Sample Site Selection Primer

Introduction

The goal of the sample site selection criteria is to cost effectively target locations which assesses the effectiveness of a public water system's corrosion control treatment and trigger additional actions to reduce exposure when necessary. Water systems must compare sampling results to an Action Level (AL). The AL for lead is 15 µg/L and the AL for copper is 1.3 mg/L. Both contaminants have maximum contaminant level goals (MCLG) based on established health effects. For lead the MCLG is zero and for copper the MCLG is 1.3 mg/L, the same as the action level. In the Lead and Copper Rule (LCR), water systems must prioritize sample sites locations (often residences) within the distribution system which are at a high-risk of elevated lead and/or copper in the water Lead and copper levels can vary between systems and sites based on water quality, and distribution system and usage characteristics. Selection and use of these elevated lead and copper sites enables a smaller number of sample sites than random or geographic site selection procedures.

The Current Rule

The 1991 LCR established a tiering system for prioritizing the selection of sampling sites based on the likelihood of the sites to release elevated levels of lead and copper; for lead, sites with lead service lines (LSLs), lead pipes, or copper pipes with lead solder; for copper, copper pipes with lead solder.

There are three tiers for community water systems (CWSs) and two for non-transient non-community water systems (NTNCWSs), with Tier 1 being the highest priority. Systems must use all Tier 1 sites if available. If systems cannot identify enough Tier 1 sites to meet their minimum sampling requirements, they must select Tier 2 sites, followed by Tier 3 sites, and then representative sites. The actual number of sites sampled depends on the size of the population served by the system (hereafter, "system size") and distribution system characteristics. Tier 3 sites are currently only applicable to CWSs. Table 1 describes the lead and copper site selection criteria in the current rule.

Table 1: Current Lead and Copper Site Selection Criteria

Tier	CWSs	NTNCWSs
Tier 1	Collect samples from Single Family Residences (SFRs)*: • with copper pipe and lead solder installed after 1982 *(but before the effective date of the State's lead ban)*, or with lead pipes; and/or • Are served by Lead Service Lines (LSLs). For any system with LSLs, 50% of the samples must come from LSL sites and	Collect samples from buildings: • with copper pipe and lead solder installed after 1982 *(but before the effective date of the State's lead ban)*, and/or • Are served by LSLs. For any system with LSLs, 50% of the samples must come from LSL sites and 50% of the samples must come from sites with lead pipes or copper pipes with lead solder.

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Table 1: Current Lead and Copper Site Selection Criteria		
Tier	**CWSs**	**NTNCWSs**
	50% of the samples must come from sites with lead pipes or copper pipes with lead solder. **Tier 1 samples can be collected from MFRs if they represent at least 20% of structures served by the water system.*	
Tier 2	Collect samples from buildings, including multifamily residences (MFR): • with copper pipe and lead solder installed after 1982, or with lead pipes; and/ or • Are served by LSLs. For any system with LSLs, 50% of the samples must come from LSL sites and 50% of the samples must come from sites with lead pipes or copper pipes with lead solder.	Collect samples from buildings with copper pipe and lead solder installed before 1983.
Tier 3	Collect samples from SFRs with copper pipes with lead solder installed before 1983.	N/A
Representative Sample: If a CWS or NTNCWS cannot collect enough samples from tiered sites, it must collect them from sites where the plumbing is similar to that used at other sites served by the water system (§141.86(a)(5)). **Acronyms:** LSL = lead service line; MFR = multi-family residence; N/A = not applicable; SFR = single family residence; CWS = Community Water System; NTNCWS = Non-transient, non-community water system.		

Number of Samples

The number of samples each system must take under the LCR is important to have in mind when considering potential changes to the sample site selection criteria. For example, an increase in the number of sites that must be sampled will result in increased cost and burden for utilities, and increased oversight for Primacy Agencies.

The current LCR sampling protocol requires water systems to collect one-liter, first-draw samples from taps in selected households for testing; currently, all CWSs and NTNCWSs must collect lead and copper tap samples. Transient, non-community water systems are not subject to the lead and copper regulations. The frequency of the monitoring and number of samples to be collected and analyzed is based primarily on a system size and its tap water monitoring results. Standard monitoring for the LCR has systems collecting samples every six months.

