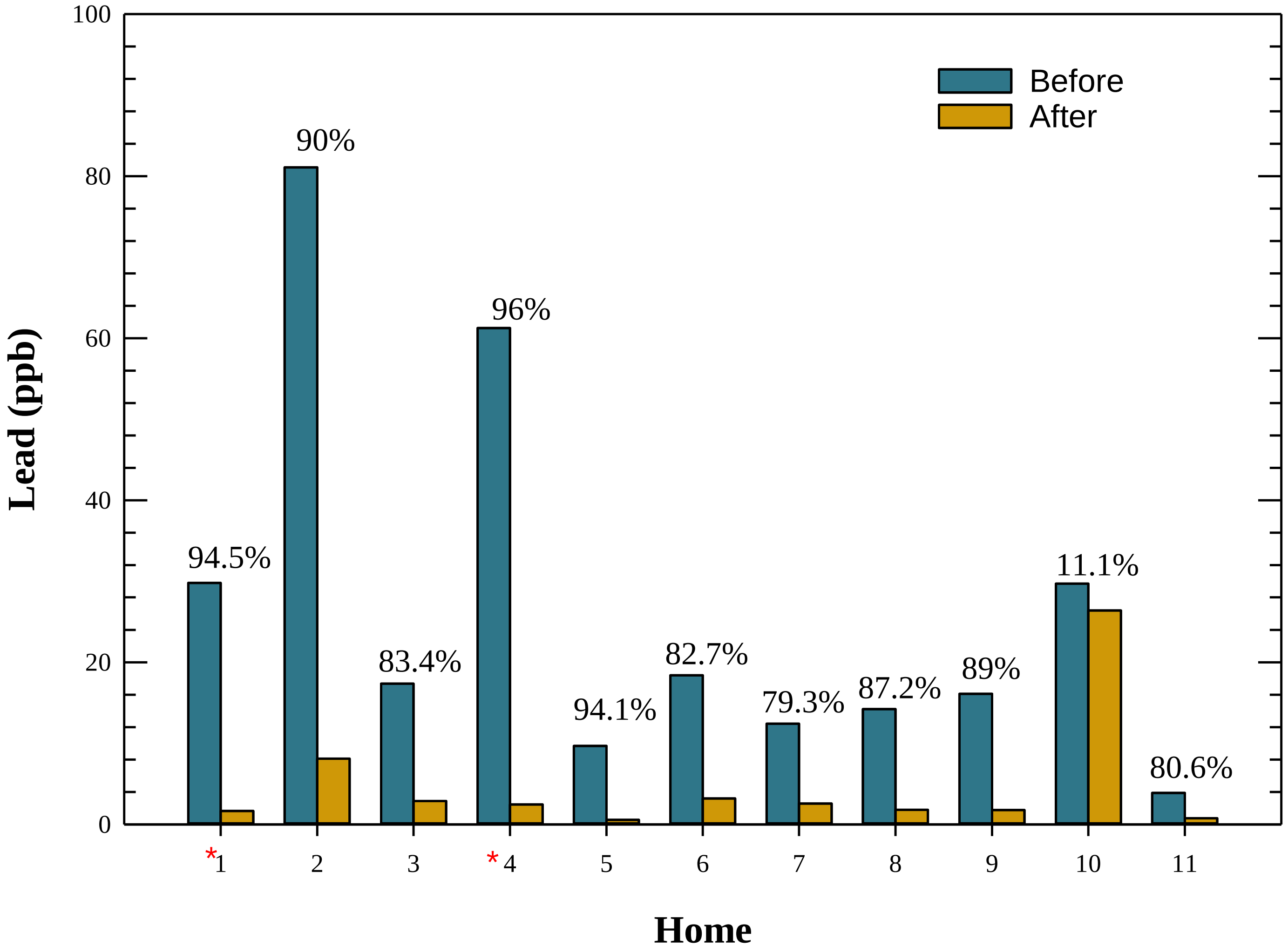
The Role of Particles and Galvanized Pipes





