PHILADELPHIA WATER DEPARTMENT

Randy E. Hayman, Water Commissioner

February 12, 2020

Andrew R. Wheeler
Administrator
Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Mail Code: 1101A
Washington, DC 20460

RE: Submission of Comments Concerning National Primary Drinking Water Regulations: Proposed Lead and Copper Rule Revisions - Docket No. EPA–HQ–OW-2017-0300

Dear Administrator Wheeler:

On behalf of the City of Philadelphia, the Philadelphia Water Department (PWD) is pleased to submit comments regarding the US EPA's Proposed Lead and Copper Rule Revisions dated November 13, 2019. PWD has been a long-standing supporter of local and national efforts to minimize the levels of lead in drinking water, and to better protect the health of our nation's children.

Philadelphia provided comments and technical information for the existing Lead and Copper Rule, and has since supported ongoing research, as well as EPA and water industry committees along with information sharing to continue to improve the nation's management of lead in drinking water. Our comments today reflect our continuing commitment to reducing lead through sound policy, science-based regulation, and industry best practices.

The Philadelphia Water Department also joins and incorporates by reference specific comments submitted to this docket by the American Water Works Association pertaining to EPA's Proposed Lead and Copper Rule Revisions.

If you have any questions regarding Philadelphia's comments, please contact Gary A. Burlingame at 215-685-1402 or gary.burlingame@phila.gov.

Respectfully submitted,

Gary A. Burlingame
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Philadelphia Water Department
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Attachments:

I. Executive Summary
II. Philadelphia Water Department's Long-standing Support of Local and National Initiatives to Reduce Lead Exposure Through Drinking Water
III. Comments
IV. Appendices of Supporting Information for Comments

cc: Jennifer McLain, EPA/OW/OGWDW mclain.jennifer@epa.gov
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I. Executive Summary

The Philadelphia Water Department's (PWD) comments regarding the US EPA's Proposed Lead and Copper Rule Revisions (dated November 13, 2019 in the Federal Register) are provided herein along with supporting information and facts. PWD finds the revisions to the Lead and Copper Rule (LCR) to be onerous, complicated, costly, and counter-productive for reducing lead exposure through our nation's drinking water supplies. The EPA has underestimated the level of effort that a public water system would need to take to come into compliance with all aspects of the revisions should they be made into the rule. Even though PWD has maintained compliance with the LCR's action level, optimized its corrosion control treatment (CCT), assisted Philadelphia's public schools in understanding how to manage lead in school water, is voluntarily replacing customer-owned lead service lines during water main replacements at no additional cost to the customers, and is providing financial support for homeowners to proactively replace lead and galvanized service lines, the proposed revisions to the LCR would in many cases be counter-productive and costly for Philadelphia's ongoing efforts to maintain lead at the lowest levels possible.

PWD, therefore, provides comments under the following headings:

1. EPA under-emphasizes the importance of shared responsibility in reducing lead exposure through drinking water and under-estimates the level of support needed for water systems to achieve compliance with the revisions.
2. EPA introduces new aspects to the rule that complicate national efforts to reduce exposure to lead through drinking water.
3. EPA's public education requirements are not well coordinated.
4. EPA's lead and water quality parameter monitoring requirements are a disincentive for compliant water systems to be proactive.
5. The proposed monitoring program for schools and child care facilities is not an appropriate obligation of public water systems.
6. Additional changes to the proposed revisions are needed to move the nation forward in successfully reducing exposure to lead through drinking water.

PWD supported the National Drinking Water Advisory Council's (NDWAC) efforts to recommend revisions to the LCR and, with these comments herein, continues to support the development of a revised Lead and Copper Rule that will, under the Safe Drinking Water Act, move the nation closer to a lead-free drinking water supply in a feasible, economical, and reasonable manner undergirded by sound engineering and science.

II. Philadelphia Water Department's Long-standing Support of Local and National Initiatives to Reduce Lead Exposure Through Drinking Water

The Philadelphia Water Department (PWD) operates a distribution system that consists of over 3,000 miles of drinking water mains, serving more than 1.6 million people through about 480,000 service connections. PWD operates three water treatment plants (WTPs) from two surface water sources—the Delaware River and the Schuylkill River—to provide about 220 million gallons per day (MGD) of safe drinking water to Philadelphia.

PWD complied with the Lead and Copper Rule (LCR), following its promulgation in 1991, with two six-month monitoring periods during 1992. The 90th percentile for the two rounds in 1992 were 21 and 15 parts per billion (ppb). Following the two rounds of sampling in 1992, PWD worked to implement unified corrosion control treatment (CCT) at all three WTPs in addition to launching, in coordination with the Philadelphia Department of Public Health, an education campaign about lead in drinking water. By the first round of sampling in 1997, PWD had implemented uniform CCT. The Pennsylvania Department of Environmental Protection's permit for PWD's corrosion control application systems was granted in January 1999 and later amended in 2003 as PWD continued to optimize its CCT.

Since 1997, PWD's 90th percentile for lead has been below the lead action level (AL) of 15 ppb and PWD has been on reduced triennial monitoring since 1999. In 2016, PWD's sampling pool and sampling instructions were changed to closely follow EPA's sampling guidance using only homes with lead service lines (LSL) and telling customers to not pre-flush before stagnation and to not remove faucet aerators prior to sampling. PWD's successful implementation of CCT and reduction of lead was demonstrated in a peer reviewed paper in *Journal AWWA* (Bradley and Horscroft, 2018) titled *Using Historical LCR and Water Quality Data to Evaluate Corrosion Control Treatment.*

PWD developed voluntary programs, during 2016, for the removal of customer-owned LSLs along with educational materials for customers to reduce the risk of exposure to lead. PWD included replacement of LSLs and galvanized lines to its capital projects at no additional cost to customers; when PWD replaces a water main, if an LSL or galvanized line is found, a full replacement is made unless a customer declines or otherwise does not approve removal. Customers are given intensive flushing instructions after a replacement has occurred along with instructions for daily flushing of cold water and routine cleaning/replacing of faucet aerators. In addition to printed and web materials, PWD created detailed videos for identifying LSLs and flushing service lines.

PWD expanded the zero-interest Homeowner Emergency Loan (HELP) Program to provide financial assistance for residential LSL replacement. PWD has been working with community organizations to provide presentations and educational materials to residents about the various programs and has created a website to centrally host all related information for easy access: https://www.phila.gov/water/lead.

PWD also worked with sister City of Philadelphia departments such as the Department of Public Health to create a centralized resource for lead issues: https://www.phila.gov/guides/lead-guide/.

Background

In the 1970s and into the early 1980s, the issue of lead centered around tin-lead solder, which Philadelphia banned in advance of the national ban. PWD conducted research and investigations to help the national effort in understanding the occurrence of lead in tap water. PWD found that tin-lead solder under five years of age contributed high levels of lead to tap water. In one case, in a newly built condominium, particles (visible chunks of solder) collected on faucet aerators due to an inferior plumbing job. As the issue of lead in water grew nationally, PWD maintained robust engagement with health experts and regulators, sharing experience and commenting on proposed regulations.

When the Lead & Copper Rule became effective, PWD directed employees to inspect homes throughout the city, thereby building a representative population of volunteer homeowners with confirmed lead-soldered pipes and lead service lines. The effort was substantial and thorough. The first round of sampling came in just above the AL, and the second round fell below the AL. Nonetheless, PWD participated with the Philadelphia Department of Public Health in a broad and balanced educational campaign. Years of studies followed to define a uniform water quality that would minimize the corrosion, or leaching of lead, in Philadelphia. Using the best-available information, PWD established that a certain range of pH and orthophosphate addition would minimize, or set us on the path towards minimizing, the corrosion of lead in plumbing.

During the 1990s, PWD actively promoted the need for, and participated in, ongoing research through The Water Research Foundation to address unanswered questions about lead.

Into the next decade, PWD assisted the School District of Philadelphia in developing and operating a successful program to test all drinking water outlets in every public school facility. This effort helped EPA Region III provide valuable input for updating the EPA's 3Ts guidance.

PWD participates in EPA and AWWA committees and discussions at a national level. Two employees participated in the EPA's National Drinking Water Advisory Council (NDWAC) working group which reviewed the Lead and Copper Rule to recommend revisions. As the final NDWAC recommendations came out, PWD began following them immediately. Since the greatest remaining mass of lead in plumbing is the lead service line (which is not part of PWD's system), PWD initiated voluntary programs to increase public communication and better estimate and identify where LSLs are in the city.

PWD provided its LCR monitoring program and practices for obtaining representative samples for lead and copper to the Pennsylvania Department of Environmental Protection (PaDEP) for their review and approval. An explanation of these practices, with supporting data, were provided to the EPA (Burlingame, G.A. Letter dated March 3, 2016 to Peter Grevatt, Eric Burneson, Rick Rogers, and Lisa Daniels. *Questions regarding sampling practices under the Safe Drinking Water Act's Lead and Copper Rule*, Philadelphia Water Department, Philadelphia, PA). Nonetheless, PWD met with EPA Region III and PaDEP and agreed to make requested changes to its sampling instructions to customers along with a significant change in sample siting: collecting samples exclusively from homes with lead service lines. During the second half of 2016, PWD completed a special monitoring round, wherein PWD obtained its lowest 90^{th} percentile of 0.003 mg/L for lead to date.

This information and all supporting data were provided to the EPA and to PaDEP. PWD has maintained these changes such that in 2017 PWD's 90^{th} percentile was 0.002 mg/L and in 2019 it was 0.003 mg/L.

III. Philadelphia Water Department Comments: Proposed Lead and Copper Rule Revisions as published in the Federal Register vol. 84, no. 219 (November 22, 2019)

Comments (with technical support provided in the following pages of appendices)

1. EPA Under-emphasizes the Importance of Shared Responsibility in Reducing Lead Exposure Through Drinking Water and Under-estimates the Level of Support Needed for Water Systems to Achieve Compliance with the Revisions.
   a. PWD applauds the EPA's participation and leadership in The Federal Action Plan to Reduce Childhood Lead Exposures and Associated Health Effects. EPA is encouraged to continue to play a proactive, lead role in fostering commitments from other federal agencies since the goal of getting the lead out is a shared responsibility.
   b. The EPA should develop a clearinghouse for information about lead in drinking water for all people to access, to help water systems be successful with compliance, and to provide up-to-date information and guidance to all people.
   c. EPA underestimates the level of effort that would be needed to achieve compliance with the revisions. The EPA's timeline of three years is unrealistic considering all the new and competing requirements proposed. EPA under-estimates the impact of school and child care requirements.
2. EPA Introduces New Aspects to the Rule that Complicate National Efforts to Reduce Exposure to Lead Through Drinking Water.
   a. EPA introduces a new trigger level at 0.010 mg/L in addition to the action level at 0.015 mg/L. It would be better to provide data analysis tools for triggering re-evaluation of CCT, that States and PWSs can use during the Sanitary Survey (§141.80 General Requirements).
   b. EPA introduces an "unknown" category for the service line inventory and considers them equivalent to lead lines. Each water system should make transparent to the community and State the criteria they use to define a service line as lead or non-lead, and, in turn, set a goal for converting "unknown" classified lines to lead or non-lead (§141.84 Lead Service Line Inventory and Replacement Requirements).
   c. EPA introduces pitcher filters as a required risk mitigation measure. It sets a precedent that will have repercussions beyond those intended for lead (§141.84 Lead Service Line Inventory and Replacement Requirements). Flushing before using water for drinking or cooking is a valid option to reduce the risk of exposure to elevated lead, especially for water systems that have CCT, control of water quality, and low lead levels. The EPA has not shown that a national requirement for providing filters will be sustainable.
3. EPA's Public Education Requirements are not well Coordinated

   The requirement for public education and communication is important but still needs to be better designed so as not to overwhelm people with information to the point that they ignore it, and to give them direction on risk reduction actions to take when they need it (§141.85 Public Education and Supplemental Monitoring Requirements).

4. EPA's Lead and Water Quality Parameter Monitoring Requirements are a Disincentive for Compliant Water Systems to be Proactive.
   The EPA limits a water system's ability to use existing data. The proposed revisions appear to deny water system's valuable and costly data for determination of ongoing monitoring requirements (§141.86 Monitoring Requirements for Lead and Copper in Tap Water; §141.87 Monitoring Requirements for Water Quality Parameters).
5. The Proposed Monitoring Program for Schools and Child Care Facilities is not an Appropriate Obligation of Public Water Systems.
6. Additional Changes to the Proposed Revisions are Needed to Move the Nation Forward in Successfully Reducing Exposure to Lead Through Drinking Water.
   a. The EPA inappropriately references a practical quantitation limit or PQL of 0.005 ug/L to define the 90^{th} percentile goal for determining optimized corrosion control treatment (§141.2 Definitions).
   b. EPA needs to help States with modern data evaluation tools for when a water system needs to re-evaluate corrosion control since the 90^{th} percentile is limited in the useful information it provides (§141.81 Applicability of Corrosion Control Treatment Steps to Small, Medium, and Large Water Systems).
   c. The find-and-fix approach is mis-applied and should be represented as "follow-up sampling" not directly linked to CCT monitoring but rather used for helping customers reduce exposure to lead. The most important activity is to identify the lead-bearing materials in homes (solder, brass, lead pipe) followed with education about options for reducing lead exposure (§141.82 Description of Corrosion Control Treatment Requirements).
   d. It would be counter-productive for a water system to add new water quality parameter sampling locations to its corrosion control monitoring program simply based on a home having an elevated lead result. It is better to have a planned monitoring program in place that can be adjusted over time as new information is obtained (§141.82 Description of Corrosion Control Treatment Requirements; §141.87 Monitoring Requirements for Water Quality Parameters).
   e. EPA does not provide incentives for water systems that voluntarily replace lead service lines, maintain low lead levels, and operate effective corrosion control treatment. Instead, the proposed rule introduces many elements that will compete for funding and resources (§141.84 Lead Service Line Inventory and Replacement Requirements).
   f. EPA's interest in prioritizing lead service line replacement would conflict with infrastructure priorities that prioritize based on avoiding a loss in water service (§141.84 Lead Service Line Inventory and Replacement Requirements).
   g. Taking one sample, 3-6 months after a service line is disturbed, contradicts public health common sense, especially considering the high degree of variability of elevated lead results. Such a measure should be based on the risk reduction

strategy that a water system chooses to employ (§141.84 Lead Service Line Inventory and Replacement Requirements).

h. EPA's requirement for immediate 24-hour notification is not justifiable considering the length of time that has already passed since sample collection, the need to gather additional information to help customers understand next steps, and the variability of elevated lead results (§141.85 Public Education and Supplemental Monitoring Requirements).
i. Health agencies are best suited to manage communications to health care providers (§141.85 Public Education and Supplemental Monitoring Requirements).
j. EPA should not neglect homes with other sources of lead than lead service lines, as they provide valuable information for consumers and for corrosion control treatment. The EPA should withdraw the requirement that data that are allowed to be grandfathered must have followed specific sampling protocols. There is no scientific confirmation that these sampling protocols will influence a water system's 90th percentile for lead and copper (§141.86 Monitoring Requirements for Lead and Copper in Tap Water).
k. Replacement samples should be allowed when customers make errors in sample collection procedures (§141.86 Monitoring Requirements for Lead and Copper in Tap Water).
l. EPA should minimize disincentives in the rule such as those that discourage collecting data for research and quality control. Additional monitoring should be encouraged and allowed, rather than discouraged (§141.87 Monitoring Requirements for Water Quality Parameters).
m. A 5^{th-}liter sample procedure should be one of several procedures, laid out in guidance, for investigating the sources of lead in plumbing systems to help customers make better decisions about mitigating lead exposure (§141.86 Monitoring Requirements for Lead and Copper in Tap Water).
n. The EPA's change in the sampling tier, so that the age of leaded solder no longer impacts on the tiering, makes good sense (§141.86 Monitoring Requirements for Lead and Copper in Tap Water).

7. PWD joins and incorporates by reference a list of comments submitted to this docket by the American Water Works Association

IV. Appendices of Supporting Information for the Philadelphia Water Department's Comments to the Proposed Lead and Copper Rule Revisions as published in the Federal Register vol. 84, no. 219 (November 22, 2019)

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APPENDIX 1.a

1. EPA Under-emphasizes the Importance of Shared Responsibility in Reducing Lead Exposure Through Drinking Water and Under-estimates the Level of Support Needed for Water Systems to Achieve Compliance with the Revisions.

a. PWD applauds the EPA's participation and leadership in The Federal Action Plan to Reduce Childhood Lead Exposures and Associated Health Effects. EPA is encouraged to continue to play a proactive, lead role in fostering commitments from other federal agencies since the goal of getting the lead out is a shared responsibility.

Basis for Recommendations: On p 61686, the EPA states "Water systems cannot unilaterally implement the actions that are needed to reduce levels of lead in drinking water." EPA states on p 61685, "It is important to use our nation's resources wisely, and thus target actions where they are most needed and can provide the most good." These are very important statements.

In the Report of the Lead and Copper Rule (LCR) Working Group to the National Drinking Water Advisory Council (NDWAC) (USEPA 2015), the following was addressed about reducing lead in drinking water as a s*hared responsibility*:

> P 7 Effective elimination of leaded materials in contact with water and minimization of exposure to lead in drinking water is a shared responsibility. PWSs, consumers, building owners, public health officials and others each have important roles to play.
>
> P 7 Successful implementation of the revised LCR can only take place in the context of a more holistic effort on lead in water issues involving stakeholders other than just EPA and water systems, and resources beyond those able to be brought to bear by water systems.

One example of where a shared responsibility could be developed is with the plumbing community. There should be national training and certification (as an example, see what has been done for cross connection control) for plumbers to help homeowners and landlords identify lead and galvanized materials, and provide remediation. In addition, water systems who are non-community water systems would benefit as they would be trained to manage leaded materials in non-community water systems. There are likely other ways that a shared responsibility can be enhanced, and these should be explored through public input and through the Federal Action Plan to Reduce Childhood Lead Exposures and Associated Health Effects.

In the Report of the Lead and Copper Rule Working Group (LCRWG) to the National Drinking Water Advisory Council (USEPA 2015), the following was addressed about how public health departments play a very important, lead role:

> P 27 The LCRWG recommends that EPA, CDC, HHS and HUD conduct training and outreach to local health agencies, medical professionals and local and state lead poisoning prevention agencies…
>
> P 36 In response to the notification, the PWS and the health department would consider the situation and take action that they deem appropriate (e.g., testing children's blood, recommending a filter, discussing lead service line replacement with the resident or landlord, advising grandparents about risk to visiting children, or continuing to monitor the situation). We anticipate that the health department be the lead agency, and that the rule would not prescribe actions other than notice as the situations are too diverse and complicated for prescription actions.

Since lead comes from multiple sources of which water is usually not the primary source for children with elevated blood lead levels (BLLs), the health agencies need to take the lead role in addressing children at risk. The NDWAC supported this especially since lead in water is not the major route for lead exposure in children, and it is important to not under-emphasize the other routes of exposure in order to continue in a national effort to reduce blood lead levels.

The EPA should review additional means to enhance The Federal Action Plan to Reduce Childhood Lead Exposures and Associated Health Effects (December 2018) by incorporating aspects of the shared responsibility for lead in drinking water. The EPA should pursue alternatives to managing lead risk such as national requirements on real estate transfers to disclose lead, and on landlords to provide lead-free residences.

APPENDIX 1.b

1. EPA Under-emphasizes the Importance of Shared Responsibility in Reducing Lead Exposure Through Drinking Water and Under-estimates the Level of Support Needed for Water Systems to Achieve Compliance with the Revisions.

   b. The EPA should develop a clearinghouse for information about lead in drinking water for all people to access, to help water systems be successful with compliance, and to provide up-to-date information and guidance to all people.

Basis for Recommendations: The NDWAC Working Group (2015) discussed the need for EPA to commit to providing expertise to States on corrosion control and lead, and that the EPA should regularly update an online version of its corrosion control guidance. In the Report of the Lead and Copper Rule Working Group to the National Drinking Water Advisory Council (USEPA 2015), the following was addressed about how the EPA should provide regular updates to the technical guidance on corrosion control treatment (CCT) and its evaluation:

> P 5 Corrosion control treatment is complicated and will vary based on specific circumstances in each public water system. Thus, regular updates to guidance by EPA based on the latest science and the creation of a national clearinghouse of information both for the public and for PWSs are needed.

The NDWAC (USEPA 2015, p3 of cover letter) also recommended: *Creating a national clearinghouse of information for the public and templates for PWSs….* In the Report of the Lead and Copper Rule Working Group to the National Drinking Water Advisory Council (USEPA 2015), the following was addressed about how EPA should create a clearinghouse:

> P 10 The LCRWG specifically recommends that EPA revise the LCR to…Establish more robust public education, by creating a national clearinghouse of information for the public and templates for PWSs….
>
> P 14 Clear guidance, case studies, and templates for LSL replacement programs, including a toolkit of ideas for creative financing strategies….
>
> P 20 Establish an easily accessible, national clearinghouse of information about lead in drinking water to serve the needs of the public and of public water systems….
>
> The NDWAC Working Group suggested that this information clearinghouse include a website, that the materials on the web site be accessible for distribution

through the Safe Drinking Water Hotline for those who may not have internet access, and that EPA investigate and apply newer communication technologies and ideas for interactive or other innovative means of communication with the public about lead in drinking water (e.g., social media methods and outreach programs). The clearinghouse should include information in multiple languages, in clear terms understandable by the public, and should include engaging, reader-friendly graphics, photos, and video. EPA is encouraged to include the design of the clearinghouse in its consultation with people with diverse, and consumer-oriented expertise and perspectives described above. Such a clearinghouse would be intended for use by the general public, PWS's, public health agencies, and health professionals.

APPENDIX 1.c

1. EPA Under-emphasizes the Importance of Shared Responsibility in Reducing Lead Exposure Through Drinking Water and Under-estimates the Level of Support Needed for Water Systems to Achieve Compliance with the Revisions.

   c. EPA underestimates the level of effort that would be needed to achieve compliance with the revisions. The EPA's timeline of three years is unrealistic considering all the new and competing requirements proposed. EPA under-estimates the impact of school and child care requirements.

Basis for Recommendations: The EPA underestimates the costs and level of effort for compliance. An estimate is provided of the additional staff that would be needed to meet the new requirements such as: to return to semi-annual or annual compliance monitoring; to sample after lead service line replacements or the creation of partial lines; the inventory, distribution, and training of pitcher filters; the maintaining of an inventory of service lines; and the conversion of unknown lines to either lead or non-lead classifications through field work. Using PWD as an example, we estimate that 9 newly hired full time employees (FTEs), one field crew, and two supervisors would be needed to achieve compliance along with office space, vehicles, and computers.

All of this would have to be in place starting in 2023 if the EPA published a final rule in 2020. The above does not include the level for effort and resources needed to meet the proposed requirements for sampling schools and child care facilities.

The EPA should re-evaluate the burden on a PWS and look at the accumulation of costs and resource demands when all aspects of the proposed rule are taken into account. Three years will not be sufficient time in which to prepare for compliance if all of the EPA's revisions are placed into a final rule.

APPENDIX 2.a

2.EPA Introduces New Aspects to the Rule that Complicate National Efforts to Reduce Exposure to Lead Through Drinking Water.

a. EPA introduces a new trigger level at 0.010 mg/L in addition to the action level at 0.015 mg/L. It would be better to provide data analysis tools for triggering re-evaluation of CCT, that States and PWSs can use during the Sanitary Survey (§141.80 General Requirements).

Basis for Recommendations: The EPA proposes adding a Trigger Level at 10 ug/L, below the Action Level. ASDWA, according to the EPA's economic analysis (USEPA 2019), suggested the use of binning. Binning avoids a hard line. Rather than confuse everyone with a new number that has no basis, it would be better to provide data analysis tools the States and PWSs can use to trend the existing data to foster a more informed understanding of CCT and any need for re-evaluations.