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Systems must collect a minimum number of samples from sites based on system size indicated in the table below.

Table 2. Minimum Number of Lead and Copper Tap Samples for Systems		
System Size (population served)	No. of Samples Standard Monitoring	No. of Samples Reduced Monitoring
>100,00	100	50
10,001-100,00	60	30
3,301-10,000	40	20
501-3,300	20	10
101-500	10	5
≤ 100	5	5

Lead Free and the Safe Drinking Water Act

The 1986 Safe Drinking Water Act Amendments banned the use of lead solder and lead pipes under Section 1417. These Amendments were signed into law on June 19, 1986. States were required to begin enforcing the law within two years of enactment (June 19, 1988). Some States had lead bans in effect prior to the passage of the SDWA Amendments, so effective dates for lead bans will vary from State to State.

Section 1417 of the SDWA was amended under the 2011 Reduction of Lead in Drinking Water Act. These SDWA Amendments have focused on the lead content of brass and bronze fixtures in water distribution systems that are covered under SDWA. The 2011 Reduction of Lead in Drinking Water Act reduced the allowable lead content in pipe, pipe fittings, plumbing fittings and fixtures to be no more than 0.25% as a weighted average of the wetted surface area of the components that make up the pipe, fitting or fixture. Some products were exempted from coverage under this portion of SDWA. The Reduction of Lead in Drinking Water Act became effective on January 4, 2014.

The 2013 Community Fire Safety Act added fire hydrants to the list of products that are exempted from the lead free requirements of SDWA. Section 3 of the Community Fire Safety Act also required EPA to consult with and seek the advice of the National Drinking Water Advisory Council on potential changes to the regulations pertaining to lead under the SDWA and request the Council to consider sources of lead throughout water distribution systems, including through components used to reroute drinking water during distribution system repairs.

Typical lead sources include lead service lines, lead-based materials in the premise plumbing (leaded solder, brass/bronze fittings, and galvanized piping), faucets, and water meters. Leaded solder was banned by the 1986 SDWA Amendments with an effective date no later than two years after enactment (June 19, 1988). The contribution of each of these sources was evaluated by measuring lead in sequential samples taken at the tap after a minimum 6-hour stagnation time (profile sampling). The average percent contribution in Table 3 is based on the “mass of lead” – which is the contribution to the entire sequence of samples and not just the first draw sample.

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This study did not examine components that are used to reroute drinking water during distribution system repairs.

Table 3. Average Percent Contribution of Major Lead Sources[1]

Lead Source	Average Percent Contribution to the Mass of Lead Measured at the Tap During Profile Sampling[2]
Lead Service Lines	50-75%
Premise Piping	20-35%
Faucets	1-3%

1. Sandvig, et al., 2008. Contribution of Service Line and Plumbing Fixtures to Lead and Copper Rule Compliance Issues. Am. Water Works Assn. Research Foundation (now: Water Research Foundation).
2. From sites with lead service lines. Based on mass of lead results measured at the tap from sequential samples.

Considering Modifications to the LCR Sample Site Selection Criteria

The 1991 LCR requires CWSs to collect samples at taps from residences that have lead pipes and/or are served by a lead service line, and/or from sites that have copper pipes with lead solder installed after 1982 (but before the effective date of the State's lead ban) (Table 1). The rationale for the 1991 LCR sample site selection structure was to sample first from sites with the greatest likelihood of finding elevated lead levels at the time to serve as the sentinel sites for corrosion control effectiveness. As an example, the lead solder date requirement was based on studies in which lead leaching from solder was found to decrease with age. Therefore, samples collected from more recently soldered copper pipes would be expected to have higher lead results. Now, more than twenty years have passed since lead solder was banned in all jurisdictions and the leaded solder installed before the lead ban is likely leaching at much lower levels than when it was first installed (USEPA, 1988).