Value of LSL Removal

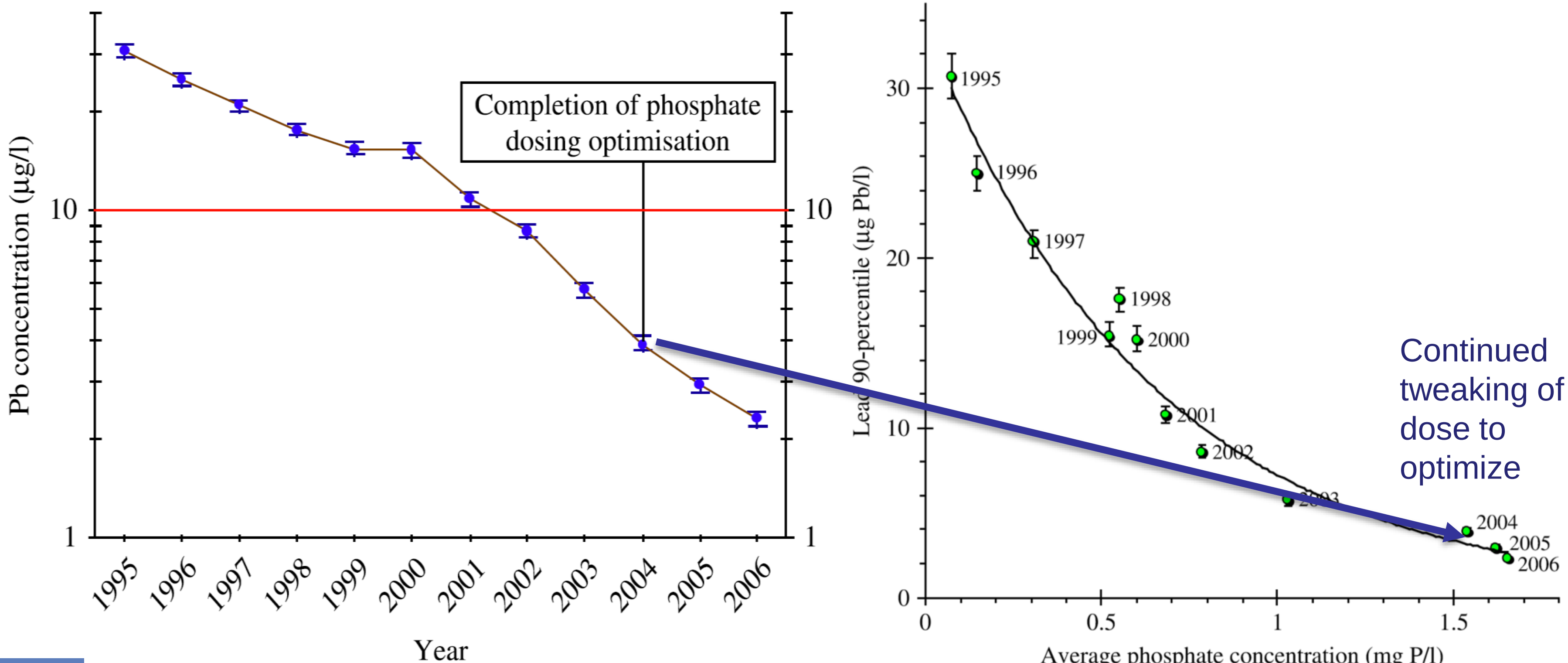
Average Concentration and %Lead Reduction



* This home has galvanized lead fixtures

Treatment Works on Both Soluble & Particulate Release

Aggregated UK Monitoring Data: Used two-pronged approach:
(1) Initial dose estimation by pipe rig study for background water
(2) RDT tap monitoring to assess progress & exposure