The 90th percentile statistic provides very limited information. Now that States are collecting actual data rather than just the final 90th percentile statistic from every round of lead sampling, States can apply trending and data evaluations which would be more informative. Trends can be automated and available during the Sanitary Survey, at which time a water system's CCT effectiveness could be reviewed. The EPA supports this on p 61692, "The EPA believes that the sanitary survey is a fitting opportunity for states to review the system's implementation of OCCT…" And "States would be required to review CCT and to assess WQPs during sanitary surveys for water systems that have installed CCT. The review must consider any updated EPA guidance on CCT during the sanitary survey." Thus, rather than set a Trigger Level, EPA should provide States with better data evaluation tools. The States then have the authority under the Sanitary Survey to require systems to re-evaluate their CCT under the State's CCT permit.

Customers and the public, in general, have been very confused by the various levels concerning lead in water, including a different one for schools, and now EPA wants to add yet one more. What is the scientific basis for selecting 10 ppb for triggering a need to re-evaluate CCT? The public, perhaps not understanding how these limits were developed and are being used, could become confused as to the meaning of the different limits.

The following technical brief was provided by The Environmental Science, Policy and Research Institute on request from the Philadelphia Water Department, to provide additional review of the issue of whether a new trigger level would provide benefits under the revised rule.

Technical Brief: Advantages and Disadvantages of the Proposed Trigger Level 90th Percentile Lead Concentration

Prepared for: The Philadelphia Water Department Bureau of Laboratory Services

By: Sheldon Masters, Corona Environmental Consulting, LLC

Tim Bartrand, ESPRI (The Environmental Science, Policy and Research Institute)

11/19/19

1 Executive Summary

Draft revisions to the Lead and Copper Rule (LCR) propose creating a trigger level lead concentration in addition to the action level. Exceeding the trigger level during a round of regulatory monitoring would initiate actions such as review of the adequacy/optimization of corrosion control and continuation/resumption of annual or semi-annual monitoring. Proposed actions associated with a trigger level exceedance differ for utilities of different sizes. The action level remains in place in the draft LCR revisions. This briefing document identifies the advantages and disadvantages of the trigger level. We find that, although the trigger level might assist with the identification and improvement of systems operating with marginal corrosion control, it duplicates available regulatory options at the cost of adding a regulatory level that will be misconstrued by the public and interest groups as a health-based standard while increasing the administrative and reporting burden on states and water systems. A defined, regulatory trigger level could also have the unintended consequence of reducing analysis of compliance data by systems or regulators that elect to comply with the LCR by doing the minimum regulatory requirements.

2 Discussion

Public water systems, their customers, and drinking water interest groups are faced with many concentrations related to risks posed by lead in drinking water and adequacy of treatment for reducing lead exposure. Levels (concentrations) relevant to drinking water in the United States and other jurisdictions are outlined in Table 1. The levels/concentrations range from 0 (the US EPA MCLG and the de facto level suggested by the National Resources Defense Council) to 20 ppb which is used in some states for assessing school lead (under the Lead Contamination Control Act [LCCA]), though this level is no longer supported by the US EPA, and the Act no longer specifies a level to which to compare school lead results. The reasons for the levels differ, with some based-on health impacts, others based on feasibility, and yet others on some combination of treatment/process control and feasibility. Determining health-based levels is difficult. First, ingestion of water even with low lead concentrations can have health impacts and toxicology models such as EPA's IEUBK (Integrated Exposure Uptake Biokinetic) model for lead in children predict health effects based on net exposure from all sources (drinking water, soil, food, air, paint). The net impact of low dose lead uptake from drinking water depends on exposure context (all sources) and could be greater for children in economically disadvantaged circumstances (e.g., residences in older, insufficiently maintained buildings with other lead sources) than children with fewer lead sources. Second, health effects and dose-response differ among population cohorts (infants, children, adults, pregnant women, etc.). Finally, lead release and exposure, particularly particulate lead release and exposure, can be highly variable. In the absence of health-based criteria, some levels are based on a zero-risk tolerance framework.

Table 1. Regulatory and Reference Lead Concentrations

Level/ Concentration	Source	Justification or citation
0 ppb	EPA, Maximum Contaminant Level Goal (MCLG)	Public health objective
"There is no safe level of lead exposure. It is a toxic at any level."	National Resources Defense Council (NRDC)	Citations of EPA documents and the opinions of health experts
5 ppb	FDA limit for lead allowable in bottled water	21 CFR 165.110
5 ppb	MAC (Maximum Acceptable Concentration), Health Canada	As Low As Reasonably Achievable (ALARA), per Health Canada analyses. The 5 ppb level does not require collection of stagnation samples.
10 ppb, 90th percentile	EPA, proposed trigger level for assessing treatment technique	The EPA is proposing the lead trigger level because the Agency has determined that meaningful reductions in drinking water lead exposure could be achieved by requiring water

Level/ Concentration	Source	Justification or citation
		systems to take a progressive set of certain actions to reduce lead levels at the tap.
10 ppb	WHO Guideline	Guideline is based on uncertain health effects, with an understanding that lead health impacts are still manifest at low doses (assuming no threshold for health effects) and based on an assumed proportion of lead exposure among food and water intakes.
15 ppb, 90th percentile	EPA, action level for assessing treatment technique	From the draft revisions to the Lead and Copper Rule (LCR): "The EPA established the lead action level in 1991 based on feasibility and not based on impact on public health."
20 ppb for 250 mL first-draw sample	Lead Contamination Control Act (3 Ts), outdated guidance	EPA revisions to the 3Ts program removed the 20 ppb level from the program and recommend that schools address lead contamination prioritizing their highest concentration faucets. Some states may retain the outdated 20 ppb level.

Statistical analyses of compliance and profile data from four utilities (not shown in this report) indicate that the objective of the proposed trigger level – providing a staged approach to addressing lead exposure – would be beneficial as a prompt for more vigorous action for systems only marginally meeting the action level. Systems only marginally meeting the current action level typically have more variable lead concentrations in compliance samples than systems that meet the action level with a wide margin of safety. This indicates that 90th percentile Water Lead Level (WLL) estimates are less certain for marginally-attaining systems than for stable systems and that those systems are well-served to increase monitoring and to critically evaluate their corrosion control treatment. For example, in two rounds of subsequent monitoring a water system may exceed the 10 ppb in one round but not in the other, yet without a difference in corrosion control or water chemistry that could be associated with the exceedance except that the lead data are variable. Therefore, instituting a trigger level as a bright red line carries disadvantages (described below) and duplicates the more positive framework that could be achieved by addressing marginally-attaining systems through sanitary surveys and other means.

Irrespective of their intent (health-based, treatment performance based or other) and in the absence of solid health-based criteria, members of the public and their interest groups tend to treat all standards as health-based standards. In their report "Threats on Tap: Widespread Violations Highlight the Need for Investment in Water Infrastructure and Protections," the NRDC included exceedance of the lead action level (clearly identified by the US EPA as a component of a treatment technique regulation and selected in consideration of feasibility) among health-based violations. In a footnote in the same report, NRDC noted that the 15 ppb action level is not health-based. This inconsistency notwithstanding and in the absence of alternative regulatory levels with a health basis, the NRDC and others treat the current action level as a health-based level. It stands to reason that the proposed trigger level will be treated similarly, even though the basis for selecting 10 ppb as a trigger level is not clearly stated in the proposed revisions. The intent of the trigger level is to prompt "meaningful reductions in drinking water lead." The basis for the trigger level is less clear and its feasibility or its expected impacts on public health are unknown. We do not argue that lead exposure reductions must await conclusive establishment of quantitative relationships between WLL and health effects or detailed investigations of feasibility. During the time required for either of these activities many unnecessary lead exposures, some with irreversible health consequences, could have occurred. Rather, we suggest alternatives to the trigger level (which could be misconstrued as a health-based level and could undermine trust of customers in their water supplier) be used for accelerating meaningful reduction in lead exposure. For example, the 10 ppb trigger level could become a component of a check list used in augmented sanitary surveys. Review of corrosion control during sanitary surveys is suggested in the draft LCR revisions.

An alternative to the trigger level would be incorporation of accelerated response to 90th percentile WLL approaching the action level into sanitary surveys, development of improved data analysis tools (e.g., tools that look at trends as well as 90th percentile values of individual monitoring rounds) to support systems in responding to sample round results above 10 ppb (or another appropriate concentration), and development of tools for use by systems approaching the action level to optimize or re-optimize corrosion control. This approach is outlined in the draft revised LCR, which states: "The EPA believes that the sanitary survey is a fitting opportunity for states to review the system's implementation of OCCT [optimized corrosion control treatment]…" And "States would be required to review CCT and to assess WQPs during sanitary surveys for water systems that have installed CCT. The review must consider any updated EPA guidance on CCT during the sanitary survey." Thus, rather than set a trigger level, the revised rule would provide states with a checklist and tools for use by systems with 90th percentile values around 10-15 ppb. The states then have the authority under the sanitary survey to require systems to re-evaluate their CCT under the state's permit. Such an approach would provide the intended benefits of the proposed trigger level (augmented monitoring and treatment for systems only marginally below the action level) without the disadvantages (confusion and misinterpretation of an additional level) and without increasing the complexity of the rule, nor adding to the administrative burden of states and water systems.

3 Approaches for Comparing Sampling Rounds

Mechanisms are in place for effective use of historic compliance monitoring data to identify systems at risk for suboptimal corrosion control. States now receive individual data results from water systems rather than the final 90th percentile statistic. Therefore, states have the data by which to perform evaluations and look for trends that provide better, more nuanced insights into whether corrosion control is optimized than strict focus on 90th percentile lead concentrations. And, as noted in the draft revised LCR, sanitary surveys – the purview of State regulators – are an opportunity for States and utilities to review optimized corrosion control.

Many parametric and nonparametric statistical analyses could be brought to bear for identification of trends and to develop a more complete picture of shifts in all modes of lead release (dissolved, particulate and colloidal) over time as well as quantitative assessment of variability in lead release within sample rounds and between sample rounds. Detailed knowledge of variability is important because it allows assessment of the adequacy of sample sizes (or can guide determination of sample size) and because it provides insights into particulate lead release. A danger of a trigger level based exclusively on 90th percentile lead concentration is the likelihood that many systems or states will only conduct the minimum required analysis (since it is spelled out in the regulation) and miss the opportunity for optimizing corrosion control, even when a 90th percentile is below the trigger level.

Burlingame and Sandvig (2004; Burlingame, G. and A. Sandvig. 2004. How to mine your lead and copper data. *Opflow* 30:6:16-19) demonstrated nuanced use of compliance data and identification of trends from monitoring round to monitoring round. Their analyses, summarized below, showed that analysis of monitoring data can provide insights into corrosion and corrosion control, even for systems with a low 90th percentile lead concentration. Burlingame and Sandvig analyzed compliance data for three utilities for multiple sample rounds. All three systems began the study period out of compliance and achieved 90th percentile lead concentrations below the action level after implementing improved corrosion control. Data for the three systems (utility A, utility B and utility C in the original paper) were presented in tabular form in the original paper and are shown as histograms (frequency plots) in Figure 1 – Figure 3. Frequency plots show lead concentrations in successive monitoring rounds.

Burlingame and Sandvig observed that shifts in different statistical measures provide different useful information about corrosion control. For all three systems, the median lead concentration fell sharply after implementation of improved corrosion control. A declining and low median lead concentration is likely related to the performance of corrosion control in reducing dissolved lead release. Ninetieth percentile lead concentrations were more difficult to interpret. For example, for utility C (Figure 3), the 90th percentile lead concentration was below the current and proposed action level for the final 3 sample rounds, despite much higher variability for each sample round and despite evidence of persistent very high lead concentrations and likely particulate lead release in the final three sample rounds. That is, corrosion control implemented prior to 2002 for utility C did not appear effective for particulate lead release control despite improvements in both the median and 90th percentile lead concentrations over time.

Detailed analysis of trends as a component of a sanitary survey would also benefit optimizing corrosion control of lead release for non-compliant systems. For example, frequency plots for monitoring data in successive rounds for Flint from shortly after resuming Detroit water supply to 10 months after the switch are presented in Figure 4. The Flint results show that a single-round 90th percentile lead concentration can be deceiving and miss long-term trends. The Flint results also show an encouraging reduction in very high (particulate) lead concentrations above the round's 90th percentile concentration over time. Had only the 90th percentile data been analyzed, important knowledge regarding overall effectiveness of the corrosion control treatment would have been lost.

Therefore, rather than introduce another red line based on a 90th percentile statistic, states and water systems would benefit more from the collection of individual lead data from sampling rounds from water systems combined with the availability of various data analysis programs to evaluate the data and present the data for trending and for discussion during Sanitary Surveys as well as for review from round to round as water systems improve with corrosion control treatment and the replacement of lead service lines.

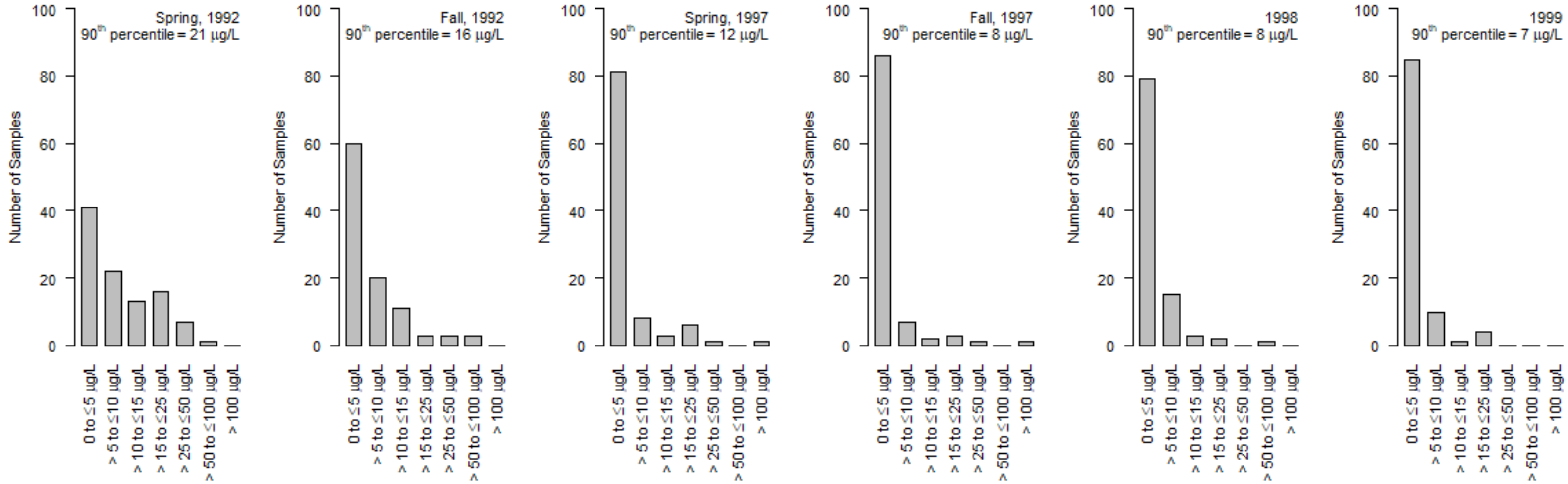

Figure 1. Compliance Sampling Lead Frequency Distribution, from Non-Compliance to Stable Corrosion Control (Utility A in original paper)

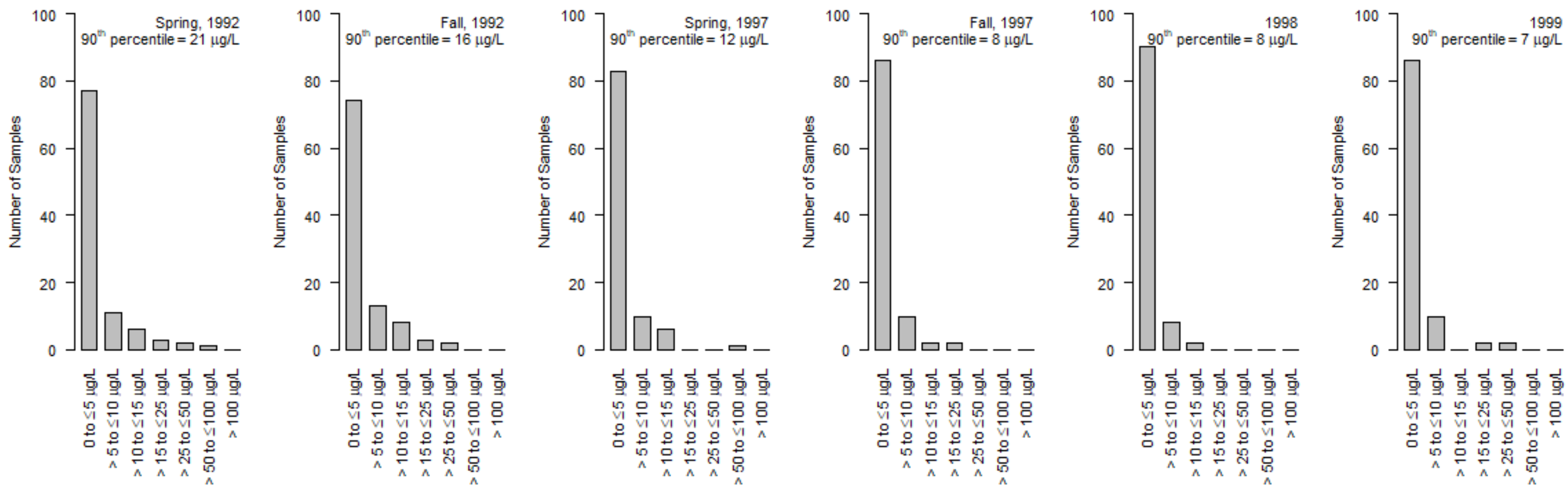

Figure 2. Compliance Sampling Lead Frequency Distribution, from Non-Compliance to Highly Stable Corrosion Control (Utility B in original paper)

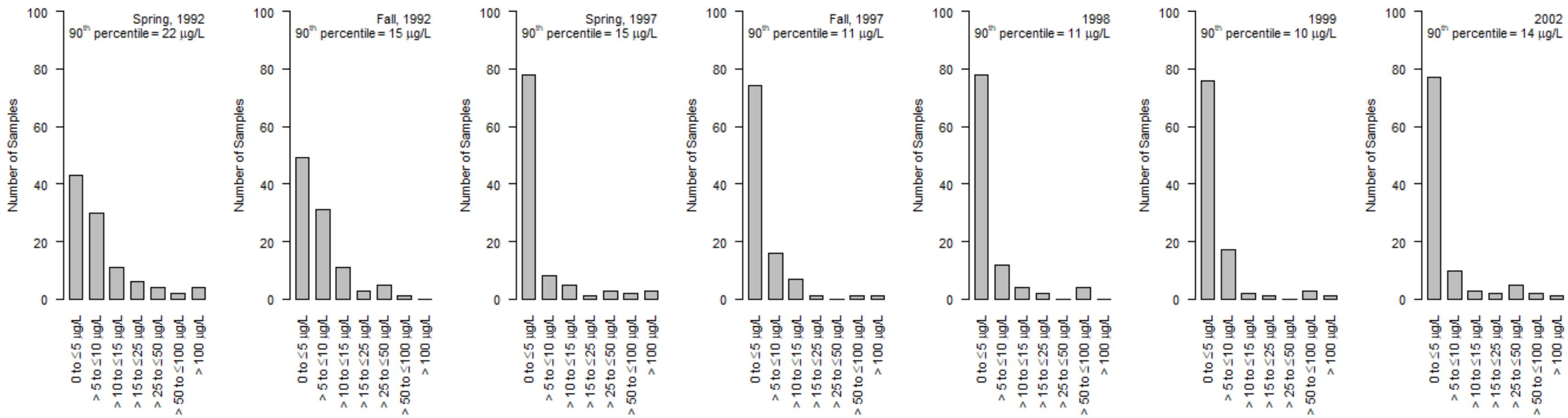

Figure 3. Compliance Sampling Lead Concentration Frequency Distribution, from Non-Compliance to Compliance, but with High Variability and Frequent Very High Lead Concentrations

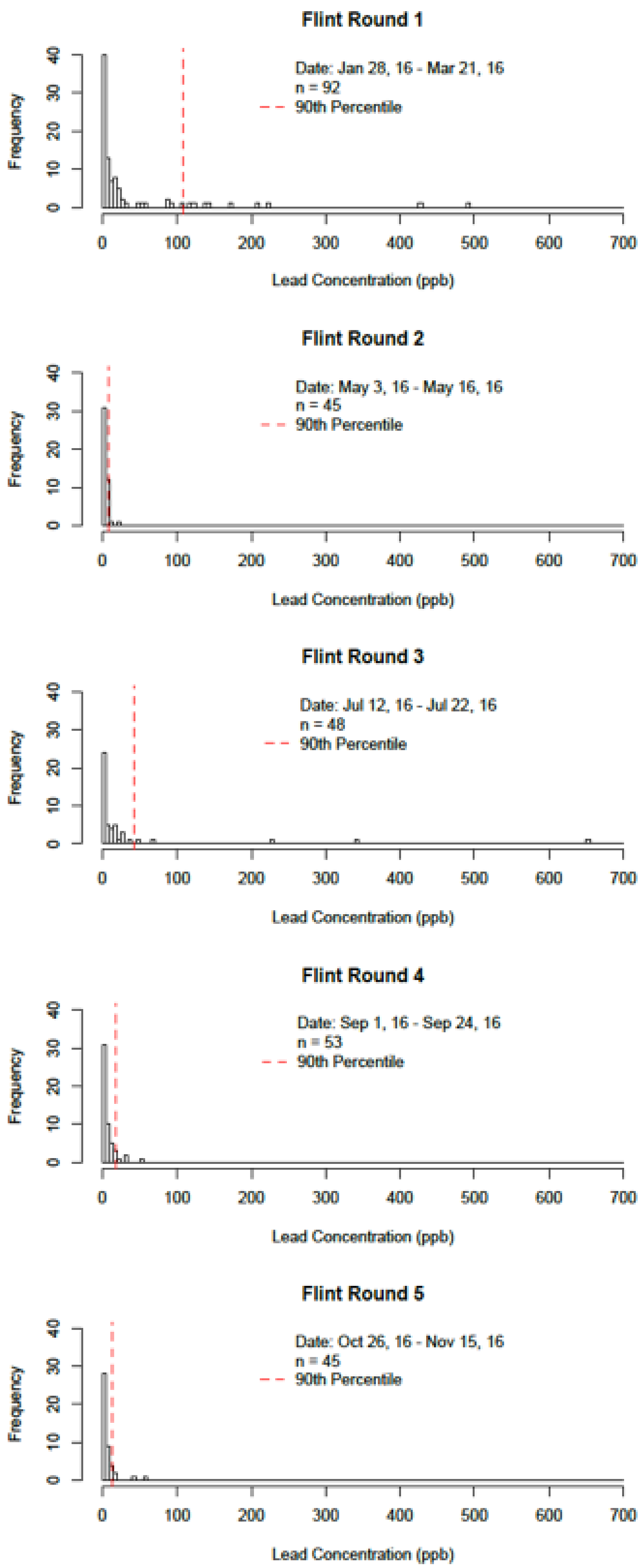

Figure 4. Frequency Distribution of Lead Concentration in Five Sampling Rounds in Flint

APPENDIX 2.b

2. EPA Introduces New Aspects to the Rule that Complicate National Efforts to Reduce Exposure to Lead Through Drinking Water.

   b. EPA introduces an “unknown” category for the service line inventory and considers them equivalent to lead lines. Each water system should make transparent to the community and state the criteria they use to define a service line as lead or non-lead, and, in turn, set a goal for converting “unknown” classified lines to lead or non-lead (§141.84 Lead Service Line Inventory and Replacement Requirements).

Basis for Recommendations: We agree that identifying service line material (creating and maintaining an inventory) is good for many reasons. For example, service line failures and leaks can account for a significant amount of unaccounted for water.