Given what we know about lead and copper release over time, and since new scientific information from the research exists regarding lead and copper release patterns raise the question of whether the current sample site selection criteria should be revised. Key points include:

Lead

- Full and partial LSLs represent the greatest source of lead to drinking water. Partial lead service line replacements are frequently associated with short-term elevated drinking water lead levels, that tend to gradually stabilize overtime, sometimes at levels below and sometimes at levels similar to those observed prior to the replacement (USEPA, 2011). The current criteria do not solely prioritize sampling from LSLs (full or partial);
- Studies have shown that higher lead levels are found in water in contact with lead service lines vs. first-draw, first-liter samples (Boyd 2004; Del Toral et al. 2013);
- Because lead release from solder decreases with time, research suggests that these sites now are likely releasing much lower levels of lead during the stagnation period (levels that could be comparable to contributions by brass plumbing components and interior pipe corrosion byproduct scales) (USEPA, 1988).

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Copper

Published corrosion literature since 1991 on copper has shown that copper and lead leaching patterns differ. The original LCR sample site selection criteria for copper no longer targets highest-risk copper sites, since these sites have now aged (copper corrosion decreases over time) Water chemistry and pipe age play a more dominant role than what was originally thought for copper release.

- Corrosion can occur to copper plumbing of any age. However, in the presence of certain water qualities, copper levels in excess of the action level are most likely to occur in newly constructed homes and buildings with copper plumbing, or at sites that have been recently renovated with new copper plumbing (Grace et al. 2012; Turek et al. 2011; Schock and Sandvig 2009; Rajaratnam et al. 2002; Edwards et al. 2001; Lagos et al. 2001; Schuerman et al. 2000; Knobeloch et al. 1998; Schock et al. 1995; Schock et al. 1994)
- Corrosion of new copper pipes is not a problem for many water systems. It is limited to water systems that have water quality aggressive to copper. Water chemistry characteristics that contribute to copper release also can vary in different zones within a distribution system as well as between different systems with respect to aggressiveness to copper (Schock and Lytle 2010; Edwards et al. 2001, 1996; Friedman et al 1999; Broo et al 1997; Ferguson et al. 1996; Schock et al. 1995; Schock et al. 1994);
- When age and water quality variation is taken into account, there is less variability in copper release than lead release (Kirmeyer et. al. 2004, 1994; Merkel et al. 2002; AwwaRF 1990).

Lead and Copper

- Differences exist between lead and copper release; thus, high risk sites for lead and copper differ;
- Water chemistry variations within the water distribution system can vary temporally and spatially (Grace, 2012; Schock 1994). Because water qualities such as pH, alkalinity, and temperature affect the solubility of these metals in water, variations in water qualities within the distribution system could affect where high risk sites are found. In order to capture high-risk sites, it is important that sampling schemes consider zones where water quality is aggressive to these contaminants;
- Research since the 1991 rule indicates that brass and other metallic premise plumbing materials may be a more significant immediate and long-term source of lead in drinking water than originally believed, especially in newer homes (Kirmeyer et al. 1994; Knobeloch et al. 1998, Hidmi and Edwards 1999; Edwards et al. 2001; Lagos 2001; Lagos et al. 2001; Kimbrough, 2007; Kimbrough, 2001).

In light of this new information, EPA is seeking input on identifying how the sample site selection criteria for lead and copper could be modified to capture the current sources of high risk sites for lead and copper in a simple and cost effective way. We also seek input on the choice of sites for lead and copper sample collection (in order to be representative of each contaminant).

A few approaches EPA is considering are:

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- Separate tiering structures for lead service line and non-lead service line systems;
- Separate sampling sites for lead and copper;
- Waiver of copper monitoring based on water quality parameters that demonstrate water quality not aggressive to copper. This could be used to exempt systems from copper monitoring (copper monitoring waiver);

Options for Revising the Sample Site Selection Criteria: Separate Tiering Structures for Systems with Lead Service Lines (LSL)

One option for revising the sample site selection criteria is to create separate tiering structures for systems with lead service lines. Table 4 outlines one possible way of creating separate tiering for LSL systems.

Table 4: One Option for Revising the Lead and Copper Sample Site Selection Criteria

Tier	CWSs and NTNCWSs *with* Lead Service Lines	CWSs and NTNCWSs *without* Lead Service Lines
Tier 1	Sample from SFRs served by full or partial LSLs or contain lead interior plumbing.**	Sample from SFRs with known metallic plumbing components.*
Tier 2	CWSs: Sample from buildings, including MFRs, served by full or partial LSLs or with lead interior plumbing. NTNCWSs: Sample from buildings, including MFRs, served by full or partial LSLs or with lead interior plumbing.	CWSs: Sample from buildings, including MFRs, with known metallic plumbing components* NTNCWSs: Sample from structures, including MFRs, with known metallic plumbing components.*
Tier 3	CWSs: Sample from buildings, including MFRs, with known metallic plumbing components.* NTNCWSs: Sample from structures, including MFRs, with known metallic plumbing components*	Sample from representative sites throughout the distribution system.