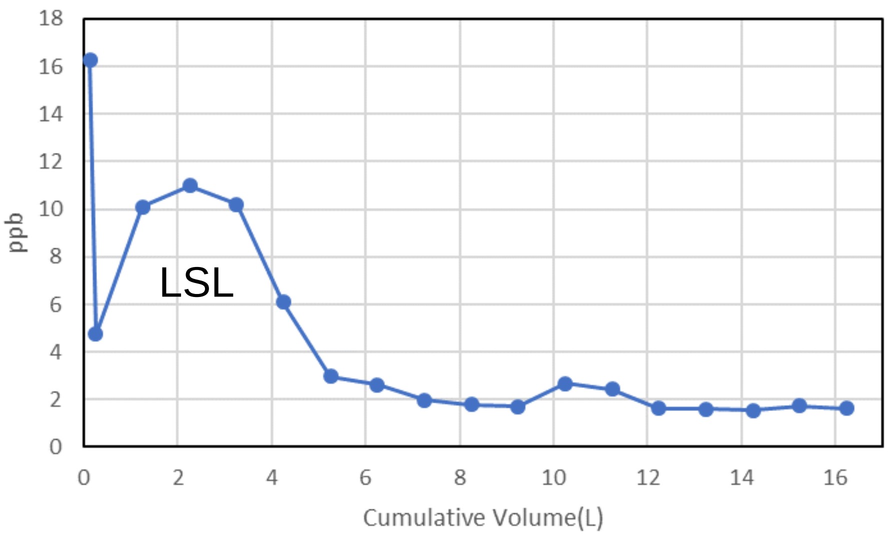


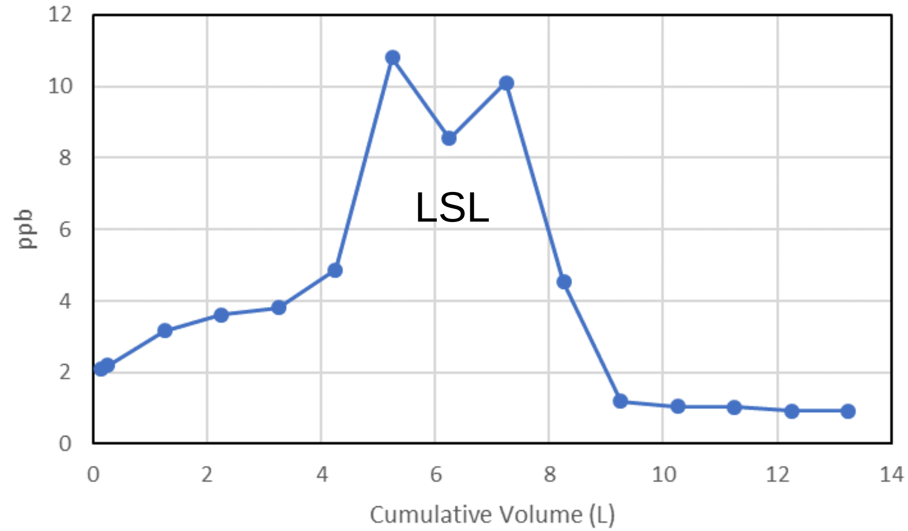
mg/L as PO_4 = 3 x mg/L as P

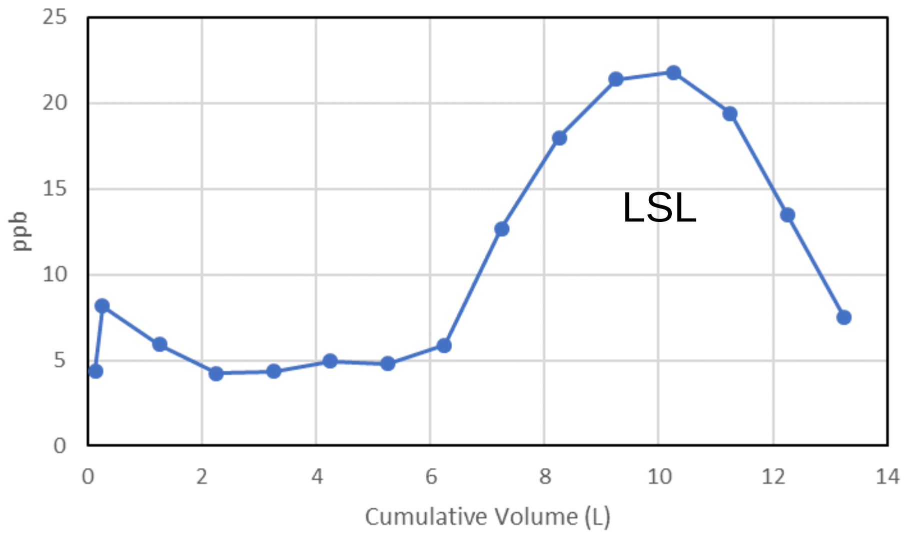
Cardew, P. T. Measuring the benefit of orthophosphate treatment on lead in drinking water. *J Water Health* **2009,** *7* (1), 123-31.