Service lines are proposed to be defined as:

- Lead – whether whole or partial (but not goosenecks, pigtails, connectors)
- Lead – where galvanized pipe is or at one time was downstream of a lead pipe
- Non-lead – where the whole line is not lead (or where the only lead is a pigtail, gooseneck, or connector)
- Unknown – where either the whole line or part of the line is of unknown material

A galvanized line that is or was downstream of an LSL is to be considered an LSL (p 61696). EPA requests comment on this inclusion of galvanized pipe as equivalent to LSL (p 61735). Galvanized pipe in Philadelphia is often in a very corroded condition and should be replaced when it is found. PWD replaces galvanized service lines when they are found during water main replacements, at no cost to the customers.

EPA specifically requests comment on how they plan to address unknown lines in the inventory (p 61735). EPA requests comment on the inclusion of “unknowns” in notifications and education that goes out to customers (p 61735). On p 61696, a service line whose material cannot be confirmed must be stated as “unknown.” “Unknown” lines will be equivalent to lead lines for purposes of determining how many lines must be replaced according to the required percent removal rate for LSLR that is required.

PWD does not recommend labelling service lines as “unknown” and treating them as if they were lead lines. This could add potentially 250,000 service lines in Philadelphia to a category of “unknowns” that would be addressed as if they were lead lines. The use of the term “unknown” and its application to service line replacement requirements could, for many systems, make even a 3 percent rate of replacement unachievable.

The use of the term “unknown” would be confusing to the public. As an option, the EPA could require that a PWS be transparent about how it determines a lead service line from a non-lead service line and provide the disclaimer as to the accuracy of this determination. For example, a water system might use various parameters to define whether a home likely has a lead service line: age of home, age of water main, date when lead was last used in the community, size of service, etc. Having “unknowns” in the rule makes it more confusing and complicated. The inclusion of “unknowns” could be a bigger issue than tracking and reporting on LSLs depending on how it is handled by the States. The inclusion of “unknowns” presents various problems, one being the need for effective disclaimers on characterizing services and providing consumers with warnings that may or may not be applicable.

The revisions do not adequately address how a water system can determine dates for when homes were built, and other factors by which to classify “unknowns” as unlikely to be lead. Triantafyllidou, S., Parks, J. and Edwards, M. (2007) stated that as of 1986 lead pipe and leaded solder were banned from use in potable water plumbing systems. Local records may point to earlier dates and the use of other information. Philadelphia’s dates pertaining to the stoppage of LSL installations and uses of leaded materials are well established with extensive information from city codes, plumbing practices, current records and field observations. Such information includes when the last known, on record, installation of an LSL occurred in Philadelphia, the limit on the size of the service line that could have been made of lead, the age of the buildings, the age of the water mains, water main repair and installation records, plumbing code changes, and current information from replacing lead lines during planned water main construction.

The EPA underestimates the impact of classifying a service line as “unknown” and addressing it as if it were a lead line. Philadelphia’s current inventory of approximately 480,000 service connections includes approximately 257,000 residential properties that could be classified as “unknowns” compared to an estimated 25,000 properties estimated to have LSLs. As an alternative approach, the EPA could require that water systems establish a separate database of “unknowns” and set a goal for an annual rate of conversion of unknowns to either “lead” or “non-lead”. This information comes in via normal operations and replacements at about 20,000 determinations per year. Thus, at this rate, in about 13 years we would have all services determined. Such conversions would take place during normal operations such as when service line leaks are repaired, when meters are changed out, and when water mains are replaced.

APPENDIX 2.c

2. EPA Introduces New Aspects to the Rule that Complicate National Efforts to Reduce Exposure to Lead Through Drinking Water.

c. EPA introduces pitcher filters as a required risk mitigation measure. It sets a precedent that will have repercussions beyond those intended for lead (§141.84 Lead Service Line Inventory and Replacement Requirements). Flushing before using water for drinking or cooking is a valid option to reduce the risk of exposure to elevated lead, especially for water systems that have CCT, control of water quality, and low lead levels. The EPA has not shown that a national requirement for providing filters will be sustainable.

Basis for Recommendation: Providing filters would set a precedent for a PWS that could have repercussions beyond those intended by the EPA for high risk homes and lead exposure. There is no evidence that this was evaluated nor that costs were accounted for. For example, for many water distribution systems that have aging infrastructure, rusty water can be a routine nuisance. Rusty water can foul a pitcher filter, making in unusable. Nonetheless, customers would likely demand filters and replacements during rusty water events or during other water quality events.

Philadelphia adds fluoride to the city’s drinking water supply, following guidelines from the Centers for Disease Control, for public health reasons. An unintended consequence of providing pitcher filters to households with children is that some pitcher filters are quite good at removing fluoride from the water and would thereby negate the public health benefit. Public education would need to be developed to address this along with options for providing fluoride. The EPA has not addressed such consequences nor shown any data as to what pitcher filters will remove from water in addition to lead.

On p 61735, the EPA requests comment on the appropriateness of pitcher filters for risk mitigation. Requirements for when pitcher filters would need to be supplied to consumers are found in § 141.85 for LSL disturbances and § 141.84 for LSL replacements and partial LSLs. When a PWS learns that a customer has already replaced an LSL in the past three months (but not after 3 months), the PWS must provide a pitcher filter within 24 hours. The distribution of filters would be a large challenge if filters were to be provided to homes that were classified as “unknowns” and treated as if they had lead service lines under the proposed revisions.

Finally, the EPA must show that it will maintain an updated list of approved and certified filters, provide standards (containing soluble, colloidal, and particulate lead) by which to test the performance of filters, and provide specifications for testing filter performance that PWSs can use. This has not been shown and thus, the requirements for pitcher filters is premature and not fully developed. Water filters will have to be certified and tested to make sure they meet purchase specifications. PWD will need this information in order to purchase filters on a bid system and will need to test the filters to make sure that what is purchased will perform as required. EPA must develop the performance testing requirements for the meeting of specifications along with lead standards by which to test the filters for performance. If future standards, such as NSF, change concerning the ability of pitcher filters to remove soluble, colloidal, and particulate lead, then these changes could greatly impact the customers who have used and are still using filters. Will the PWS be required to identify and replace filters that have been decertified, and that were initially provided to homes?

Water filters (faucet mount and pitcher filters) were evaluated for Newark's lead crisis (City of Newark Point-of-Use Filter Study, August-September 2019. November 2019, CDMSmith; November 22, 2019 letter from the USEPA to New Jersey Department of Environmental Protection and the Mayor of Newark). This study preferred faucet-mount filters although 25% of users did not maintain or install the filters properly, ran hot water through them, used other filter cartridges, or continued to run the filters even though the red light was on. Filters had at most a 5% failure rate (did not reduce lead to less than 10 ppb). The study and EPA concluded that the filters were viable as long as strong public education was provided for proper installation and operations, and that prior to their use water be flushed for five minutes through the filter's bypass. It is unclear whether the EPA evaluated these conditions for filters under the proposed LCR revisions such as: providing faucet-mount filters; requiring flushing prior to use of filters; providing very clear requirements for maintenance and operations and installation; and providing disclaimers. Newark's study showed a very significant number of people who failed to use filters properly. And if people get water from various faucets in a home, will they install a filter around the house on the various taps where drinking water could be obtained?

Flushing before using water for drinking or cooking is a valid option to reduce the risk of exposure to elevated lead, especially for water systems that have CCT, good control of water quality, and low lead levels. It is an incentive for water systems to achieve these conditions so as to maximize the risk reduction measures that they make available to their communities. The EPA should require public education about risk reduction measures but should not write into the rule the actual measures that must be used. These measures will change over time. These measures will look different for different communities. Risk mitigation measures for customers to use, such as providing pitcher filters, faucet-mounted filters, point-of-entry devices, bottled water, or education about flushing, should be determined at the community level.

Flushing the tap is a viable option for contaminants such as lead and copper (Burlingame et al 2019; Batterman et al. 2019) as flushed water can provide water that is low in lead. Flushing or rinsing taps can be an easy to understand and broadly applied strategy to reduce exposure to lead:

- It can be done at any tap in the house
- It can become as natural as washing hands before eating
- People should follow this wherever they are, not just at home
- It requires no extra tools or devices
- It is inexpensive

A kitchen tap (as reported by the EPA) allows a flow rate of about 2.2 gallons per minute. The flow rate could be half that rate if the aerator is kept on.

	Volume of Water					
	Tap* to Meter		**Meter to Main**		**Tap* to Main**	
	Liters	**gallons**	**Liters**	**gallons**	**Liters**	**gallons**
Minimum	0.76	0.20	1.17	0.31	3.49	0.92
25th percentile	2.61	0.69	3.10	0.82	6.83	1.80
Average	**5.04**	**1.33**	**5.53**	**1.46**	**10.57**	**2.79**
75th percentile	6.07	1.60	5.64	1.49	11.25	2.97
Maximum	18.72	4.95	40.07	10.59	52.34	13.83

*Tap – measured distance to LCR sample taps (kitchen or bathroom)

The table above looks at the total volume of water between the tap and the water main of 79 homes with LSLs that participated in recent rounds of the Lead and Copper Rule for Philadelphia. On average there is about 2.8 gallons of water in the plumbing and service line between the kitchen faucet and the water main.

Thus, to get turnover of standing water – replacing the stagnant water with fresh water – in the plumbing of an average home it takes 2-4 minutes at most to flush the kitchen tap (or a toilet flush followed by a 1 to 2-minute flush to clear the plumbing feeding the kitchen faucet). Thus, within 1 minute of high flow from the kitchen tap, the average home’s plumbing water has been turned over and replaced with new water. Some homes could require 2 minutes of water flow. Again, with the aerator left on this could vary between about 2 to 4 minutes.

Toilet flushing alone refreshes and flushes the service line and plumbing to the toilet about 16 times a day if the volume of water in the plumbing is 2 gallons. A single toilet flush could account for about 2.6 gallons of water such that one flush of the toilet replaces the water from the toilet to the water main. A dishwasher might clear the plumbing about once per day.

The following technical brief was provided by The Environmental Science, Policy and Research Institute on request from the Philadelphia Water Department, to provide additional review of whether tap flushing is a valid alternative risk reduction measure that could be included under the revised rule.

Technical Brief: Flushing as a Lead Risk Mitigation Strategy

Prepared for: The Philadelphia Water Department Bureau of Laboratory Services

By: Sheldon Masters, Corona Environmental Consulting, LLC

Tim Bartrand, ESPRI (The Environmental Science, Policy and Research Institute)

1/15/20

Executive Summary

One viable Lead and Copper Rule Revision [LCRR] risk mitigation strategy following a lead service line [LSL] disturbance or partial LSL replacement is flushing. Several studies have found that flushing, especially in systems with stable corrosion control, can be effective at reducing lead levels to non-detectable levels. There are two applications of flushing: first, the whole-house removal of particulate lead following the disturbance of a lead service line; second, the daily rinsing or running of a cold-water faucet prior to use of the drinking water. There appears to be general agreement that a whole-house flush following a lead service line disturbance is good practice. For ongoing risk reduction, routine daily flushing is a valid risk reduction measure for stable systems with corrosion control treatment and low lead levels.

Advantages of Flushing

The advantages of flushing to reduce lead exposure are:

- It is a relatively simple procedure that most water customers can perform,
- It is inexpensive compared to other methods of reducing lead exposure (e.g., LSL replacement),
- Flushing before filtration can further reduce lead exposure compared to filtration alone for water systems that have high lead levels.

Potential Limitations of Flushing

The potential limitations of flushing to reduce lead exposure are outlined below:

- Compared to filtration, the results of flushing for lead exposure reduction may be less certain in water systems with poor corrosion control.
- Flushing will efficiently clear dissolved lead from the plumbing system but in some cases (e.g., systems with unstable corrosion control) shearing from flushing can cause particulate lead release.
- The volume of water that must be cleared from the plumbing system to get fresh water from the distribution system can vary widely and depend on site-specific factors such as type of plumbing material, length of the service line, and plumbing configuration.
- If there is low water use in the home and the system has poor corrosion control, flushing may need to be performed frequently if the water is being used for consumptive purposes.

Key Finding/Recommendations

- In systems with optimized corrosion control treatment, clearing the volume of water from the tap to the distribution can reduce lead exposure similar to filtration.
- If flushing is used as the only risk mitigation strategy, system-specific customer communications should be developed and tested, and a solid communication strategy should be developed and executed for delivering flushing guidance to customers.
- In systems with poor corrosion control, flushing alone is unlikely to produce low/non-detectable lead levels reliably. In these systems, flushing and using a filter is an effective risk mitigation strategy.

Introduction

The proposed LCRR acknowledges that water systems “cannot unilaterally implement the actions that are needed to reduce levels of lead in drinking water” and consumers play a critical role in achieving the goals of the LCR. For example, water systems must “engage with consumers to encourage actions such as flushing that reduce their exposure to lead in drinking water”. The proposed revisions would require flushing after an LSL disturbance or replacement. A service line disturbance is considered any planned work or an emergency repair that requires water service to be shutoff. In this case flushing instructions would be delivered to the consumer. A replacement of a meter, gooseneck, or pigtail is expected to be a more significant disturbance to the LSL, so in addition to flushing, water systems would be required to provide consumers with pitcher filters certified to remove lead. This memo provides information on the effectiveness of flushing after an LSL disturbance and as a routine procedure for lead risk mitigation.

Flushing after LSL Disturbance

Different types of LSL disturbances (e.g., lead service line replacement [LSLR], utility work, or main replacement) have been reported to increase water lead concentrations and whole-house flushing is a common strategy for reducing this lead risk. Deshommes et al. (2018) conducted a utility survey in 2015 and found most of the 19 water systems conducting LSLR did not specify mandatory flushing after replacement. Seven utilities implemented flushing, but the procedures varied widely from flushing on the day of LSLR to repeated flushing for periods of 5-60 minutes over six months after LSLR. The wide variation in recommendations was attributed to a lack of guidance and gaps in scientific findings regarding flushing. Recognizing the need for better guidance, AWWA developed standard ANSI/AWWA C810-17: Replacement and Flushing of Lead Service Lines (AWWA, 2017). The standard includes strategies for locating LSLs, and flushing, testing and verification methods after replacement. Three types of flushing techniques are recommended after replacement:

- Flushing the water from an outside connection (such as hose-bib) to remove any particles in the service line and near point-of-entry at full velocity for at least 10 minutes.
- Flushing the interior premise plumbing by removing the aerators and opening all the taps in the home, from the bottom floor to the top. The taps should be run at the highest rate possible for 30 min. After 30 min, the taps are closed in the same order in which they were opened.
- Conducting a daily "mini-flush," which is a minimum 5-minute displacement flush for six months following replacement.

The ANSI/AWWA C810-17 premise plumbing procedure is similar to the high velocity flushing (HVF) approach described by Cornwell et al. (2018). The researcher recommended HVF after PLSLR and FLSLR because the procedure was effective at removing particulate lead after an LSL disturbance. Findings from the study suggest that for PLSLR it may take 2 months or more for beneficial effects of HVF to be evident, and in the interim customers should employ additional risk mitigation strategies to reduce lead exposure from drinking water. HVF was not recommended for house with an LSL but no preceding disturbance since the HVF creates disturbed conditions that can cause particulate lead release.

Batterman et al. (2019) studied the effects of disturbances from main replacements on lead concentrations after flushing. They sampled 542 homes before and after main replacement. The residents were given instructions to flush water lines after the service was transferred to the new mains by first removing the aerator screens then opening the cold water tap nearest the service line not used for drinking for at least 5 minutes. Main replacement was associated with a less than 1 ppb increase in median and 90th percentile lead concentrations. Changes were smaller or not detectable after controlling for other factors such as temperature, water use, and stagnation time. The researchers recommended continued outreach to promote flushing and other actions to minimize lead exposure, and routine profile sampling.

There appears to be agreement that a one-time whole-house flushing following a LSL disturbance is a good practice. The question, though, remains as to whether additional risk mitigation is needed beyond routine daily flushing to continue to minimize risk to an acceptable level on a daily basis. It is a near-certainty that risk mitigation strategies for post-LSL disturbance will differ among systems and among plumbing systems connected to a given system. All strategies would benefit from inclusion of post-disturbance whole system flushing as well as routine, regular flushing for clearing out residual and mobile lead. Development of system-specific post-LSL disturbance flushing guidance (for impacted customers) could be an important element of risk mitigation and lead exposure abatement. System-specific guidance could provide critical information to customers such as the frequency of flushing, the duration of flushing, the time period post-LSL-disturbance during which routine flushing would be beneficial, specific guidance for at-risk populations such as young children and pregnant women, and an assessment of the additional/marginal benefits of other risk mitigation steps such as use of pitcher filters.

Routine Flushing for Lead Reduction

Routine flushing is an easy low-cost way to reduce water lead exposure for homes with LSLs. The EPA recommends flushing taps for 15-30 seconds or until the water becomes cold or reaches a steady temperature if the water has not been used for several hours (US EPA, 2008). This guidance is faulty and could inadvertently promote exposures to high levels of lead; for many residences 30 seconds is not enough to clear the water volume between the LSL and a faucet used for drinking water and food preparation. Further, the water temperature from a faucet could feel cold when the water represents the plumbing system in a cool basement rather than in the water supply main. The flushing duration may vary based on site-specific and system-specific conditions. As such, the EPA allows systems to tailor the flushing recommendations to their system with Primacy Agency approval (US EPA, 2008). Data from a system with stable corrosion control and a system with unstable corrosion control were used to evaluate the efficacy of flushing as a risk mitigation strategy.

System with Stable Corrosion Control

Profile sampling data from Philadelphia were used to evaluate whether flushing can be an effective lead risk mitigation strategy in a system with well-maintained corrosion control. The samples were collected between May and September 2017. The first-draw is a weighted average of the first three sample volumes (i.e., 0.25 L, 0.25 L and 0.5 L) to estimate a 1 L sample concentration. Figure 1 shows that the volume of water that must be flushed to clear the premise plumbing varies from home to home. Figure 2 compared the first-draw samples to the flushed samples representative of the water quality in the main. The mean first-draw lead concentration was 2.6 ppb while the flushed samples were consistently non-detect. The results demonstrate that in a system with stable corrosion control, flushing alone can be an effective risk mitigation strategy. However, the sample size is small and the results should be corroborated with a larger sample set and/or using data from more systems. Further, these results do not extend to systems prone to particulate lead release (the Philadelphia data are indicative of dissolved lead release, not particulate lead release and transport). What is generally applicable is the low (non-detectable) concentration of lead in the building supply (i.e., in the distribution system) and that obtaining water from the water supply mains (after flushing) minimizes exposure to lead when soluble lead is the primary type of lead in the water.

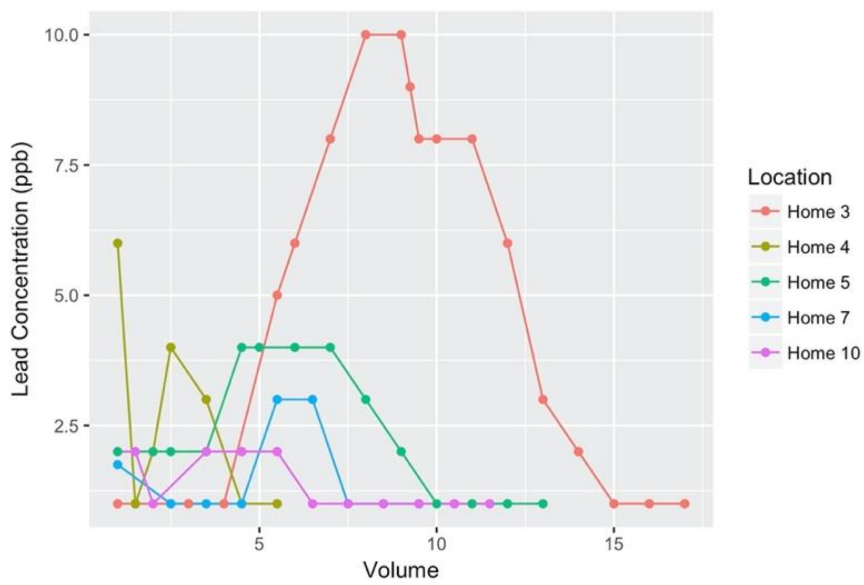

Figure 1. Lead profiles in Philadelphia, PA

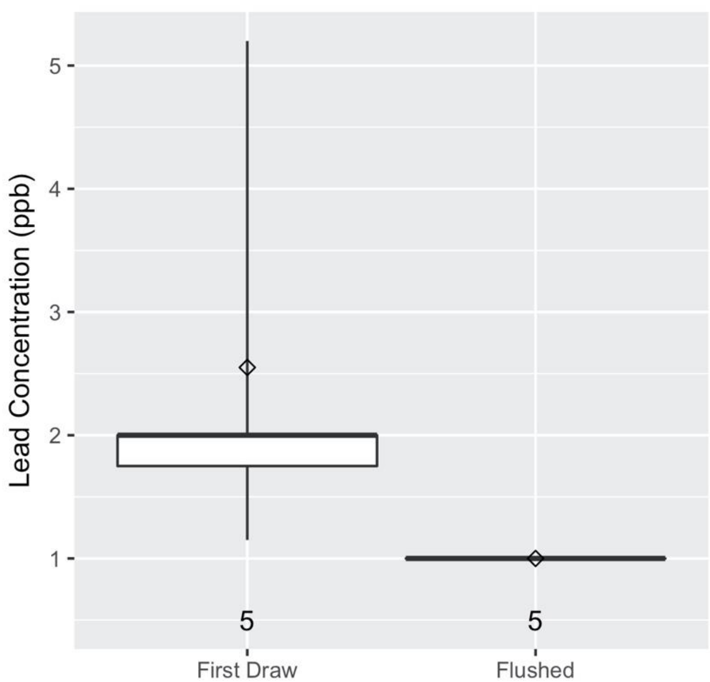

Figure 2. Comparison of first draw and flushed samples in Philadelphia, PA

System with Unstable Corrosion Control

Profile data from 5 rounds of sampling in Flint, MI were used to evaluate the efficacy of flushing in a system with unstable corrosion control treatment. Similar to the results in Philadelphia, Figure 3 shows that the volume of water that must be flushed to clear the premise plumbing varies from home to home. Figure 4 compared the first-draw samples to the flushed samples representative of the water quality in the main. The results show that fully flushed lead concentrations were much lower than the first draw samples. For example, in Round 1, the average first-draw lead concentration was 34.4 ppb versus a flushed lead concentration of 6.4 ppb.

Since particle filtration was not done, Lytle et al. (2019) used 20 ppb lead as a cutoff to examine lead spikes which were possibly due to lead particulate release in Flint. The boxplots show that there were elevated lead concentrations in some flushed samples. Most of the elevated lead concentrations in the flushed samples were above 20 ppb which is indicative of particulate release due to shearing or random release. While flushing does provide some benefit, since there are still elevated lead levels in some flushed samples, flushing should be used along with POU filters in systems with unstable corrosion control. This is similar to the recommendation issued in Newark, NJ which experienced recent lead problems. In the study conducted by Newark they found that 97.5% of the filters, when properly installed and maintained, reduced lead to 10 parts-per-billion (ppb) or below. When the faucet was flushed for 5 minutes prior to filtering, 99.5% of the filters reduced lead to 10 ppb or below. Therefore, they recommended flushing for a minimum of 5 minutes prior to filtering to maximize filter performance in reducing lead in drinking water (City of Newark, 2019).

Although the EPA has not identified a one-time exposure, acute risk level for lead, if a water system experiences high lead samples as rare events, then routine flushing would still be a valid risk reduction technique to use without the need for additional measures. Flint data show that, though high lead levels (> 20 ppb and probably particulate) can occur for volumes of water later in profile samples, they occur most frequently in the first 4 to 6 liters of water flushed and very infrequently in water representative of that in the distribution mains.