*__Metallic plumbing components__ include lead or brass plumbing components and copper pipes with lead solder, steel, and galvanized steel.

**LSL samples would not be tested for copper.

Acronyms: LSL = lead service line; MFR = multi-family residence; N/A = not applicable; SFR = single family residence; CWS = Community Water System; NTNCWS = Non-transient, non-community water system.

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Considerations for separate tiering structures for LSL and non-LSL systems:

- Prioritizes lead release from LSLs and PLSLs;
- Has separate tiering structure for LSL and non-LSL systems;
- Prioritizes sampling sites likely to demonstrate the greatest release for lead, by consideration of brass as an equally important contributor of lead as soldered joints;
- LSL systems would not have to monitor for copper at LSL sites; they would conduct copper monitoring only if they run out of LSL sites;
    - LSL systems may still have areas with new copper piping or renovated copper piping/plumbing as part of their system which would not get sampled;

Separate Monitoring Sites for Copper

The Table 4 site selection scheme could include sampling at separate sites for copper (for both LSLs and for non-LSL systems). This would require a separate sampling pool for copper, and would allow for copper to be sampled at sites likely to leach elevated levels of copper. These separate copper sites could be structured (tiered, or prioritized) in such a way to capture copper samples from sites most likely to leach elevated levels of copper (new copper, and systems/water quality zones with water qualities which aggressively leach copper).

Considerations for separate copper sampling sites:

- Separate sampling sites will better assess corrosion control effectiveness for both lead and copper;
- Lead and copper are co-sampled from the same tap *when LSLs are not present*, in spite of the research that shows that the corrosion chemistries are different;
- Brass/bronze components installed after January 4 2014 will contain less than 0.25% lead and sites containing only these newer brass and bronze materials may not be high risk for lead corrosion;
- Systems must maintain two sampling pools of available sampling sites, potentially increasing burden and costs for systems. And potentially increasing burden for Primacy Agencies and customers who collect samples;
- Some water systems may have to install copper corrosion control that have not previously been required to under the current sampling requirements.

Copper Monitoring Waiver

One possibility for reducing the sampling burden for copper is to use water quality parameters to characterize the potential aggressiveness of water to copper plumbing with sufficient precision to help reduce both the total number of systems required to monitor for copper and the total number of samples needed to be taken.

Studies have shown that where water quality is aggressive to copper, especially for newly-installed copper pipe, it is possible for maximum soluble copper levels to approach and/or exceed the MCLG of 1.3 mg/L (Reiber, et al., 1997; AWWA 1988; AWWA 1993; Edwards et al. 1996). It is possible that the monitoring burden could be reduced by allowing systems that demonstrate water qualities which are not aggressive to copper to receive copper monitoring

waivers. Some criteria that may be used as a starting point for determining waiver eligibility could include:

- The system provides no disinfection or oxidation treatment, and the pH is at or above 6.5;
- The pH is at least 7.0 and up to 7.5, and alkalinity is at or below 200 mg/L (as $CaCO_3$);
- The pH is greater than 7.5 and the alkalinity is at or below 250 mg/L (as $CaCO_3$);
- The system has installed optimal corrosion control for lead[1].

Considerations for copper monitoring waivers:

- Copper sampling is limited only to those systems with water quality aggressive to copper, reducing overall sampling burden;
- Allows copper monitoring to target new copper plumbing (sites with the highest potential for copper release), while still allowing lead monitoring to target older plumbing with LSLs and PLSLs (sites with the highest potential for lead release);
- Some systems may incur a new and ongoing monitoring cost for water quality parameters unless they are currently required to monitor them to demonstrate optimal corrosion control. The number of samples and frequency of water quality monitoring may offset the savings from the copper monitoring waiver;

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[1] Further discussion of this criterion is necessary. Systems with optimal corrosion control for lead may still have sources of water quality aggressive to copper and insufficient treatment in place to control for copper.

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