Lead Sequential Profiles

January 2018

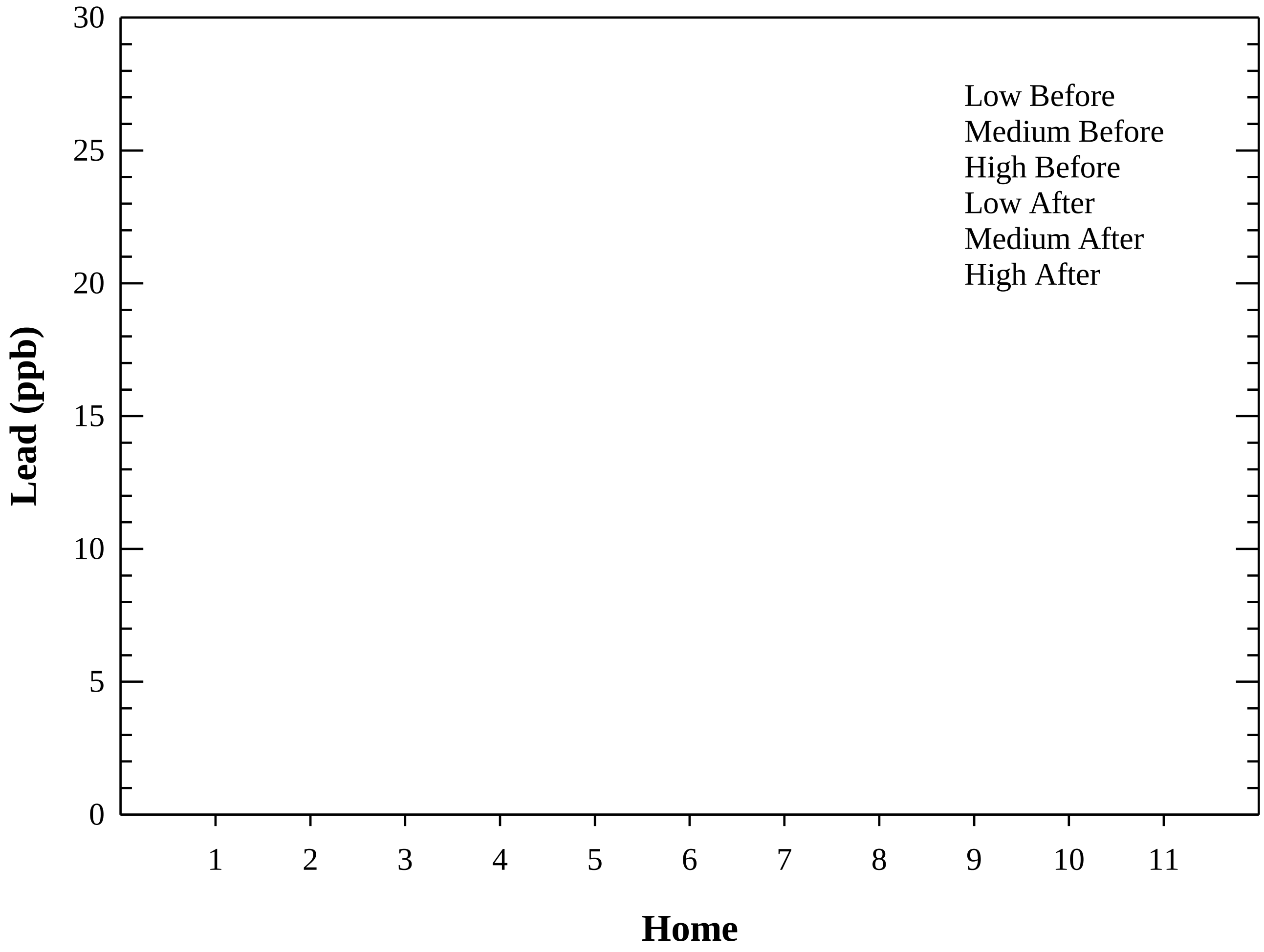






Flushed Samples

LSL Identification



Discussion

Notice

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Questions?

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