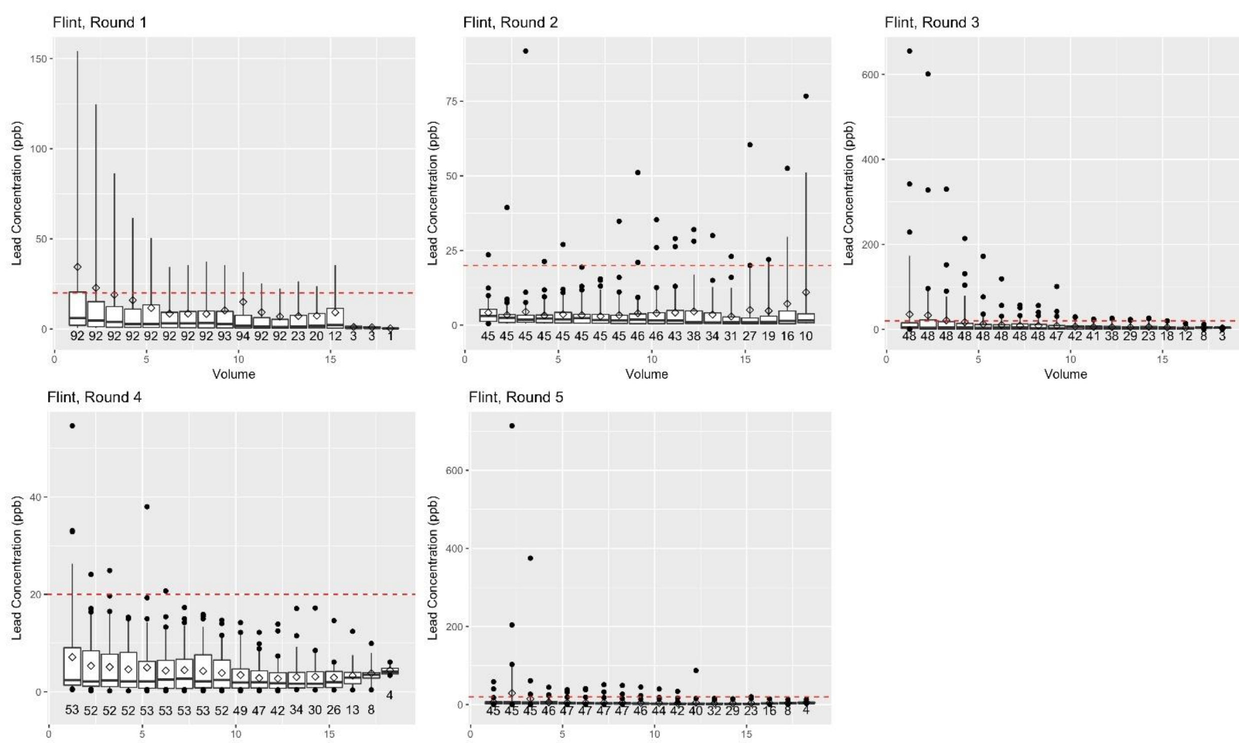

Figure 3. Lead profiles from 5 sampling rounds in Flint, MI

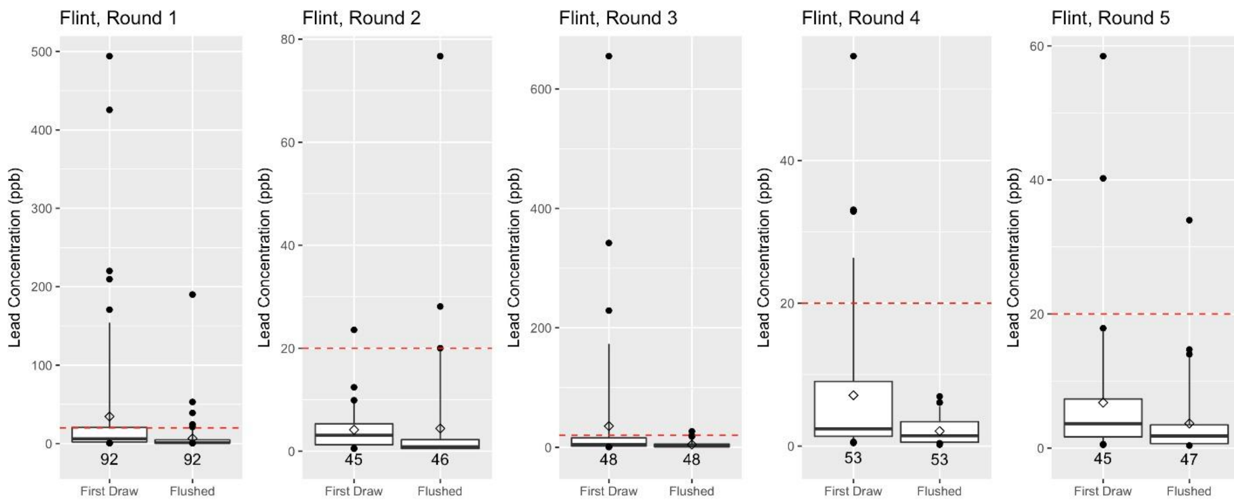

Figure 4. Comparison of first draw and flushed samples during 5 sampling rounds in Flint, MI

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APPENDIX 3

3.EPA's Public Education Requirements are not well Coordinated

The requirement for public education and communication is important but still needs to be better designed so as not to overwhelm people with information to the point that they ignore it, and to give them direction on risk reduction actions to take when they need it (§141.85 Public Education and Supplemental Monitoring Requirements).

Basis for Recommendations: In § 141.85, the EPA addresses proposed requirements for public education and communication. PWD agrees that this is a primary means by which to reduce exposure to lead. However, public education and communication should be done well so that they are more than just education; that they change people's habits. Such education includes: information on the health risks of lead; information on where lead in drinking water comes from; information on measures that consumers can take to reduce the risk of exposure; information on what the water system is doing to reduce lead levels in drinking water; information on how to get water tested or plumbing checked for lead; information on how to get a lead service line replaced; information on what to do if your service line is disturbed or replaced.

Annual communication is proposed to happen for all customers who have an LSL or "unknown", or a galvanized line (note that it will be difficult to explain differences between galvanized pipe that are upstream or downstream of a lead pipe). Similar communication will occur when new customers hook up to the system and have one of these service lines. In addition, similar communication will occur when the following happens: an LSL is replaced; a partial LSL is created or replaced; a lead gooseneck pigtail, or connector is replaced; a galvanized pipe is replaced; an LSL or "unknown" is disturbed.

The use of public education and communication needs to be better designed so as not to overwhelm people with information to the point that they ignore it, and to give them direction on risk reduction actions to take when they need it.

The Consumer Confidence Report (CCR) should be the place to provide annual notice to everyone because lead is an issue not just for homes with LSLs, but homes with other sources of lead. The CCR should contain brief points such as: lead is a health hazard; lead can be in drinking water from various materials used in plumbing and service lines; there are things your water system is doing to control lead in the drinking water; there are additional things that you can do; if you have a lead service line, the water utility has various programs through which it can be replaced; to determine if you have a lead service line, go to the water system's link; more details are provided at the water system's web page or by calling and requesting the information. The web page, or information that can be mailed to consumers, would then provide the details for all these issues along with a link to the EPA's clearinghouse of information on lead.

The revisions to the LCR also propose to require annual notification of lead in water from the water utilities to the health care providers in their service areas. The CCR is already sent to customers who are primary care physicians and who have other health care practices, which would take care of notifying them. The local health agency is the more appropriate agency to inform their list of contacts in the medical fields about the existence of this information. Going through the health agency is very important for providing uniform and consistent public health information, and health agencies and States have existing networks to accommodate such communications.

When a service line is repaired or replaced, when a service is disturbed, or when a partial is created, the customer would be given specific information on what to do to reduce lead, along with a link to the website for detailed information. But at this time, the focus should be on the action to take, such as flushing the plumbing system. This would avoid overloading customers with information and would help to focus them on the actions they need to take.

There is no mention of communication about homes with lead solder, old brass valves, and old brass faucets even though elevated lead can come from them. As a result, some customers will be overloaded with information throughout the year such that it becomes confusing or gets ignored, while other customers will receive very little if any information. The requirements for public education and communication in the revisions are not well organized and, thus, will not be as effective and efficient as they should be.

APPENDIX 4

4. EPA's Lead and Water Quality Parameter Monitoring Requirements are a Disincentive for Compliant Water Systems to be Proactive.

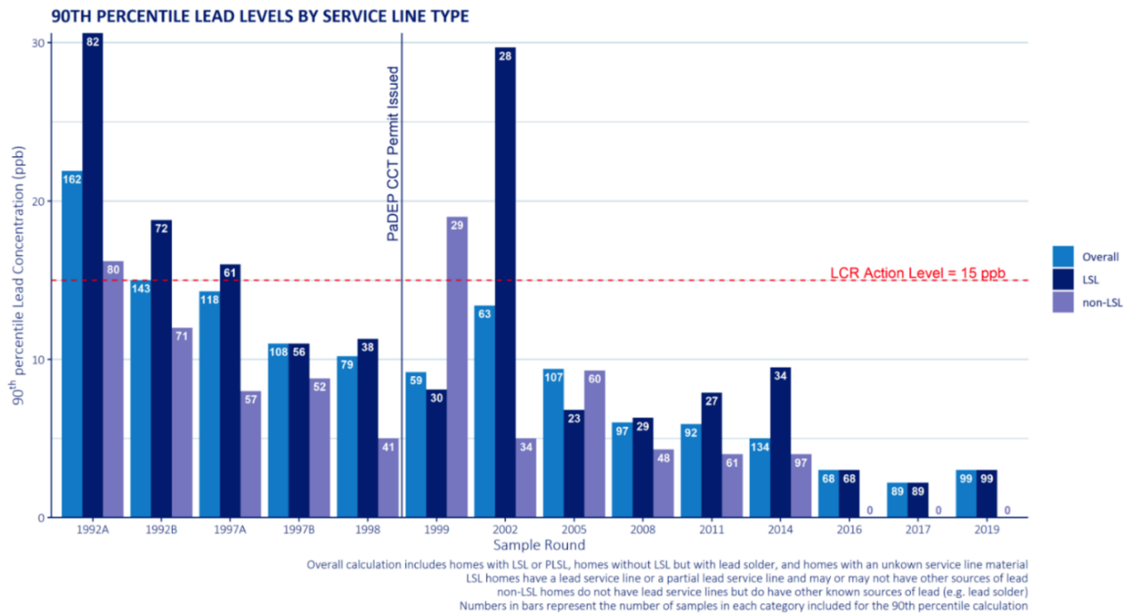
> The EPA limits a water system's ability to use existing data. The proposed revisions appear to deny water system's valuable and costly data for determination of ongoing monitoring requirements (§141.86 Monitoring Requirements for Lead and Copper in Tap Water; §141.87 Monitoring Requirements for Water Quality Parameters).

Basis for Recommendations: The use of "grandfathered" data to meet newly enacted regulations or changes in existing regulations applies to the use of a water system's existing data, collected prior to the start of compliance monitoring, for determining a water system's compliance status. Stated on p 61704, "The EPA is proposing to permit the use of grandfathered data to meet initial lead monitoring requirements if the data are from sites that meet the proposed tiering requirements." Page 3-3 of EPA's economic analysis (USEPA 2019) states: "A system can use grandfathered data that meets the tap sampling protocol and revised tiering criteria under the proposed rule…." The data must be collected between the time of the final publication and the start of the compliance. Otherwise, systems would use the 90th percentile results from the first sampling period after the compliance date.

For PWD, despite maintaining low lead levels and having sampling data that already meet the new sampling requirements, it seems that PWD would have to: conduct annual monitoring for three years after which, if below the trigger level, PWD could go back to triennial monitoring. This would only be for lead. Copper testing would remain at every three years.

The EPA limits a water system's ability to use grandfathered data even though most water systems (EPA data from their economic analysis) are below 10 ug/L for their 90th percentile and have CCT in place, if needed. Water systems should be allowed to stay on their current monitoring plan (sample count and frequency) if they are low in lead, have CCT, and have not changed source or treatment. The first monitoring round under the revised rule could be set as the first year following the effective date. This round would clearly contain all new tiering and sampling protocols. If the data changes, such as trends upward, then the State can discuss with the water system the implications and need for follow-up action such as a second round of monitoring the following year.

The EPA's restrictions on what data can be used for grandfathering place unsupported emphasis on the effects of the tap sampling protocol: (page 3-9 of economic analysis (USEPA 2019)) "…. To help ensure that collection procedures do not potentially result in tap samples that erroneously reflect lower lead concentrations." This has not been the case with Philadelphia where, instead, by following the new tiering and sampling protocols, Philadelphia has obtained its lowest lead concentrations since 1992 (see graph below).



Breakdown of Homes Sampled During LCR 1992 – 2019

LCR Round	**1992 A**	**1992 B**	**1997 A**	**1997 B**	**1998**	**1999**	**2002**	**2005**	**2008**	**2011**	**2014**	**2016**	**2017**	**2019**
Total Homes Sampled	162	143	118	108	79	59	63	107	97	92	134	68	89	99
# of LSL Homes Sampled	81	71	60	55	37	29	27	20	33	27	34	68	89	99

The sampling protocols have not been demonstrated to change the lead results for a water system; in fact, Philadelphia has had its lowest 90th percentile lead values for the last three rounds since the EPA approved Philadelphia's changes in protocols to strictly meet their requirements. Sampling from only LSLs instead of including leaded solder has also shown the same trend for Philadelphia. Thus, there is no reason to assume that lead levels will increase for systems that have low lead levels, CCT in place, and have not made changes. Yet the proposed revisions appear to penalize water systems by defaulting them backward in monitoring requirements.

The following technical brief was provided by The Environmental Science, Policy and Research Institute on request from the Philadelphia Water Department to provide additional review of the issues with sample number and frequency, and the use of grandfathered data.

Technical Brief: Statistical Assessment to Evaluate the Impact of Sample Size on Lead and Copper Rule Regulatory Monitoring Reliability

Prepared for: The Philadelphia Water Department Bureau of Laboratory Services

By: Sheldon Masters, Corona Environmental Consulting, LLC

Tim Bartrand, ESPRI (The Environmental Science, Policy and Research Institute)

11/19/19

Executive Summary

Statistical analyses of customer lead concentration data from four systems (Greater Cincinnati Water Works [GCWW], Chicago, Providence and Flint) show that very stable systems (systems with compliance monitoring, first-draw 90th percentile lead concentrations significantly below the action level) and unstable systems (systems with a 90th percentile significantly above the action level) require fewer samples to accurately determine compliance (i.e., above or below the action level) with the Lead and Copper Rule (LCR) than systems that are marginally stable (with 90th percentile lead concentrations in the vicinity of the action level). For Flint, roughly three months after return of the system to purchased water from Detroit, fewer than 30 samples would have demonstrated reliably and with high confidence that the system remained unstable and out of compliance. For Cincinnati (with stable corrosion control), as few as 10 samples can confirm that the system remains stable and can continue on reduced monitoring, provided that the sites properly capture the variability in WLLs among Tier 1 homes. After Flint had returned to Detroit water for 12 months and the Flint system was approaching stability and

was marginally in compliance (the 90th percentile was more than 13 ppb), between 70 and 90 samples were required to know with high confidence whether the system was still out of compliance.

Precise and accurate determinations of system 90th percentile lead concentrations are different from accurately determining whether a system is above an action level. In general, determining the system's 90th percentile with precision and accuracy requires more samples than what would be required for reliably determining whether a system's 90th percentile WLL is above or below the action level. Increasing number of samples improves precision in 90th percentile concentration estimates by reducing the likelihood that rare observations bias the result and by including enough sites in the sample pool to increase the likelihood that variability among results for the sites is representative of variability of high-risk homes (Tier 1) of the system overall. For Cincinnati, a stable system with low variability in their first-draw lead concentrations, roughly 30 samples are required to reach a point of diminishing returns above which additional samples do not provide an observable improvement in precision in the 90th percentile lead concentration estimate. For an unstable system that is currently in compliance with the LCR (Chicago), roughly 90 sites must be sampled to reach the point of diminishing returns. For out-of-compliance systems with highly-variable, first-draw sample concentrations (Flint shortly after return to Detroit water and Providence, RI), 90 to 130 sample locations are required for a precise estimate of 90th percentile concentration.

We find that the current and proposed number of samples for determining LCR compliance is sufficient for highly-reliable determinations of whether large systems are above or below the action level and that 90 or fewer sample sites is a practical target for developing as precise an estimate of the 90th percentile first-draw lead concentration as practicable. Additionally, the analyses support reduced monitoring, as currently allowed in the LCR, for systems that have demonstrated that their corrosion control treatment is stable and that have 90th percentile lead compliance sample lead concentrations below the action level with a margin of safety. Reduced monitoring (less frequent monitoring with lower number of sites monitored) is justified for large systems with stable corrosion control that collect a large number of samples because compliance determinations for a large number of samples are highly certain. The results indicate that the current sample size requirements (i.e., 5-60 sample sites) for small and medium systems that are only marginally stable do not provide as reliable an assessment of compliance as for large systems.

Our analysis supports EPA's proposed use of "grandfathered data" for determining whether systems are eligible to continue reduced monitoring when LCR revisions are finalized, though additional aspects need to be addressed. Grandfathered data should refer to data collected during sampling rounds preceding LCR revisions despite different requirements for site selection than those proposed in the draft revised LCR. The current LCR requires systems to collect 50% of samples from homes with lead service lines, if available. The proposed LCRR would require systems to collect all samples from sites served by lead service lines, if available. Grandfathered historic monitoring data (including those from the 50% of sites with LSLs) provide sufficient information on whether the system is close to the action level as well as the variability between sample sites. If the system is well below the action level, the WLLs are not variable and corrosion control treatment is optimized, our analyses indicate that fewer samples than the number required in standard monitoring can confirm that the 90th percentile WLL is below the action level. That is, the system can continue reduced monitoring with a low likelihood that the monitoring round 90th percentile WLL is below the action level when the population 90th percentile WLL (the 90th percentile if all Tier 1 homes were sampled) is above the action level. However, for systems close to the action level, increased monitoring is required to determine the system's 90th percentile WLL with adequate precision and accuracy to determine initial monitoring requirements under the revised rule.

Background, Purpose and Methods

The Lead and Copper Rule (LCR) requires periodic customer home sampling for lead and a comparison of the 90th percentile concentration with an action level. Systems with a 90th percentile lead concentration below the action level for three consecutive sample rounds can reduce monitoring frequency (from annually to once each three years) and number of sample sites. Number of sites required for compliance sampling varies with system size (Table 1).

Table 1. Current LCR Sample Site Requirements (40 CFR § 141.86)

System size (number of people served)	Number of sites (standard monitoring)	Number of sites (reduced monitoring)
>100,000	100	50
10,001 to 100,000	60	30
3,301 to 10,000	40	20
501 to 3,300	20	10
101 to 500	10	5
≤100	5	5

The number of sampled connections determines

i. the precision and accuracy of the 90th percentile concentration estimate,
ii. how likely it is that a given set of results provides the "true" answer to the question "is the system above the action level?" and
iii. a level of confidence that the connections sampled are representative of conditions throughout the distribution system.

More accurate and precise 90th percentile estimates provide a better indication of maintaining optimal CCT than less accurate and precise estimates. Higher number of samples contribute to accuracy by including a larger number of locations from more distribution system zones and to precision by reducing sampling uncertainty (i.e., reducing the likelihood that you missed results simply because you collected too few samples). More certain comparisons of 90th percentile estimates with the action level yield more reliable regulatory assessments and promote improvement of corrosion control monitoring when needed.

Statistical analyses were conducted to determine the impact of sample size on compliance determination (i.e., reliable determination of whether a system is above or below the action level) and precision and accuracy of the system's 90th percentile first-draw lead concentration. Data from four systems (GCWW, City of Flint Water Department, Chicago Drinking Water Management and Providence Water) were analyzed via bootstrap analysis[1] to assess the number of samples required for an accurate determination of the 90th percentile and the number of samples required to provide as precise an estimate of the 90th percentile concentration as practicable. The systems were chosen because they had available profile data and because they include systems ranging from highly stable and in compliance (Cincinnati) to a highly unstable and out of compliance system (Flint, shortly after return of water supply to purchased water from Detroit). Analyses were done on 1st draw (1st liter) and 5th liter data from profile sampling and on the higher of either the 1st liter or 5th liter. Findings based on first-draw samples are emphasized in this memo because they are currently used in compliance monitoring and are proposed for continued used in draft revisions to the LCR.

Although 5th liter sample data were used in this analysis, we did not evaluate whether the 5th liter sample gives better or different information than a first-draw sample in this memo.

Bootstrap analysis entails simulation of monitoring rounds by drawing a given number of samples from existing data (assuming all observations in the existing data are equally likely) and calculating the 90th percentile WLL for the bootstrap sample. The result is many estimates of potential 90th percentile WLLs for the system and for the sample size.

Impact of Variability on Estimating Sample Population 90th Percentile

The goal of this section is to determine how many samples should be collected to determine the true population 90th percentile as precisely as practicable. Sample size (number of sites sampled in a compliance sample round) determines the accuracy of predictions of the 90th percentile water lead level (WLL); the greater number of sites sampled, the closer the resulting estimate of 90th percentile WLL approaches the true population 90th percentile. However, there is a point of diminishing returns at which additional samples will result in sampling uncertainty being very small relative to natural variability and at which additional samples do not produce a significant improvement in precision of the 90th percentile WLL estimate.

System with Stable Corrosion Control

The plot showing the impact of sampling size on 90th percentile WLL in Cincinnati is shown in Figure 1. In Cincinnati where corrosion control is stable and lead concentrations are low, additional sample sites produced diminishing returns (in precision of 90th percentile estimate) around 30 samples, irrespective of the median concentration for the particular sampling strategy.

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[1] Bootstrap replicates were a random draw of observations from utility data, with replacement. All bootstrap analyses had 10,000 replicates.

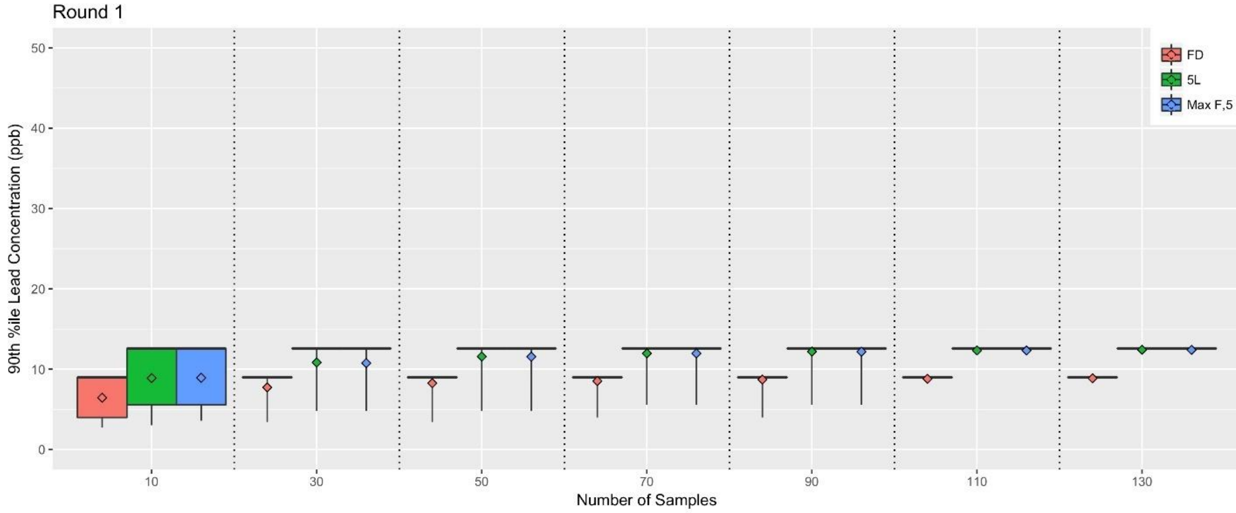


Figure 1. Sample Size Impact on 90th Percentile Estimate, Cincinnati, OH, Round 1

System with Unstable Corrosion Control

Since the promulgation of the LCR, Chicago has only exceeded the action level once. However, consecutive suburban systems to Chicago have experienced lead issues recently and the Chicago corrosion control treatment may be considered unstable. Plots showing the impact of sample size on 90^{th} percentile estimates for Chicago (FD, 5L and Max F,5) are shown in Figure 2. Two rounds of profile data (June and September) were analyzed, though only results from the September sample round are shown. For all protocols, additional sample sites produced diminishing returns (in precision of a 90^{th} percentile estimate) around 90 samples, irrespective of the median concentration for the particular sampling strategy.

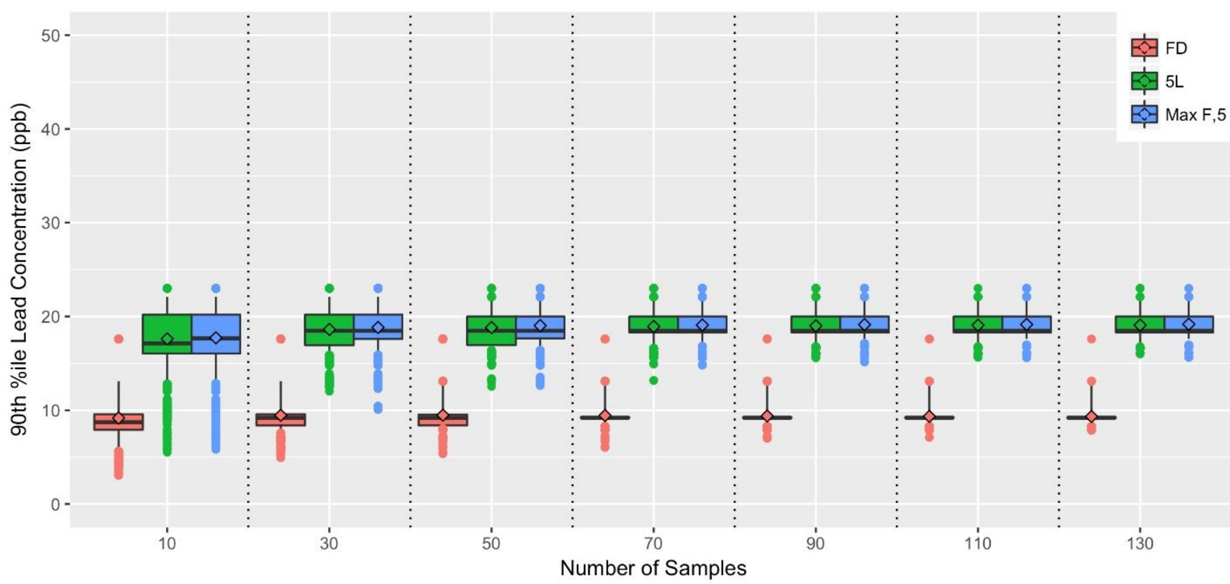


Figure 2. Sample Size Impact on 90th Percentile Estimate, Chicago, IL

Systems out of Compliance

Results for Flint's first round of sampling, roughly three months after switching the system supply water back to purchased water from Detroit, are presented in Figure 3. At the time of sampling, the system was out of compliance and highly unstable. For all sampling strategies, the precision (length of the interquartile range or 90th percentile range of 90th percentile estimates) decreased significantly as sample size was increased to about 90 samples, after which increasing the sample size yielded modest improvements in the estimate of the 90th percentile WLL. Although the median WLL was somewhat different for FD, 5L and Max F,5, the sample size at which additional samples yielded diminishing returns was not different. Data from Providence, RI, another unstable system, were also analyzed (but not shown here) and more than 110 sample were required to reduce sampling uncertainty in the 90th percentile WLL estimate.

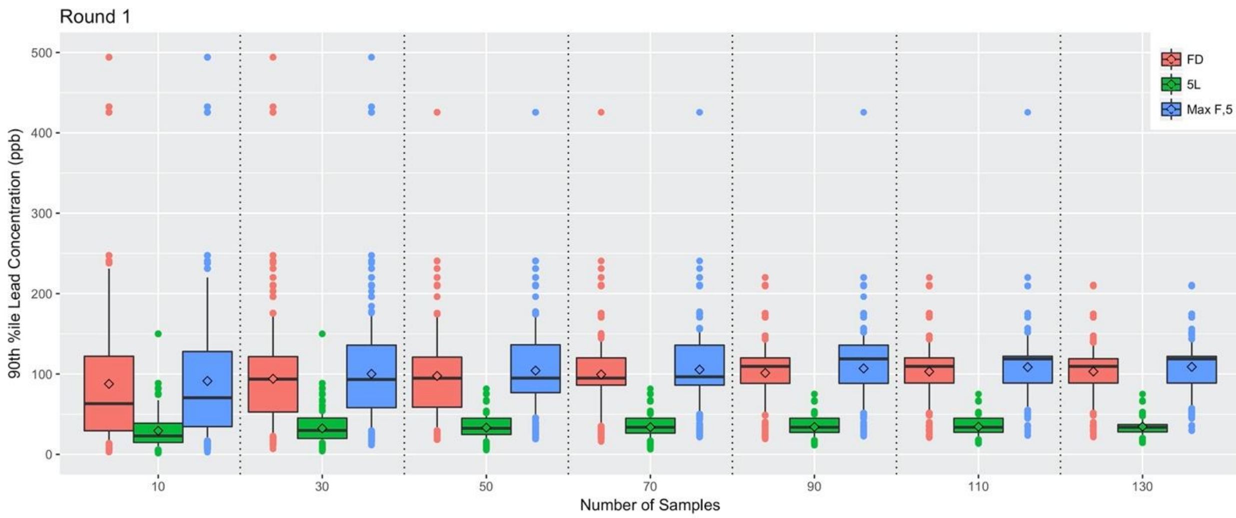


Figure 3. Sample Size Impact on 90th Percentile Estimate, Flint, Final Round of Sequential Samples

General Findings on Sample Size for Precise Estimation of 90th Percentile WLL

Ideally, the number of sites sampled is determined using knowledge of the variability in WLL among sample sites. Based on our analysis, in systems with stable corrosion control and low variability between homes a relatively small number of samples is required to estimate the true population 90th percentile. For example, in Cincinnati only 30 samples would be needed. This finding supports the EPA's approach of allowing utilities to conduct reduced monitoring based on meeting compliance targets. In systems with high lead variability between sites (e.g., systems with unstable corrosion control or are out of compliance) significantly more samples are needed to determine the true population 90th percentile.

Impact of Sample Size (Number of Sites Sampled) on Comparison of System 90th Percentile WLL with the Action Level

Samples to Determine Action Level Exceedance for Systems with Different Stability

Bootstrap analyses generated many possible estimates of the 90th percentile WLL. Descriptive statistics (5th, 25th, 50th, 75th and 95th percentile estimates of 90th percentile WLL and interquartile range) for Flint Round 1 (shortly after resuming Detroit purchased water supply) 90th percentile WLL corresponding to sample sizes ranging from 10 to 130 are presented in Table 2. We consider the sample size (number of sites) sufficient and likely to produce reliable assessments against the action level when the 5th percentile of the 90th percentile WLL estimates provides the same outcome (i.e., is above or below the action level) as the median outcome for a large sample size (130 sites). For Flint in Round 1, between 10 and 30 samples would be required to reliably indicate that the true system 90th percentile WLL was above an action level of 15 ppb.

Table 2. Descriptive Statistics for 90th Percentile WLL Estimates, Flint, Approximately Three Months after Resuming Detroit Water Supply

	Descriptive Statistics for 90th Percentile WLL Estimates (ppb), Flint, First Round					
N	**5th %ile**	**25th %ile**	**Median**	**75th %ile**	**95th %ile**	**Interquar-tile range**
10	13.9	29.1	61.3	124.1	231.2	95.0
30	22.8	52.7	93.2	121.6	175.7	68.9
50	29.6	58.3	94.8	121.0	170.7	62.7
70	36.3	86.2	95.7	120.1	143.6	33.9
90	49.0	88.4	109.5	120.1	140.6	31.7
110	51.4	88.8	109.5	120.1	140.6	31.3
130	54.9	88.8	109.5	120.1	136.3	31.3

Results for GCWW are presented in Table 3. Ten samples from sites representative of the GCWW distribution system are sufficient for reliably determining that the true 90th percentile WLL is below an action level of either 10 ppb or 15 ppb.

Table 3. Descriptive Statistics for 90th Percentile WLL Estimates, GCWW

	Descriptive Statistics for 90th Percentile WLL Estimates (ppb), GCWW					
N	**5th %ile**	**25th %ile**	**Median**	**75th %ile**	**95th %ile**	**Interquar-tile range**
10	2.737	3.986	8.99	8.99	8.99	5.004
30	3.43	8.99	8.99	8.99	8.99	0
50	3.43	8.99	8.99	8.99	8.99	0
70	3.986	8.99	8.99	8.99	8.99	0
90	3.986	8.99	8.99	8.99	8.99	0
110	8.99	8.99	8.99	8.99	8.99	0
130	8.99	8.99	8.99	8.99	8.99	0

Results for Flint's 5th round of profile sampling, conducted roughly 1 year after resuming Detroit water supply and as the system approached stability are presented in Table 4. A best estimate of the "true" 90th percentile concentration is the median 90th percentile WLL at 130 samples and is 13 ppb. More than 70 samples are required to reduce the false negative rate (estimating a WLL below 10 ppb when the actual 90th percentile WLL is above 10 ppb) to less than 5%. Because the "true" 90th WLL is very close to an action level of 15 ppb, we recommend basing sample size in this case on collecting sufficient samples for the most precise practicable 90th percentile estimate (discussed in the previous section).

Table 4. Descriptive Statistics for 90th Percentile WLL Estimates, Flint, Fifth Round

Descriptive Statistics for 90th Percentile WLL Estimates (ppb), Flint, Fifth Round						
N	5th %ile	25th %ile	Median	75th %ile	95th %ile	Interquar-tile range
10	5.19	8.65	10.89	15.64	42.06	6.99
30	8.48	10.12	12.28	15.39	20.11	5.28
50	9.73	10.32	12.51	15.39	20.11	5.07
70	9.77	10.41	13.08	15.39	17.87	4.98
90	10.11	12.19	13.08	15.39	17.87	3.20
110	10.11	12.19	13.08	15.39	17.87	3.20
130	10.12	12.19	13.08	15.39	17.87	3.20

General Findings on Sample Size for Precise Estimation of 90th Percentile WLL

For very stable and highly unstable systems, few sample sites (as few as 10) are required to determine reliably whether the system 90th percentile WLL is above or below the action level. For systems with a "true" 90th percentile WLL near the action level, many more sites are required for an accurate determination and the sample size should be based on achieving the most precise practicable estimate of the 90th percentile WLL. These results assume that sampled sites are representative of all of the sites in a distribution system. Larger sample sizes than 10 would be required for improving the chances that the sufficient sites are sampled to develop a representative data set for large systems or systems with differences on corrosion among distribution system sections.

APPENDIX 5

5. The Proposed Monitoring Program for Schools and Child Care Facilities is not an Appropriate Obligation of Public Water Systems.

Basis for Recommendations: National efforts to provide safe environments for children who occupy schools and child care facilities are needed. This requirement (§141.92 Monitoring for Lead in Schools and Child Care Facilities) should be removed from the Lead and Copper Rule and evaluated through public input and through the EPA's role in the Federal Action Plan to Reduce Childhood Lead Exposures and Associated Health Impacts.

APPENDIX 6.a

6. Additional Changes to the Proposed Revisions are Needed to Move the Nation Forward in Successfully Reducing Exposure to Lead Through Drinking Water.

a. The EPA inappropriately references a practical quantitation limit or PQL of 0.005 ug/L to define the 90th percentile goal for determining optimized corrosion control treatment (§141.2 Definitions).

Basis for Recommendation: In § 141.81(b)(3) and on p 61747, "Any water system is deemed to have optimized or re-optimized corrosion control if it submits results of tap water monitoring in accordance with 141.86 demonstrating that the 90th percentile tap water lead level is less than or equal to the practical quantitation level of 0.005 mg/L for two consecutive 6-month monitoring periods." In § 141.81(b)(3), the EPA's definition of the PQL is: "the minimum concentration of an analyte (substance) that can be measured with a high degree of confidence that the analysis is present at or above that concentration."

Proper use of the PQL is needed in the rule. The PQL is dependent on the lab method used and can change from lab to lab:

> Science Direct: A statistical method for computing **practical quantitation limits** (PQL) is developed. The PQL is operationally defined as the concentration at which the instrument response signal is 100/α times its standard deviation (e.g., for a 10% relative standard deviation (R.S.D.) α = 10).

The EPA can explain that the level of 0.005 ug/L was chosen based on the existing method for measuring the level of lead in drinking water. Perhaps a better way of stating this would be:

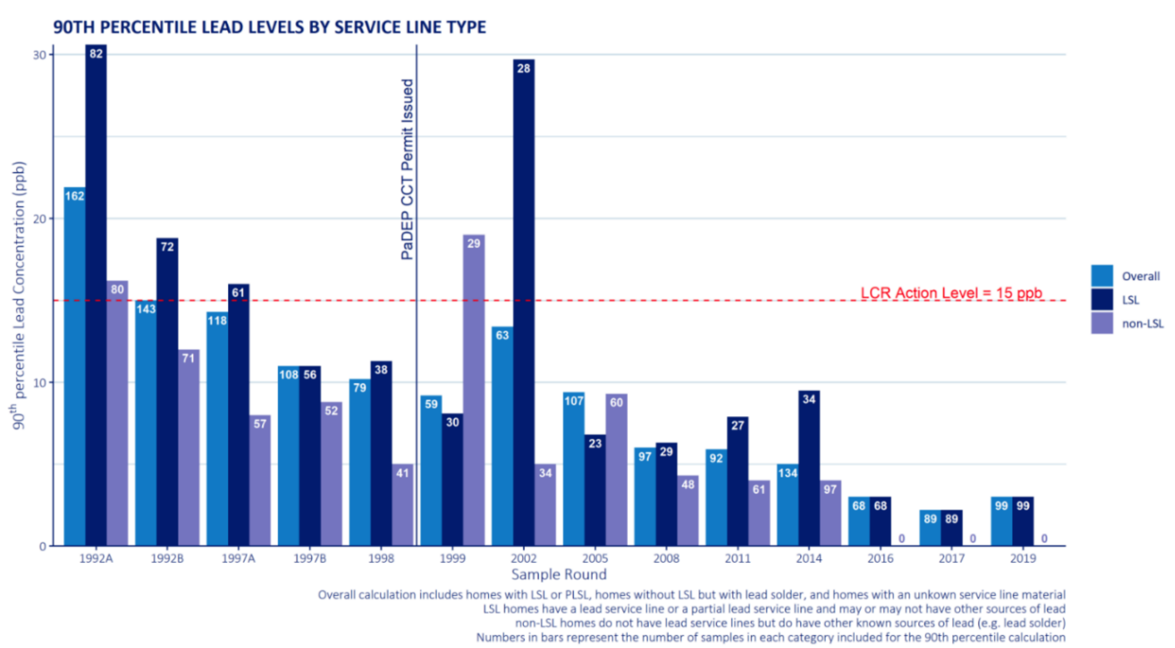
> "Any water system is deemed to have optimized or re-optimized corrosion control if it submits results of tap water monitoring in accordance with 141.86 demonstrating that the 90th percentile tap water lead level is less than or equal to 0.005 mg/L for two consecutive 6-month monitoring periods. This level was chosen based on the current practical quantitation level (PQL) for the analytical method for measuring lead in drinking water that was currently in use by the EPA and is above the usual method detection limit."

APPENDIX 6.b

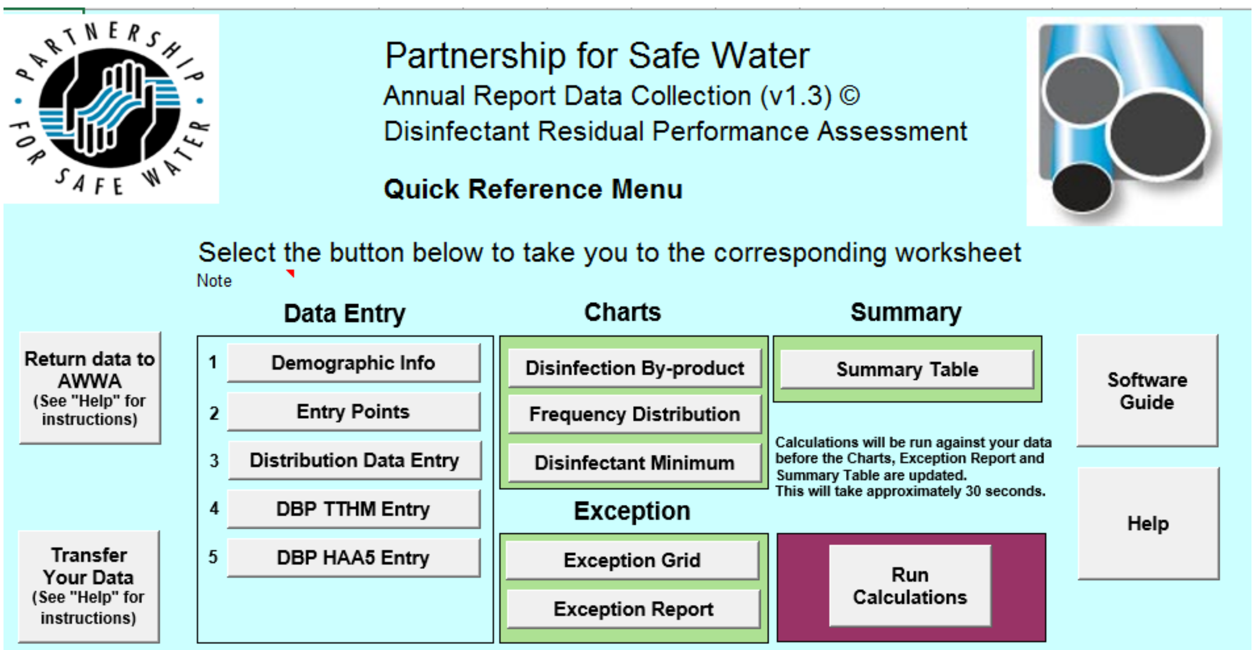
6. Additional Changes to the Proposed Revisions are Needed to Move the Nation Forward in Successfully Reducing Exposure to Lead Through Drinking Water.

b. EPA needs to help States with modern data evaluation tools for when a water system needs to re-evaluate corrosion control since the 90th percentile is limited in the useful information it provides (§141.81 Applicability of Corrosion Control Treatment Steps to Small, Medium, and Large Water Systems).

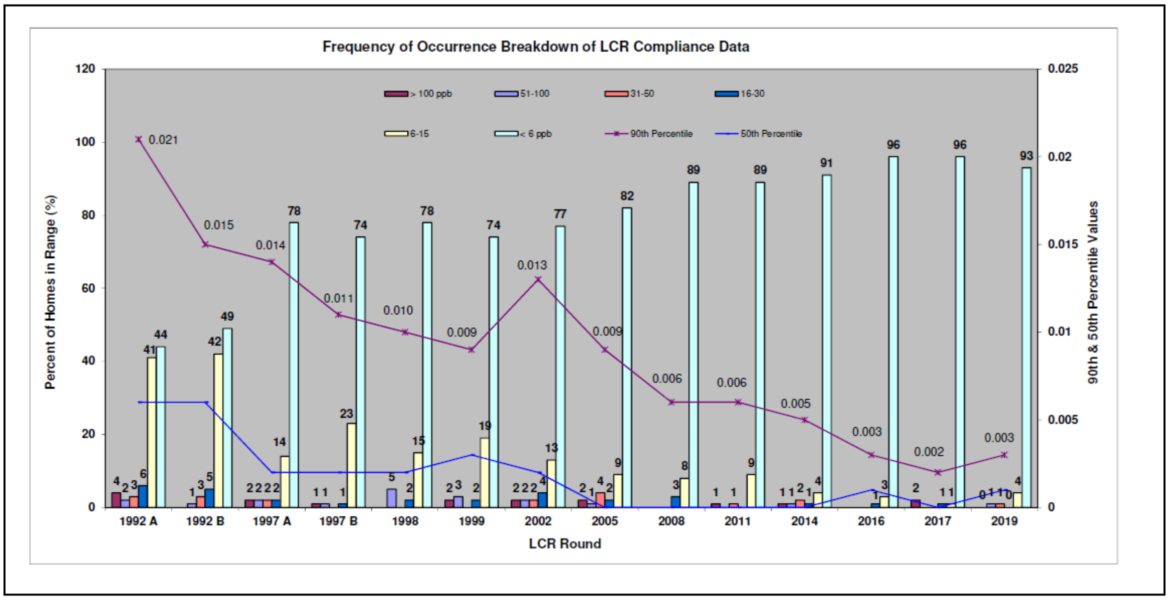
<u>Basis for Recommendations</u>: A successful and well-written rule would encourage and spur on the development of evaluation technologies that are more cost effective and more informative and accurate. The determination of when a water system needs to be re-evaluated for CCT should not only look at the water system's latest 90th percentile, but at the historical trends in the system's data and should conduct a more detailed data analysis. The 90th percentile is limited in the useful information it provides. There are many examples of data analysis and tools in use today to help States evaluate and trend data. The EPA should develop these tools for the LCR and for use during a Sanitary Survey to help States evaluate CCT performance. Historical trends are important to consider, as shown below for Philadelphia's data. For example, the years 1999 and 2002 were unusual years; 1999 was unusual for homes without LSLs and 2002 was unusual for homes with LSLs. Incomplete data analysis could lead to uninformed decisions.



Since States may not have the sanitarians and inspectors with expertise to evaluate WQPs and lead data to determine whether CCT is performing well and whether it should be re-evaluated, the EPA could develop data analysis tools. An example of a data review tool is the Distribution System Optimization Program (DSOP) data collection software which is used for benchmarking and reporting chlorine residual and disinfection by-product data to the Partnership for Safe Water program. The software allows the user to enter raw data from a 12-month reporting period in a specified format. The software then calculates statistics and displays charts to aid in data analysis. Monthly and yearly results of these calculations are shown in the table format. Data for individual parameters are aggregated and can be displayed in chart form for easier review. Exception reports can be generated based on the specified time period. This tool is being successfully used by a variety of water systems today. An example of the main PfSW user interface screen that allows users to enter data, run calculations and review charts, identify exceptions, and provide a summary table is shown below.



EPA defined the Action Level as “the concentration of lead or copper in water… which determines, in some cases, the treatment, lead service line replacement, and tap sampling requirements that a water system is required to complete.” We agree that keeping the AL at 15 ppb is appropriate. However, EPA needs to provide more robust ways for data trending and analysis than the 90^{th} percentile statistic, which is very limited. See Bradley and Horscroft (2018) and Burlingame and Sandvig (2004) for examples. See chart below as an example of trending lead data.



In the Report of the Lead and Copper Rule Working Group to the National Drinking Water Advisory Council (USEPA 2015), the following was addressed about how EPA should develop data analysis for CCT water quality data:

> P 31 ….that a more rigorous data review process such as control charting and similar process control techniques be used to take advantage of the collected data to improve the consistency of operation, encourage fine-tuning of processes, reduce variability of water quality within the distribution system and detect and manage excursions.

EPA's proposed language uses terms "optimal" and "optimized" throughout the document, sometimes interchangeably. In the rule's language "optimal" appears to mainly refer to initial/existing implementation of CCT treatment and "optimized" or "re-optimized" is used to refer to CCT processes that had to be re-evaluated or amended after re-evaluation. "Optimal" has the definition: best, ideal. The terms "optimal" and "optimized" sometimes appear together in the same sentence and this is extremely confusing. See page 61747 and § 141.81(b) where the terms "optimized corrosion control" and "optimal corrosion control" are used. Since "optimal" CCT will have a potential to be re-optimized, the term is not ideal to describe a current state of CCT treatment. It is suggested that the word "optimal" not be used in the rule language, since corrosion control efforts may need to be amended at some later date. If the intent is to differentiate between initial and re-evaluated/re-optimized, it is suggested that these different types of efforts be designated as such: initial CCT or existing CCT, and re-optimized CCT. The term “initial CCT” is already used in some parts of the proposed rule, especially in the cost estimates section.

APPENDIX 6.c

6. Additional Changes to the Proposed Revisions are Needed to Move the Nation Forward in Successfully Reducing Exposure to Lead Through Drinking Water.

c. The find-and-fix approach is mis-applied and should be represented as "follow-up sampling" not directly linked to CCT monitoring but rather used for helping customers reduce exposure to lead. The most important activity is to identify the lead-bearing materials in homes (solder, brass, lead pipe) followed with education about options for reducing lead exposure (§141.82 Description of Corrosion Control Treatment Requirements).

Basis for Recommendations: The term "find-and-fix" was appropriately applied under the Revised Total Coliform Rule where it pertains to samples taken that represent the drinking water in the public distribution system. Thus, the samples would indicate when a water utility should find a cause for total coliform positive samples and fix it. This is appropriate because the samples represent water distribution system issues under the control of a water utility. However, the find-and-fix approach would be different under the Lead and Copper Rule, where samples often represent issues within the plumbing systems of buildings under private ownership.

In addition, where lead levels are low and CCT is in place, the chances of returning to the same home to detect a repeat elevated lead result in such a way as to identify a cause is unlikely. Thus, there will likely be no "find" and, in addition, nothing the utility can "fix". However, the utility could recommend possible solutions that would come from a home plumbing survey (Does the home have an LSL? Does the home have leaded solder? Does the home have older faucets that have leaded brass?) rather than from another sample of the water.

On page 2-14 in 2.2.7.1, *Input from PWSs*, the EPA incorrectly characterizes information provided by the Philadelphia Water Department: "PWD conducts find-and-fix steps when LCR compliance sampling yields high lead results." First, as stated above, PWD explained to the EPA that the likelihood of confirming lead >15 ppb through follow-up sampling is low, and that often the solution seems to be something the customer must fix. In addition, in Philadelphia's case, elevated lead has not yet been associated with water quality parameters being outside limits in localized areas of the distribution system. The likelihood of taking a follow-up sample to a lead result that was greater than 15 ppb and finding a second elevated lead result is low, at least in Philadelphia's experience. Even if elevated lead is confirmed, a good portion of the time it is associated with home plumbing and not the service line.

The NDWAC WG (US EPA 2015) recognized that lead sample results can be highly variable because of the different forms of lead and sources of lead. Soluble lead, largely controlled by CCT, is fairly predictable. Colloidal and particulate lead can be very transient. For this reason, single sample results should not be driving action except perhaps to take another sample.

In the Report of the Lead and Copper Rule Working Group to the National Drinking Water Advisory Council (USEPA 2015), the following was addressed about chasing highest lead levels:

> P 29 Lead also occurs in different forms in plumbing systems, from soluble to insoluble and particulate in nature. Sources of lead vary from the very common leaded solder and brass fixtures/valves, to LSLs, and to less common lead-lined iron pipe. CCT is more effective in reducing exposure to soluble lead than it is for particulate lead, although CCT that contributes to the formation of certain scales may also provide benefits in reducing exposure to particulates. Thus, while very important, CCT is not the only lead control mechanism that a PWS must have in place. In other words, CCT should not be relied upon by itself to control lead in water. Rather, it should be one of a tool box of other required mechanisms depending on a PWS's particular conditions and lead sources (e.g., LSLs, leaded solder, leaded brass, etc.)….
>
> P 32 All data provided to customers would need to include appropriate information about the variability of lead levels, that a single sample does not represent all water quality, and that levels at a particular tap at a particular time might be higher or lower.

Triantafyllidou, S., Parks, J. and Edwards, M. (2007) commented on how particulate lead in drinking water is "variable and sporadic." This could require different sampling methods. But, they stated, "in most instances where particulate lead occurrence in drinking water is not an issue, typical procedures are adequate." In disturbed systems, such as Flint, high lead levels were found to be extremely variable (Masten et al, 2019).

How often do initial high lead results repeat themselves in order to identify sources of lead? Philadelphia has sampled 426 unique homes during the LCR rounds of sampling, starting in 1997 following achievement of CCT. Of these homes, 218 were sampled in more than 1 round in which, on average, these locations participated in 3-4 rounds of sampling out of 11 opportunities through 2017. These are homes with LSLs and/or lead solder. Out of these homes, 40 had at least one elevated lead (>15 ppb) result but only

6 had elevated lead results more than once, suggesting that elevated lead can be very transient in its occurrence irrespective of its source.

During 2014 and subsequent years through 2018, 279 samples have been collected outside the LCR requirements, at the request of customers, in which only 6 homes had elevated lead. Three homes allowed follow-up profile sampling but none of them repeated the occurrence of an elevated lead result. During 2019, 391 requests were answered. Only 84 of these requests represented homes with LSLs. Only 7 of the 391 homes had a first-draw lead result at or above the Action Level, with only 3 homes having LSLs. None of the homes repeated an elevated lead result during follow-up sampling.

A 1994 study of 1-liter, first-draw samples from 2 homes that were used for LCR monitoring found lead results below 10 ppb on all but 1 sample each out of 20 samples collected on consecutive days.

Another study, in 2002 after CCT was in place, found only 4 out of 23 homes that had at least one lead value. Only one home had repeated levels of elevated lead. Two of the homes had elevated lead in one sample out of the ten collected. Another home had two elevated lead results out of eight samples collected.

Starting in 2014, in response to Lead and Copper Rule samples that were above the action level for lead, PWD conducted profile sampling at the customers' homes when allowed. In 2014, there were 7 homes with elevated lead results with only 2 of the homes having a lead service line (LSL). The other 5 homes had copper service lines at the meter. PWD performed profile sampling at all 7 homes and repeated an elevated lead result at only 2 homes. Both the homes had copper service lines and the high results occurred in the first liter of the profile samples.

In 2016, 2 homes had LCR samples with elevated lead and only 1 home had an LSL. The second home was thought to have an LSL until a follow-up investigation found a copper service line at the meter. Profile samples were collected at both homes and elevated lead did not re-occur. A definitive source of lead was not able to be identified.

In 2017, 3 homes had LCR samples with elevated lead and all 3 homes had an LSL. PWD profile sampled 2 of the homes and elevated lead did not re-occur. A definitive source was not able to be identified.

The EPA states "Water systems should anticipate the requirement that customers must be notified within 24-hours of results for many of the "find-and-fix" follow-up samples" (p 61708). This is not a true statement. We often cannot confirm an elevated lead sample with a follow-up sample. The EPA needs to re-assess its background assumptions.

Alternative Find-and-Fix Approach

When a sample is above the LCR AL then the following is suggested as an alternative approach:

1. Schedule a follow-up sample and provide the customer with lead risk reduction information when they are notified of the elevated lead result, if the customer is willing to participate.
2. Provide the customer with initial remediation steps to take before the follow-up sampling: such as cleaning of aerators and flushing of plumbing.
3. Profile the home's plumbing materials to identify sources of lead and inform the customer of lead sources.
4. Do follow-up sampling to collect the first liter, the 4, 5 or 6th liter, and final flushed sample as appropriate if the home has an LSL. On the final flush, conduct a WQP sample.
5. If the customer refuses to allow follow-up samples, then document that and stop any follow-up activity. Another home, even next door, would be a separate case and unrelated without significant study.
6. Report to the State at end of monitoring period.
7. Compile all such results since the last Sanitary Survey and include with the CCT evaluation.
8. If a section of the distribution appears to be missed during WQP monitoring, then the State can require relocation of a WQP site to represent this section.

The above minimizes redundant work and review by States, and focuses their resources where needed most.

Note that a PWS that is above the AL is already evaluating its CCT, and thus a Find-and-Fix approach would be redundant and a diversion of resources. New data that come in concerning lead samples >15 and follow-up sampling with WQPs would simply feed into any ongoing assessment. Evaluation of one sample at a time would be non-productive for evaluating CCT. Rather, a compilation of reported sites that come in above the AL should be reviewed during the Sanitary Survey.

Therefore, PWD recommends that the "find-and-fix" wording would be better represented as "follow-up sampling."

In addition, the NDWAC (USEPA 2015, p3 of cover letter) recommended: *Closing the science gaps and providing guidance in sampling methodologies and techniques to ensure the samples provide the desired information.* EPA should provide guidance on different sampling methods based on whether the home has an LSL, leaded solder, a galvanized line, and/or leaded brass.

In Philadelphia's experience, the most important activity is to identify potential lead-bearing materials (solder, brass, lead pipe). This can be followed with education and options for reducing lead exposure: replace the LSL, replace old faucets and valves which often need replacement anyway, and always flush or rinse the plumbing prior to using water for drinking. A water system will NOT make changes or corrections within home plumbing (changing valves, redoing soldered plumbing joints, changing faucets) if these are the most logical sources for elevated lead samples.

APPENDIX 6.d

6. Additional Changes to the Proposed Revisions are Needed to Move the Nation Forward in Successfully Reducing Exposure to Lead Through Drinking Water.

> d. It would be counter-productive for a water system to add new water quality parameter sampling locations to its corrosion control monitoring program simply based on a home having an elevated lead result. It is better to have a planned monitoring program in place that can be adjusted over time as new information is obtained (§141.82 Description of Corrosion Control Treatment Requirements; §141.87 Monitoring Requirements for Water Quality Parameters).

Basis for Recommendation: EPA states that a PWS must add the new sampling sites used in Find-and-Fix for WQPs to the ongoing WQP monitoring program (it does not say that this is done only when the WQP falls outside of limits). As a result, a PWS will be adding more WQP monitoring sites year after year after year. The EPA was encouraged by the NDWAC WG (US EPA 2015) to enhance WQP monitoring: to increase the frequency of sampling and to make sure the distribution system is well covered in a *routine* monitoring program. Such a planned monitoring approach is more easily managed by systems than a reactionary approach to elevated lead samples. It would be counter-productive for a PWS to add new WQP sampling locations to its monitoring program for CCT simply based on a home having an elevated lead result. It is better to have a planned monitoring program in place that can be adjusted over time as new information is obtained and reviewed during the Sanitary Survey.

APPENDIX 6.e

6. Additional Changes to the Proposed Revisions are Needed to Move the Nation Forward in Successfully Reducing Exposure to Lead Through Drinking Water.

> e. EPA does not provide incentives for water systems that voluntarily replace lead service lines, maintain low lead levels, and operate effective corrosion control treatment. Instead, the proposed rule introduces many elements that will compete for funding and resources (§141.84 Lead Service Line Inventory and Replacement Requirements).

Basis for Recommendations: The proposed revised rule does not address an exit ramp for water systems that achieve the removal of known LSLs or get to a high percentage of LSLs removed. The rule does not provide an incentive for water systems that stay well below the AL. One incentive would be for the requirement for sampling of Tier 1 LSL homes, to reduce to 50% then 25% of the required number (with the remainder of homes made up using other Tiers) as a water system reduces its inventory of LSLs to 50% and then 25% of its initial inventory count.

Water systems have been moving toward proactive replacement of LSLs since the NDWAC recommendations came out. LSLs are considered the focus of the revised LCR and are the greatest mass of lead left in customer plumbing systems. NDWAC placed a great deal of focus on replacing LSLs as the priority direction for getting the lead out of drinking water. AWWA has agreed and promoted this proactive movement among water systems. However, competing requirements in the proposed revisions to the LCR could offset that movement. Water systems have limited resources. Many are coping with an aging infrastructure. Heavy demands for CCT re-evaluation and school/child care lead programs, for example, would compete with a water system's voluntary, proactive programs. The EPA has not provided incentives in this proposed revision. Instead, there are disincentives to being proactive. In USEPA's economic analysis (USEPA 2019), on page 3-1, the following statement is made about the revisions: "….designed to identify and reduce lead exposure at systems with elevated lead concentrations in their drinking water without unduly burdening systems that effectively control lead."

In the Report of the Lead and Copper Rule Working Group to the National Drinking Water Advisory Council (USEPA 2015), the following was addressed about how the rule should incentivize proactive LSLR:

> P 7 Proactive action is needed to remove the sources of lead, with appropriate incentives both for PWSs and their customers needed to encourage such action.

> P 14 Creating incentives for understanding where LSLs and PLSLs exist, while making action on full replacement, rather than on investigation of the location of LSLs and PLSLs the priority;
>
> P 14 Requirements that provide strong encouragement for full LSL replacements….

Between August 2016 and October 2019, approximately 3 years, Philadelphia has voluntarily assisted in customer replacement of 1,237 LSLs. That is about 412 replacements per year. That gives Philadelphia an annual rate of replacement estimated at about 2.2%. This replacement rate is voluntary; not a requirement of the Lead & Copper Rule. EPA should provide incentives to voluntarily remove LSLs, as PWD is doing, while complying with the rule.

APPENDIX 6.f

6. Additional Changes to the Proposed Revisions are Needed to Move the Nation Forward in Successfully Reducing Exposure to Lead Through Drinking Water.

f. EPA's interest in prioritizing lead service line replacement would conflict with infrastructure priorities that prioritize based on avoiding a loss in water service (§141.84 Lead Service Line Inventory and Replacement Requirements).

Basis for Recommendation: In § 141.84(b) and on pp 61688 and 61696-98, a PWS with "known or possible LSLs" must develop an LSLR plan within 3 years after publication of the revised rule. On p 61735, EPA requests comment on how water systems can prioritize which LSLs should get replaced first, such as those with highest lead level or those involving the most susceptible populations. Should a prioritization method be in the LSLR Plan?

Water utilities have varying factors to account for when developing a LSLR plan. For example, if that plan greatly relies on water main replacement to identify and remove lead service lines, the priorities must be based on water main replacement criteria where the risk of losing water service is a priority. Such criteria as water main leak and break occurrences, age of water main, size of water main, etc. must be prioritized over other issues that might be used for prioritizing a LSLR plan.

In addition, "unknowns" should not be included in the determination of the replacement rate. The number of "unknowns" can be ten times or more the number of LSLs in a water system, which could make even a 3 percent replacement rate unachievable.

APPENDIX 6.g

6. Additional Changes to the Proposed Revisions are Needed to Move the Nation Forward in Successfully Reducing Exposure to Lead Through Drinking Water.

g. Taking one sample 3-6 months after a service line is disturbed contradicts public health common sense, especially considering the high degree of variability of elevated lead results. Such a measure should be based on the risk reduction strategy that a water system chooses to employ (§141.84 Lead Service Line Inventory and Replacement Requirements).

Basis for Recommendations: In § 141.84 and § 141.85, prior to a planned replacement of an LSL, a water system must notify the owner of the home as well as any residents who are not owners, at least 45 days in advance, and explain what will be done and why, and how the owner can participate, that lead levels could increase, the health effects of lead, actions to take to minimize lead exposure, how to flush. Then take a follow-up sample between 3-6 months after the water is restored and construction is done. The same must be done when a partial LSL is created (§ 141.84(d)).

One sample is misleading if the lead is particulate lead, which is what the issue would be following replacement of an LSL. Particulate lead is highly variable. Batterman et al (2019) found that water main replacement caused spikes in lead only about 7% of the time. Masten et al (2019) found high lead results to be extremely variable for Flint's data. Data from PWD (provided earlier in this document) show that elevated lead results are very transient. The sample could be a false negative (thus, misguiding consumers that the water is now free of lead) or a misleading positive (over-alerting consumers on the risk of lead exposure). The taking of a sample should be up to the water system and how it decides to communicate and manage risks with its customers based on the risk management tools it uses and the stability of the system due to CCT and water quality.

Philadelphia has been using non-leaded connectors when partial LSLs are created. These connectors contain non-metallic materials that separate dissimilar metals, thus preventing galvanic corrosion which is considered a significant cause of elevated lead following the creation of partial LSLs. This practice reduces lead along with education on flushing and cleaning aerators or screens.

The EPA oversimplifies risk management options and strategies that are currently available for PWSs to use to minimize exposure to elevated levels of lead in drinking water.

APPENDIX 6.h

6. Additional Changes to the Proposed Revisions are Needed to Move the Nation Forward in Successfully Reducing Exposure to Lead Through Drinking Water.

h. EPA's requirement for immediate 24-hour notification is not justifiable considering the length of time that has already passed since sample collection, the need to gather additional information to help customers understand next steps, and the variability of elevated lead results (§141.85 Public Education and Supplemental Monitoring Requirements).

Basis for Recommendations: When an elevated lead result occurs, with adequate time, a PWS can gather ancillary information that it might have in its records about the property, earlier test results, surrounding asset information, other results in the vicinity, water main age, any planned main replacements in the near future, etc. A quick 24-hours does not allow a water system to provide the customer with as much information as possible at the time of the notification. If the sample was part of a Find-and-Fix investigation or follow-up to previous lead results, then the most important information is that which helps the customer understand what remediation options exist (such as identify whether the home has leaded solder, an old faucet, a brass valve, an LSL).

A more productive notification procedure might be:

1. When the water system samples a home that has sources of lead (solder, faucets, service line), then the water system should leave information about lead risk reduction measures.
2. The laboratory should notify the water system, or the State in the system's absence, of an elevated result (above 15 ppb) within 2 business days.
3. The water system should then contact the customer within 5 business days of the result (and provide information in writing within 30 business days) along with information about additional sampling or risk reduction measures the customer can take, if known. All results should get sent by letter by the water systems to the customer within 30 business days of receiving any laboratory result, whether above 15 ppb or not.
4. The information that is documented for the State regarding an elevated lead result would be: sample date, time, location, elevated result; laboratory report form to the water system/State; water system letter to the customer and log of when customer was first notified; results of any follow-up testing or surveys; and any other letters provided to the customer about the elevated sample. All of this together can be audited by the State during the Sanitary Survey.
5. The information that is documented for the State for lead results at or below 15 ppb would be: sample date, time, location, result; and water system letter to the

customer. All of this together can be audited by the State during the Sanitary Survey.

The notification clock should be based on a work-day clock (not include weekends, for example) as contacting the State after-hours can be difficult and unnecessary in comparison to other reasons for immediate, emergency contact. Note the timeline of the whole situation: the sample had 14 days to get to the laboratory when it had to be acidified for analysis; the laboratory could take 1-2 months to analyze the sample, check quality controls, and report the data. If an elevated result is found, the water system should offer to return and take additional samples. Lead results can be very transient and, thus, the best course of action is to take a follow-up sample and try to identify a possible source(s) for remediation in order to provide good information to each customer.

APPENDIX 6.i

6. Additional Changes to the Proposed Revisions are Needed to Move the Nation Forward in Successfully Reducing Exposure to Lead Through Drinking Water.

i. Health agencies are best suited to manage communications to health care providers (§141.85 Public Education and Supplemental Monitoring Requirements).

Basis for Recommendations: The local or State public health agency maintains lists of health care providers, and provides regular communications on public health matters, and thus is seen as the authority. Questions regarding public health risks are best answered by a public health agency. Concerns about health risks from lead, in general, and elevated BLLs would be addressed by them. The EPA should reinforce the public health agencies as the main contact on public health and on communications with health care providers rather than replace this relationship with a water system who has no relationship with the health care providers. However, the PWS would still provide an annual Consumer Confidence Report to all water service customers, which would include the health care providers in the communities that they serve.

APPENDIX 6.j

6. Additional Changes to the Proposed Revisions are Needed to Move the Nation Forward in Successfully Reducing Exposure to Lead Through Drinking Water.

> j. EPA should not neglect homes with other sources of lead than lead service lines, as they provide valuable information for consumers and for corrosion control treatment. The EPA should withdraw the requirement that data that are allowed to be grandfathered must have followed specific sampling protocols. There is no scientific confirmation that these sampling protocols will influence a water system's 90th percentile for lead and copper (§141.86 Monitoring Requirements for Lead and Copper in Tap Water).

Basis for Recommendations: The EPA should withdraw the requirement that data that are allowed to be grandfathered must have followed specific sampling protocols. There is no scientific confirmation that certain sampling protocols will influence a water system's 90th percentiles for lead and copper. On p 61705, we find the following statement: "The EPA is aware that some water systems provided sampling procedures to residents that included recommendations that may inadvertently reduce the lead levels detected, including a recommendation to run water from the tap, called flushing…." The significance of these sampling protocols is over-stated and the statement has not been validated.

The use of a wide-mouth sample bottle makes sense and allows customers to open the faucet as much as they deem necessary to fill the bottle without letting it overflow and dilute down the first-draw sample. Rather than try and instruct customers to fill the sample bottle at a specified flow rate, it is easier to provide a bottle that will allow them to fill it as quickly as possible, but this will, no doubt, vary from customer to customer.

The faucet aerator must not be removed (this will be "prohibited") nor the faucet cleaned prior to sampling, or if initiated by sampling according to the EPA's protocols. This is quite unnecessary in a regulation for two reasons: (a) most modern faucets do not facilitate easy cleaning and removal of screens or aerators and (b) there is no scientific data to show that it makes a difference. Triantafyllidou, S., Parks, J. and Edwards, M. (2007) commented that a high flow rate, such as when preparing food, tended to abrade (rub and wear down the surface of) lead particulates trapped on the faucet aerator screen which in turn would, presumably, introduce higher levels of lead into the water. However, their article was about the testing of samples containing particulate lead in order to obtain more complete analysis of particulates, which means that when the particulates entered the sample bottle, they got the higher lead results. PWD did a small study and found that levels were potentially lower, not higher, by keeping the aerator on. This information was shared with the EPA in a letter dated March 3, 2016. Nonetheless, PWD has no problem with this requirement to keep the aerator on as long as the EPA does not overstate that this practice is based on actual evidence that higher lead results will be obtained.

The proposed requirements would also “prohibit” pre-stagnation flushing prior to sample collection. P 61705 explains that “pre-stagnation flushing” is when “the water from the tap is run until water from the LSL is flushed out…” although this explanation is muddied at other places in the proposed revisions. The EPA prohibits this because “Flushing, or running taps, has long been understood to decrease water lead levels overall, and thus has been a recommendation by Federal, State and local authorities as a way to reduce lead exposure prior to water use….” The EPA recommends that consumers flush taps regularly and clean aerators but *not* in connection with tap sampling.

Note that the word “flush” can mean different things to different people. A “flush” could be used to remove particulates from the plumbing. Running a single kitchen faucet for a few minutes prior to the start of the stagnation time may not be enough to flush out the plumbing depending on the mobility of particulates in the system. Such flushing may or may not influence lead particulates, even move them closer to the faucet and make them more likely to affect the sample. The use of the word “flush” could also mean to displace water. For example, a PWS might want to advise customers who have lead service lines to flush their water for several minutes before drinking it to avoid the water that has been sitting stagnant and in contact with the lead pipe. That “flush” would only apply to the immediate use of the water and not to its use 6 or more hours later.

Consider an example of water usage that might occur prior to the start of the stagnation time. Imagine you come home from work and use the toilet, which flushes about 2.6 gallons of water; this could flush the plumbing all the way to the main. Then you wash your hands (about 0.75 gallons) and take a shower (about 12 gallons) which flushes the plumbing another 6 times. Then you go to the kitchen to cook dinner, perhaps using about 1 gallon of water for cooking and cleaning. After dinner, you put on the dishwasher, using about 6 gallons which flushes the plumbing 3 times. Then you brush your teeth and wash your face (about 1.5 gallons) and use the toilet (about 2.6 gallons), thereby flushing the plumbing another two times. If just prior to starting the stagnation time you ran the cold water for another 1-2 minutes (about 2.5 gallons), you would flush the plumbing 1 more time after flushing it 12 times already. It’s hard to imagine that running the water from the kitchen faucet again, prior to initiation of the stagnation time, would make a difference in the sampling results for most plumbing systems in occupied residences, at least in a city such as Philadelphia.

Note that the EPA states that the intent of sampling is to sample the cold-water plumbing (p 287). Sample collectors or customers must run cold water prior to letting the tap begin its stagnation period to make sure that cold water was the last water run through, and left standing within, the faucet, as PWD explained in its letter to the EPA in 2016. Hot water left overnight in faucets can increase lead levels and not represent the cold-water system. In one study, a homeowner was asked to let hot water sit overnight in the fixture; then in the morning, take a first draw using cold water. Some small volume of hot water that was sitting in the fixture came out first. Faucets can hold about 50-100 mL of water. The background level of lead in the flushed cold water was 6 ppb. The hot water that had been sitting in the faucet overnight increased in lead to an average of 365 ppb which then increased the first draw, cold-water liter sample from 6 ppb to an average of 60 ppb. This study was conducted back in 2001 when the lead-free standard for brass was not what we have today. Faucet manufacturers were aware of this and some provided consumer information such as: "Faucets made of leaded brass alloys contribute small amounts of lead to water that is allowed to stand in contact with the brass. The amount of lead contributed by any faucet is highest when the faucet is new. Always run the water for a few seconds prior to use for drinking or cooking. Use only cold water for drinking or cooking."

In a recent study, using a kitchen faucet that meets the latest lead-free standard, and with an aerator that could not be cleaned or removed, hot water left standing in the faucet for 5-7 hours produced two water samples with a lead level of 2 ppb. The cold water had <1 ppb of lead. However, many homes still have older faucets. In three homes with lead service lines that produced, each, 6 samples of first-draw cold water with lead <1 ppb, lead was found at 1-2 ppb in the hot water in 3 of 6 samples.

With instructions to customers that are easy to follow in a consistent manner, it is important to make sure that cold water was the last water that was run through the faucet prior to the start of the stagnation time. For LCR compliance sampling, the PWS needs to make sure that cold water will come out of the faucet by displacing any hot water prior to the start of the stagnation period and by making sure that the cold-water lever is in the right position to provide cold water when the first-draw sample is taken.

The EPA and State both approved Philadelphia's 2016 instructions as meeting the requirements of the new EPA sampling requirements. PWD used this language, which was approved by EPA Region 3 and the Pennsylvania Department of Environmental Protection for a 2016 special sampling program: "Make sure that COLD WATER was the LAST WATER used at this faucet BEFORE you begin the 6-hour stagnation period or the 6-hour No Water Use period." This wording was used during the 2016, 2017, and 2019 LCR compliance monitoring programs.

PART 3 OF 3
Call for sample pick-up:

CHECK

1. 

Place the sample bottle and the completed Chain-of-Custody Form in the sample box. ☐

2. 

Before you call or text for pick-up, make sure you can tell us: ☐

- **Loc ID number** (located on the label on the sample box)
- **Your name**
- **Your address**
- **A contact number** where we can reach you.

3. 

For pick up: ☐
Call or text 267.207.4194.

In your message, let us know the information listed above, and where you left the sample.

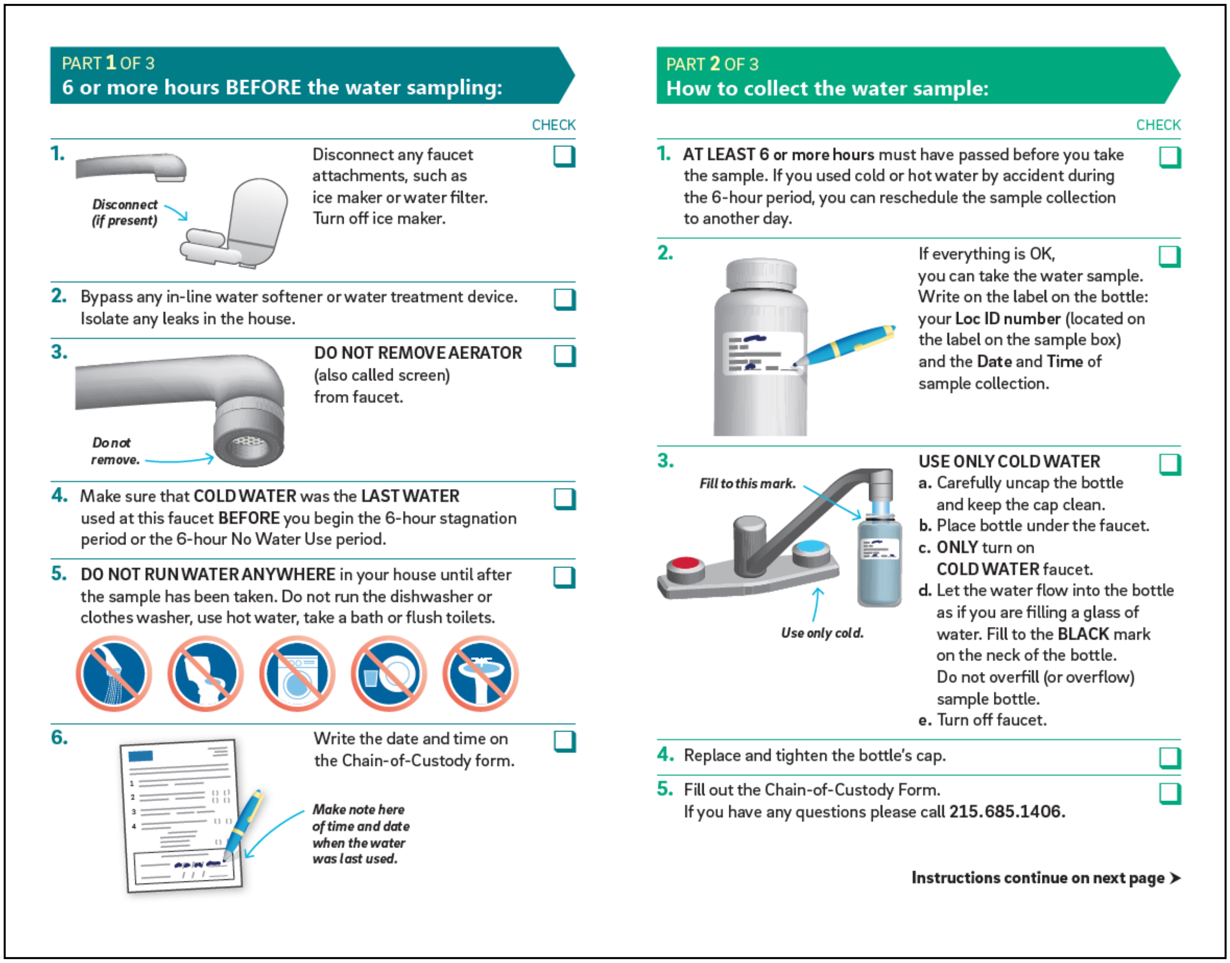
We will pick up the sample from your front door on the day of your call or the following business day. If you call on a weekend, we'll pick the sample on Monday.

Questions?
Call PWD's Bureau of Laboratory Services at **215.685.1406**.

Lead and Copper Water Sampling Instructions

Last Reviewed: March 2019

PHILADELPHIA WATER DEPARTMENT



PART 1 OF 3
6 or more hours BEFORE the water sampling:

CHECK

1. Disconnect any faucet attachments, such as ice maker or water filter. Turn off ice maker. ☐
   Disconnect (if present)

2. Bypass any in-line water softener or water treatment device. Isolate any leaks in the house. ☐

3. **DO NOT REMOVE AERATOR** (also called screen) from faucet. ☐
   Do not remove.

4. Make sure that **COLD WATER** was the **LAST WATER** used at this faucet **BEFORE** you begin the 6-hour stagnation period or the 6-hour No Water Use period. ☐

5. **DO NOT RUN WATER ANYWHERE** in your house until after the sample has been taken. Do not run the dishwasher or clothes washer, use hot water, take a bath or flush toilets. ☐

6. Write the date and time on the Chain-of-Custody form. ☐
   Make note here of time and date when the water was last used.

PART 2 OF 3
How to collect the water sample:

CHECK

1. **AT LEAST 6 or more hours** must have passed before you take the sample. If you used cold or hot water by accident during the 6-hour period, you can reschedule the sample collection to another day. ☐

2. If everything is OK, you can take the water sample. Write on the label on the bottle: your **Loc ID number** (located on the label on the sample box) and the **Date** and **Time** of sample collection. ☐

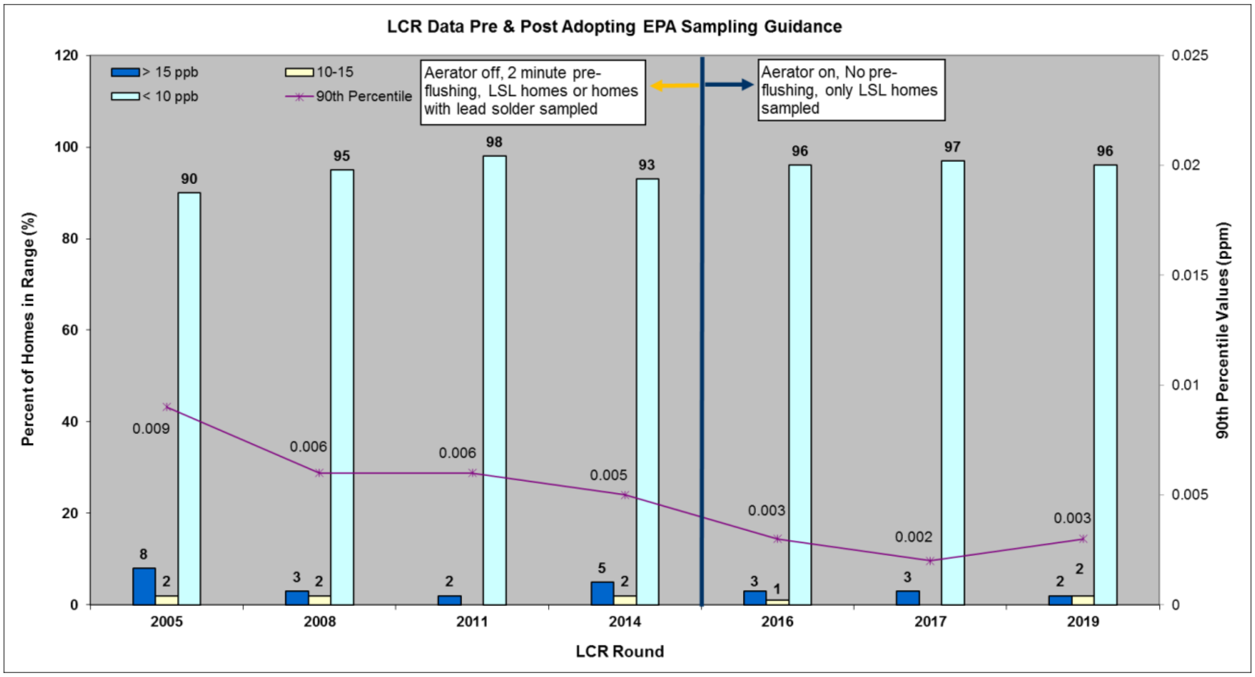
3. **USE ONLY COLD WATER** ☐
   a. Carefully uncap the bottle and keep the cap clean.
   b. Place bottle under the faucet.
   c. **ONLY** turn on **COLD WATER** faucet.
   d. Let the water flow into the bottle as if you are filling a glass of water. Fill to the **BLACK** mark on the neck of the bottle. Do not overfill (or overflow) sample bottle.
   e. Turn off faucet.
   Fill to this mark.
   Use only cold.

4. Replace and tighten the bottle's cap. ☐

5. Fill out the Chain-of-Custody Form. If you have any questions please call **215.685.1406**. ☐

Instructions continue on next page ➤

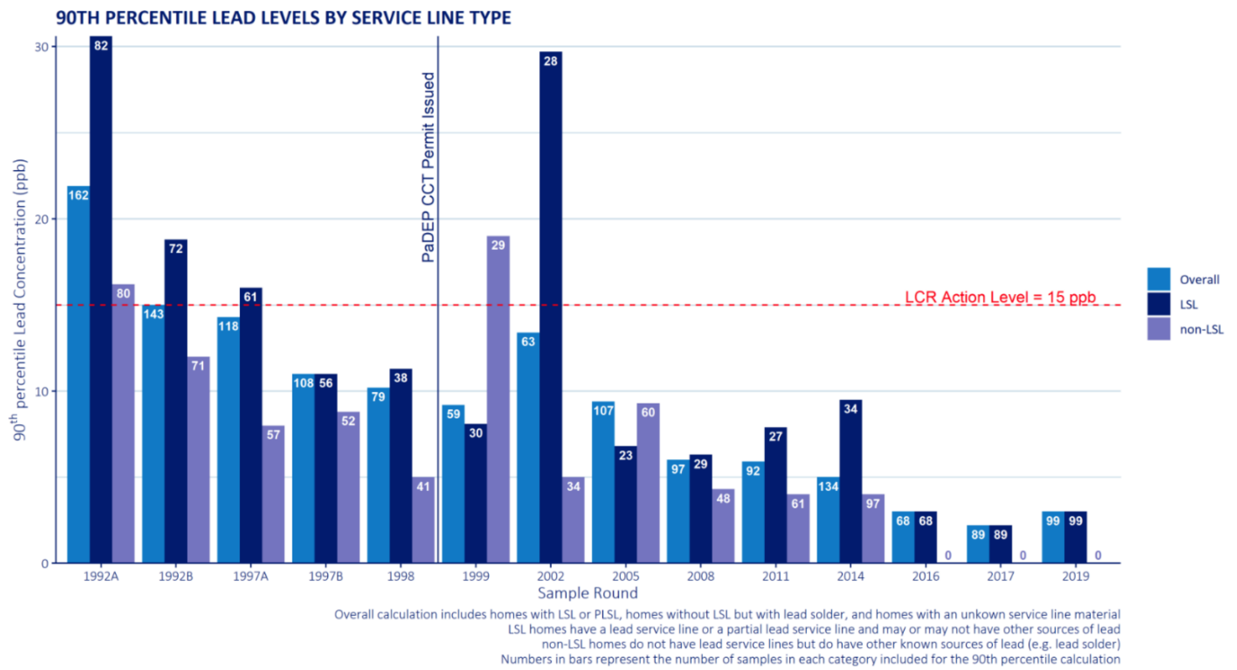
The graph below shows that, after making these protocol changes in PWD's instructions to customers, including sampling only at homes with LSLs, PWD obtained its lowest 90th percentile lead results. Lead levels did not increase, they decreased.



Breakdown of Homes Sampled During LCR 1992 - 2019

LCR Round	1992 A	1992 B	1997 A	1997 B	1998	1999	2002	2005	2008	2011	2014	2016	2017	2019
Total Homes Sampled	162	143	118	108	79	59	63	107	97	92	134	68	89	99
# LSL Homes Sampled	81	71	60	55	37	29	27	20	33	27	34	68	89	99

In addition, by only sampling homes with LSLs, important trends in data will be missed. See Philadelphia's historical data below where homes without LSLs but with other sources of lead contribute significantly to the overall picture of the occurrence of lead in Philadelphia:



EPA states that the purpose of monitoring/sampling is to collect samples "with the highest potential lead concentration." In § 141.86(a)(3) Tier 1 sampling sites are changed to Single Family Residences with LSL (this does not include "unknowns" but does include partials). Tier 3 is changed to homes with copper and with leaded solder. EPA will require sampling only from homes with LSLs and will strongly prevent sampling from homes with leaded solder and leaded brass. On p 61687, "The LCR proposed revisions are expected to improve tap sampling by better targeting higher risk sites for lead contamination, i.e., sites with lead service lines of lead containing plumbing materials."

The occurrence of lead in drinking water is complicated by the fact that lead has various sources: lead pipe, leaded solder, leaded brass, and pipe scale and corrosion products. These sources introduce lead in water in soluble, colloidal, and particulate states. Particulate lead (discrete particles) is usually highly transient whereas colloidal and dissolved lead are more consistent and vary with changes in water quality and physical properties (particularly temperature). Because exposure to any of these forms of lead is important, monitoring strategies need to account for the particular release modes for a given system which can vary based on water quality, corrosion control, age of plumbing, stability of scales, etc.

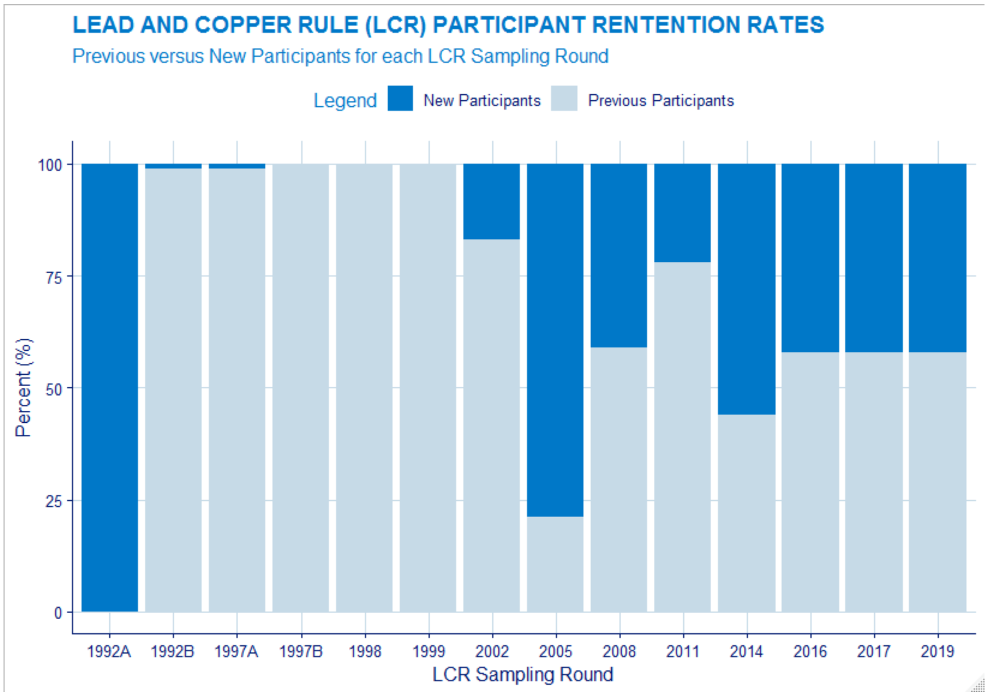
Triantafyllidou, S., Parks, J. and Edwards, M. (2007) describe lead sources as flaking particles from pipe scale, 50:50 lead-tin solder, and red and yellow leaded brass as contributing to particulate lead occurrences even in first-draw samples. Solder particles have been trapped in aerator screens. Solder can potentially contribute significantly to lead exposure. Masten et al (2019) found that for Flint's data, homes with copper service lines showed elevated lead quite significantly, causing the authors to wonder whether Tier 1 homes should be limited to only homes with LSLs.

In Philadelphia, homes with LSLs appear about as likely to produce an elevated lead result as homes without LSLs but with older solder or fixtures or valves. And homes with LSLs with an elevated lead result could just as readily show that the lead came from the plumbing as from the LSL.

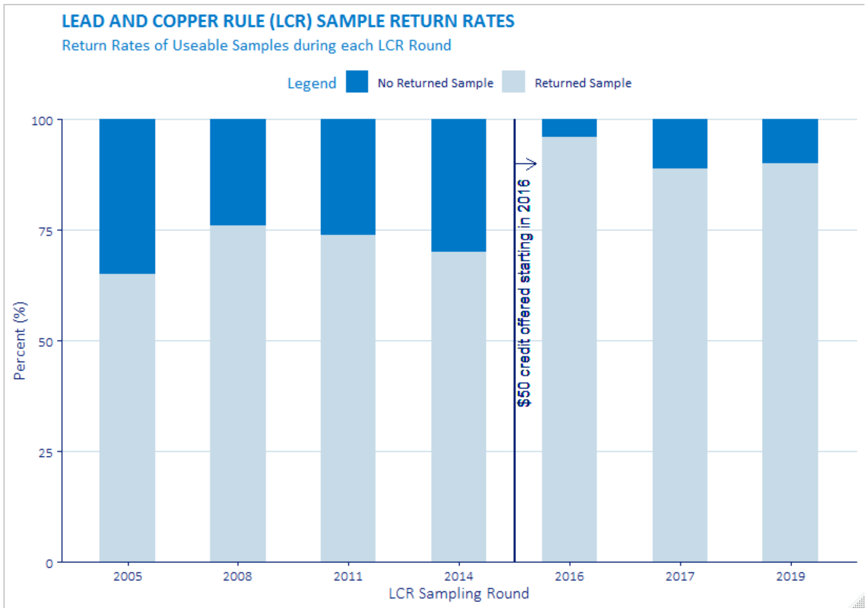
During the 2014 LCR sampling, all Philadelphia customers whose samples were above the action level (AL) for lead were asked to participate in a lead profile sampling study. The purpose of the study was to try to repeat the high result and find the possible source of elevated lead. In total, 7 out of 134 samples were above the AL and 1 sample was at the AL. Only 2 customers had a lead service line (LSL); the others had copper service lines and lead solder. Three locations had elevated results for lead in at least one follow-up sample. The other locations did not produce a repeat elevated lead and, thus, the sources of lead could not be investigated. All three locations had a copper service line and leaded solder. In almost all the profile samplings, zinc was highest in the first sample collected from the faucet, which was expected since many faucets are made with brass which contains zinc. Thus, non-LSL sources of lead are important in Philadelphia's homes, but these are downplayed through the latest changes to sampling requirements, and thus will not provide a complete historical trend for Philadelphia as to how CCT is reducing lead in the drinking water.

While it is likely true that the greatest mass of lead in plumbing from the water main to the endpoint faucet is the lead service line, it is not necessarily true that the highest risk of exposure comes from lead that was in that lead service pipe. There is a lack of studies done on stable systems; much of the studies being referenced address water systems that have had lead management problems.

The EPA also states that PWSs should use the same homes on each monitoring round, "to the extent feasible." On p 61703 the EPA states: "The water system shall identify any site which was not sampled during the previous monitoring periods and include explanations of why sampling sites have changed." Philadelphia has not been able to retain many of the same homes for sampling from round to round (see table below) even though it is in our best interest to do so.



Philadelphia began providing a $50 credit to the customer's water bill for successfully providing a sample for LCR compliance monitoring. While this has not helped retain or obtain new participants (see table below), it has helped increase the successful participation rate (the return of an acceptable sample once the sample bottle is dropped off).



Below is a summary of Philadelphia's recruitment efforts and success rates:

In 2011, 474 people, consisting of past participants and new applicants, were contacted directly to participate in the 2011 round of LCR sampling. Only 164 people applied to participate in the sampling program. 116 of the 164 applicants had participated in past years. Our efforts garnered 48 new applicants. Of those 48 new applicants, only 21 ended up collecting a sample.

In 2016 the goal was to recruit at least 50 homes with a lead service line to participate in the sampling round. In July, 136 homes were contacted that participated in an earlier LCR round and were identified as having a lead service line. In addition, 88 new homes were identified as having an LSL from meter maintenance visits. In addition, 39 people requested participation. Out of the 263 people contacted, 97 agreed to participate and 71 were eligible to sample; 25 out of the 97 were ineligible to sample due to finding no LSL or they were not considered a Tier 1 home. In total, 68 out of 71 samples were returned from homes with an LSL with 40 samples from previous participants and 28 from new participants.

In 2017, 152 previous participants with lead service lines were contacted and a bill stuffer was sent out to 500,000 accounts asking customers with lead service lines to contact PWD to participate in the 2017 LCR sampling program. A total of 142 people contacted PWD from the bill stuffers. Out of the 142 people, only 58 returned the requested survey form for participation. Calls were also placed to 99 homes that had previously received a ‘notice of lead’ after a water main relay took place. Only 12 homes applied to participate in the LCR sampling. PWD reached out to Penn Environment/Philly Unleaded to ask for participation from customers with lead service lines; 59 people were contacted, and 10 people returned survey forms for participation. Also, 20 customers who requested a water sample for lead outside of the LCR program were contacted for participation; 13 of those customers were enrolled in the LCR sampling program. Only homes that had an LSL were enrolled in the sampling program. In total 472 people, consisting of past participants and new applicants, were contacted to participate in the 2017 round of LCR sampling. A total of 158 people applied to participate in the sampling program; 58 out of the 158 were ineligible due to replacing their LSL, not having an LSL upon inspection, having a Tier 2 or 3 designation, or not being able to bypass a filtration system or to resolve a plumbing leak. 100 homes received a sample bottle between June and September 2017 and 89 samples were returned by the end of the sampling period.

In 2019, recruitment letters were sent to the addresses of all previous volunteers, including those originally sampled in 1992 at the outset of the program. A bill stuffer was sent out to 500,000 accounts asking customers with lead service

> lines to contact PWD. Also, Utility Emergency Services Fund (UESF) provided additional community outreach. The new applicants and previous volunteers were asked to complete a survey of plumbing components and were contacted to verify survey information and answer questions about the program. Each new applicant and previous participants who reported changes to their plumbing components underwent a plumbing inspection and had their plumbing materials checked. PWD contacted a total of 509 people, consisting of past participants and new applicants, to participate in the 2019 round of LCR sampling. In total, 199 people applied to participate in the sampling program. 71 out of the 199 were ineligible due to replacing their LSL, not having a LSL upon inspection, having a Tier 2 or 3 designation, not being able to bypass a filtration system, having a leak, or declining a home plumbing inspection. In June 2019, 110 homes were sent sampling bottles. Recruitment efforts continued throughout the LCR sampling round from June to September, and 99 final samples were received and reported.

EPA should omit requirements to retain homes in the lead and copper monitoring from round to round. It is in the water system's interest to retain homes as much as possible; however, the reality is that many customers will drop out of the program over time, especially if the sampling becomes more complicated.

APPENDIX 6.k

6. Additional Changes to the Proposed Revisions are Needed to Move the Nation Forward in Successfully Reducing Exposure to Lead Through Drinking Water.

k. Replacement samples should be allowed when customers make errors in sample collection procedures (§141.86 Monitoring Requirements for Lead and Copper in Tap Water).

Basis for Recommendations: In § 141.86(f), the rule retains the following from the existing LCR:

"(1) The State may invalidate a lead or copper sample analysis caused by erroneous results.

(i) The laboratory established that improper sample analysis caused erroneous results.
(ii) The State determines that the sample was taken from a site that did not meet the site selection criteria of this section.
(iii) The sample container was damaged in transit.
(iv) There is substantial reason to believe that the sample was subject to tampering."

Customers should fill out a chain-of-custody form that certifies whether the samples were collected properly: within the stagnation time limit; from the faucet that represents regular use for drinking/cooking; cold water; first draw; aerator on; no pre-flushing to clear out lead from the plumbing; 1 liter. Samples that do not meet the sample acceptance requirements should not be passed on for analyses but rather a replacement sample should be collected. This decision should be up to the PWS or laboratory who receives the samples and reviews the chain-of-custody.

In addition, the ability to not accept special samples, Find-and-Fix samples, and customer requested samples that did not follow the instructions must be allowed by the water system. The EPA's conditions are too restrictive and do not follow the same conditions for other samples collected under the SDWA.

APPENDIX 6.l

6. Additional Changes to the Proposed Revisions are Needed to Move the Nation Forward in Successfully Reducing Exposure to Lead Through Drinking Water.

l. EPA should minimize disincentives in the rule such as those that discourage collecting data for research and quality control. Additional monitoring should be encouraged and allowed, rather than discouraged (§141.87 Monitoring Requirements for Water Quality Parameters).

Basis for Recommendation: The revised rule would apply disincentives against research and quality control monitoring. Additional samples for water quality parameters or even for lead and copper are at times collected to better understand distribution and plumbing systems. However, as written, the revised rule would require that any pH measurement taken on tap water be used in determining compliance with the system's CCT permit and WQP limits. This would be a disincentive to measuring pH on customer complaints and during investigations, and even during routine quality control monitoring in general. In addition, a water system may want to conduct special studies such as when evaluating pipe scale or sections of a distribution system. It is preferable to collect samples in the same way as collected for compliance monitoring so that the results can be compared to the baseline date from compliance monitoring. However, rule requirements can prevent water systems from using the same procedures to avoid complicating the State's compliance database with special studies.

In § 141.86l, the EPA wants all tap samples taken for lead reported to the State even if not used in the compliance calculation: "*Additional monitoring by systems*. The results of any monitoring conducted in addition to the minimum requirements of this section (such as customer-requested sampling) shall be considered by the system and the State in making determinations (i.e., calculating the 90^{th} percentile lead or copper level) under this subpart."

The EPA added that when the AL is exceeded, the water system "must sample the tap water of any customer who requests…" This would be a disincentive, as written in a rule, to advertising free sampling to customers.

Finally, the Find-and-Fix response to lead >15 ppb appears to apply to any sample collected and analyzed for lead. This, too, would be a disincentive for a water system to advertise free water testing or to conduct special studies. The Find-and-Fix response, as currently written, is too onerous for a water system to offer additional, free lead testing and also be required to conduct Find-and-Fix sampling.

A water system should provide to the State a standard monitoring plan for LCR compliance and for CCT WQP monitoring. The determination of compliance should be based on these samples. States can view additional monitoring as “Special Samples.”

APPENDIX 6.m

6. Additional Changes to the Proposed Revisions are Needed to Move the Nation Forward in Successfully Reducing Exposure to Lead Through Drinking Water.

m. A 5th- liter sample procedure should be one of several procedures for investigating the sources of lead in plumbing systems to help customers make better decisions about mitigating lead exposure (§141.86 Monitoring Requirements for Lead and Copper in Tap Water).

Basis for Recommendations: On p 61732, EPA is considering adding a requirement for a 5th liter tap sample to better capture the water in contact with the LSL which would result in more proactive measures:

- Fill a one-gallon container first.
- Then fill a one-liter sample bottle without turning off the tap.
- This would be called the "fifth liter sample".

EPA states that they believe that the first-draw sampling as used is adequate for determining "when optimal corrosion control treatment is being maintained;" however, the EPA is open to comments on alternative sampling techniques and whether a water system should be required to collect samples of water that reflect the water standing in contact with LSLs. The EPA is looking for data to support first-draw sampling or 5th liter sampling as being more representative of worst-case lead from homes with LSLs.

Since copper samples would remain first-draw, then this would require a first-draw as usual and a fifth-liter separately on two different days. Sampling complexity results in (1) sampling data that are less reliable (note that water systems are being required more and more to follow stringent requirements for sample collection and processing, while at the same time the LCR relies on customers who are not guaranteeing that strict procedures are followed) and (2) more complexity will result in water systems finding it even harder to obtain customer participation.

The table below shows total volume of water between the tap and the water main for 79 homes with LSLs that participated in recent rounds under the Lead and Copper Rule for Philadelphia. On average, there are 5 liters of water between the sample tap and meter, with another 5 ½ liters in the service line. However, about half the time a 5th-liter sample would be collected, it would represent either the plumbing system or the water main rather than the service line.

	Volume of Water					
	Tap* to Meter		**Meter to Main**		**Tap* to Main**	
	Liters	**gallons**	**Liters**	**gallons**	**Liters**	**gallons**
Minimum	0.76	0.20	1.17	0.31	3.49	0.92
25th percentile	2.61	0.69	3.10	0.82	6.83	1.80
Average	**5.04**	**1.33**	**5.53**	**1.46**	**10.57**	**2.79**
75th percentile	6.07	1.60	5.64	1.49	11.25	2.97
Maximum	18.72	4.95	40.07	10.59	52.34	13.83

*Tap – measured distance to LCR sample taps (kitchen or bathroom)

Lead samples collected in Chicago found that the 4th and 6th liter samples had the highest lead levels; the first-draw sample was highest in lead 31% of the time (Batterman et al, 2019).

In addition, if the first- and fifth-liter samples are not collected at the same sample time then results should not be compared since lead results can be highly transient on different days.

As a result, the EPA should retain the first-draw sample for compliance purposes while providing a selection of other sampling procedures, including a 5th-liter sample procedure, in guidance so that a water system can help a customer identify the sources of elevated lead in a particular home.

The following technical brief, *Would a Fifth-Liter Sample be Universally Representative of Water in a Lead Service Line?*, was provided by The Environmental Science, Policy and Research Institute on request from the Philadelphia Water Department as an additional evaluation regarding the use of a 5th-liter sample for LCR compliance sampling.

Technical Brief: Would a Fifth-Liter Sample be Universally Representative of Water in a Lead Service Line?

Prepared for: The Philadelphia Water Department Bureau of Laboratory Services

By: Sheldon Masters, Corona Environmental Consulting, LLC

Tim Bartrand, ESPRI (The Environmental Science, Policy and Research Institute)

1/10/20

Executive Summary

In the revised LCCR the EPA "requested data that demonstrate collecting a tap sample liter (i.e., 5th liter) other than a first draw is more representative of water that has been in contact with a lead service line during the six-hour stagnation period".

While improved exposure estimation, identification of at-risk residences, and improved evaluation of corrosion control are shared goals of drinking water providers and regulators, collection and analysis of fifth-liter samples does not appear to be the most direct nor most reliable means to achieving those goals. Analysis of publicly available profile data indicate the following limitations of fifth liter samples as components of a revised LCR:

- The fifth-liter is seldom the highest concentration sample among profile samples (hoping the fifth liter is highest is tantamount to trying to draw to an inside straight) and often can be lower than the first-draw sample.
- The volume of water between lead service lines (LSLs) and downstream faucets differs by service area as well as among residences in a given service area.
- Fifth-liter samples might not identify customers whose greatest exposures are from sources of lead other than LSLs.
- For some systems, water lead level (WLL) variability among fifth-liter samples can be much higher than that of first-draw samples. Higher variability in WLL increases sample size (number

of residences) required to accurately and precisely characterize corrosion control and confounds analysis of data from monitoring rounds.

- Fifth-liter sample collection logistics would add significant additional complexity and effort to utilities and their customers who agree to conduct sampling. The additional complexities relate to (i) developing and following guidance of reliably capturing the fifth liter of water, (ii) recruiting the additional sample sites that would be required for developing a sufficiently precise statistical characterization of WLL (e.g., a fifth-liter 90th percentile estimate) and (iii) additional analysis and interpretation of data. The revised LCR draft provides no indication of how data could or would be analyzed. No matter how the data are analyzed, the assessment and explanation of compliance/noncompliance will be more complex and a greater communication challenge than utilities and regulators currently face.

Other challenges associated with fifth-liter samples within the revised LCR relate to interpretation of data for fifth-liter samples. First, the current first-draw sample action level was set based on feasibility. For some systems, fifth-liter 90th percentiles will be higher than first-draw 90th percentiles, yet there is no proposed basis for an action level for fifth-liter samples. That is, fifth-liter data would be collected but could not be adequately assessed. Second, fifth-liter samples are not as good as first-draw samples for characterizing exposure for systems such as the Portland Water Bureau with no LSLs, or for characterizing WLLs after LSL replacements. A regulatory program based on fifth-liter samples would be complex to implement because it would likely need to be adapted for some utilities and as LSLs are replaced. Finally, fifth-liter samples are not as useful as first-draw samples for ongoing assessment of corrosion control because most historic data are for first-draw samples. Process control and treatment assessments are done based on current and historic data and include assessments of trends which can only be quantified with consistent data.

Introduction

Draft revisions to the Lead and Copper Rule (LCR) indicate that EPA considered, but did not recommend collection of fifth-liter samples for compliance monitoring, and instead requested data and comments regarding the usefulness of fifth-liter samples in determining compliance. A motivation for collecting fifth-liter samples is improving the likelihood of collecting water that was detained in a lead service line (LSL). Water with prolonged contact with an LSL is expected to have higher water lead level (WLL) and provide more direct evidence of the performance of corrosion control strategies on the most important contributor to lead exposure (the LSL). Data from three public water systems (Flint, MI, Chicago, IL, and Philadelphia Water Department) were analyzed to determine if a 5th liter sample would be representative of water that has been in contact with an LSL. The systems were chosen because they had available profile data (i.e., WLL from sequential samples) and because they include systems ranging from highly stable and in compliance (Philadelphia Water Department) to highly unstable and out of compliance systems (Flint, shortly after return of water supply to purchased water from Detroit).

Results and Discussion

Profile data from three water systems were used to determine whether the fifth-liter sample is representative of water in contact with an LSL and to assess the value of the additional information a fifth-liter sample would provide. Use of a fifth-liter sample presupposes that it is likely that the highest lead concentration in the profile will be associated with the LSL and that the fifth liter of water in a profile is the most likely to have been detained in an LSL during stagnation.

Overall, our analysis indicates the fifth-liter sample has several limitations outlined below:

- The fifth liter is seldom the highest concentration sample among a profile of samples.
- The volume of water between LSLs and downstream faucets differs by service area as well as among residences in a given service area.
- Fifth-liter samples might not identify customers whose greatest exposures are from sources of lead other than LSLs.
- For some systems, WLL variability among fifth-liter samples can be much higher than that of first-draw samples. Higher variability in WLL increases sample size (number of residences) required to accurately and precisely characterize corrosion control and confounds analysis of data from monitoring rounds.

Profile Sample with the Highest WLL Differs by System

As noted above, many factors determine the liter (in a profile) most likely to have the highest WLL. The most important factors are

- The plumbing (materials and volume) between the distribution system and a sampled faucet,
- The stability of a system, and
- The types of lead release typical of the system (particulate, colloidal, dissolved).

Because these factors differ widely both within and between systems, the liter (in the profile) most likely to have the highest WLL also differs widely among systems (Figure 1).

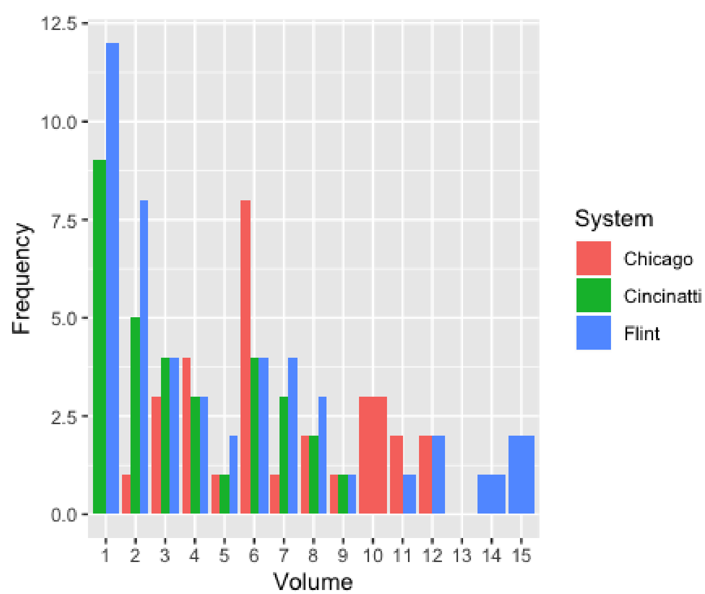


Figure 1. Bar plot showing frequency of maximum lead for each liter of sample

Particulate and Dissolved Lead

Boxplots of WLL from profile samples for two sample rounds for Chicago, IL, are presented in Figure 2. Chicago has been in compliance with the current LCR, though the 90th percentile is relatively close to the current action level (15 ppb), indicating marginal stability and corrosion control. Assuming that lead in samples with WLL less than 20 ppb is primarily dissolved lead, Chicago data show a clear pattern of increasing dissolved lead through liters 6 to 9. This trend is a result of both the mechanisms of lead release most important for Chicago and of the plumbing configurations for the housing stock in Chicago. For Chicago, fifth-liter samples would provide a more conservative (higher) 90th percentile lead concentration than first-draw samples but would miss the highest potential dissolved lead concentrations and exposures seen for the sixth-liter through ninth-liter samples.

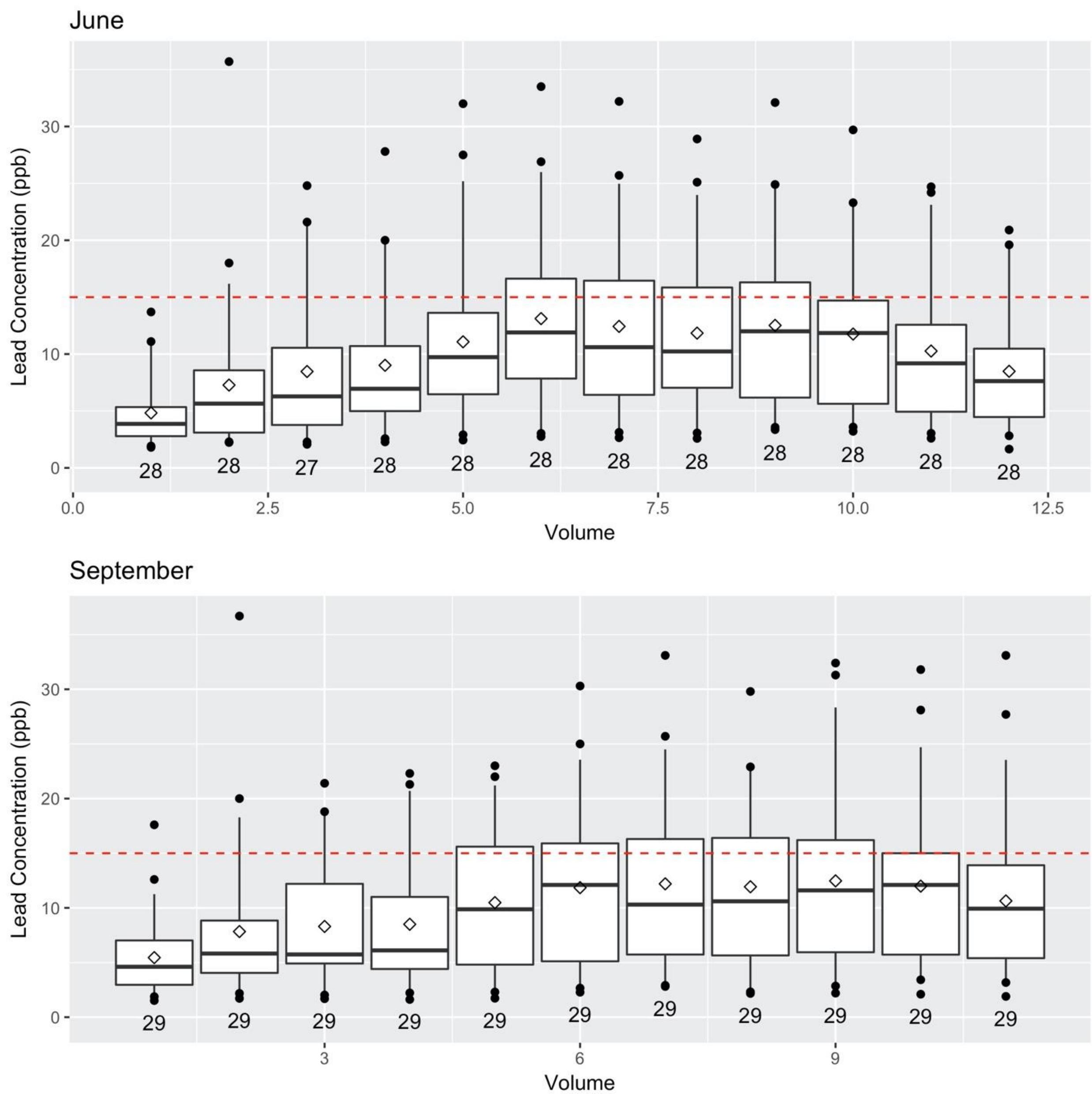


Figure 2. Profile sampling data from 2 sampling rounds in Chicago, IL. Dashed red line is the EPA action level of 15 ppb.

Boxplots of WLL from profile samples for five sample rounds for Flint, MI, are presented in Figure 3. Numbers below each of the boxes give the number of samples for that particular liter of the profile.

Assuming high WLL (e.g., above 20 ppb) is indicative of the presence of particulate lead, Flint data demonstrate that fifth-liter samples are seldom the samples with the highest particulate lead concentrations. With the exception of the third sampling round, in which the highest WLLs are spread evenly among samples, the highest WLLs and the highest frequency of WLL above 20 ppb (and likely indicative of particulate lead) are the first, second and third liters, even when the system was nearing stability (the fifth sample round).

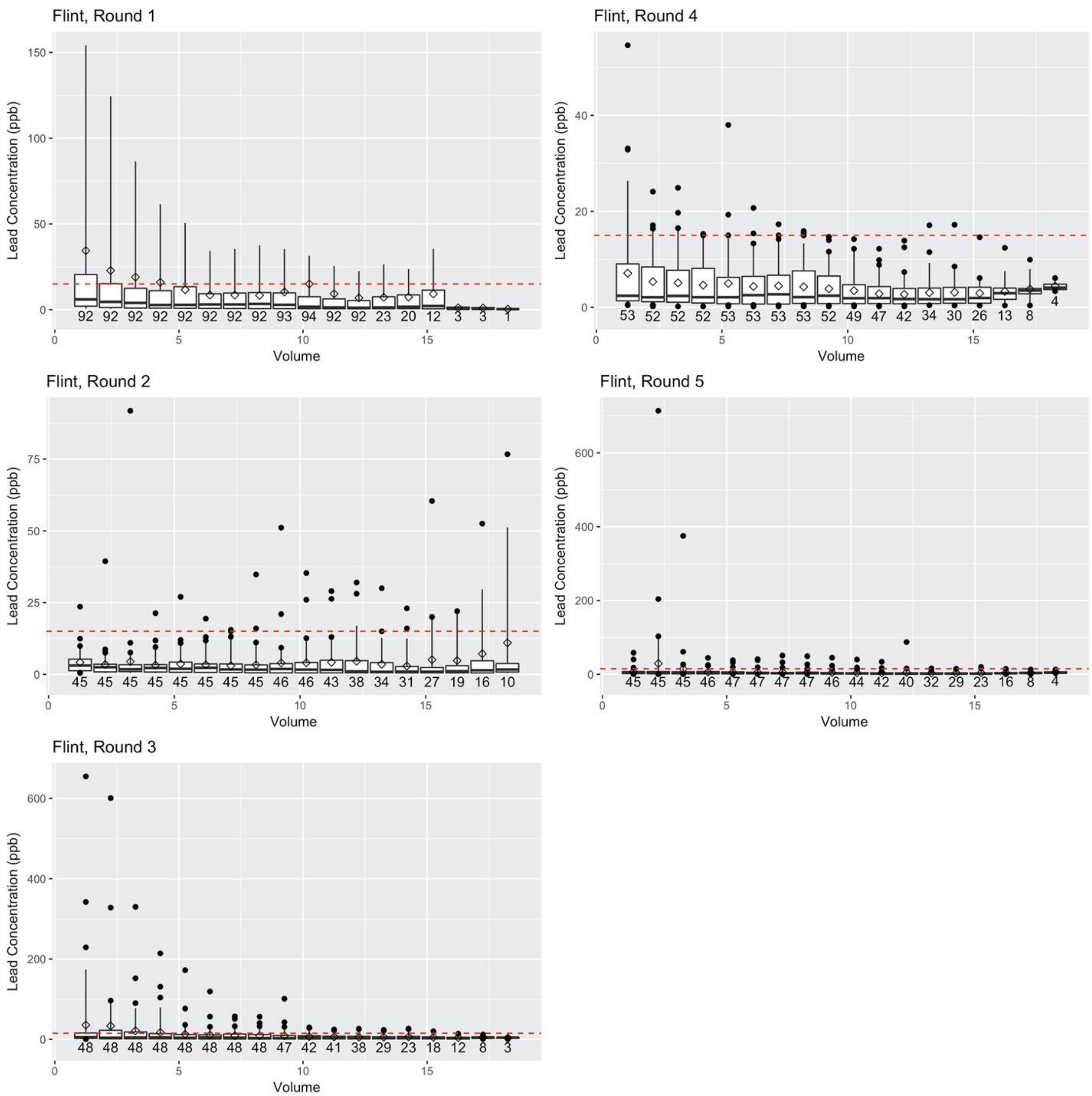


Figure 3. Profile sample WLLs for five sampling rounds in Flint, MI. Dashed lines show the current EPA Action Level (15 ppb).

Profile Data for a Stable System

Profile data from 10 homes with LSLs supplied by the Philadelphia Water Department are presented in Figure 4. Data from homes with non-detect WLL for all samples are not shown. Prior to profile sampling, the volume of water between the sample faucet and the distribution main was estimated and profile data were collected to ensure the final sample was representative of water in the distribution system. The houses sampled had a wide distribution of water volume between the faucet and the distribution system, ranging from about 6 liters to about 17 liters. No WLL above 20 ppb was observed, indicating most of the lead in the profile samples was likely dissolved or colloidal. Generally, for homes with detectable lead, the highest WLL was observed at or after the 5th liter and, with the liter corresponding to the highest WLL occurring later than the fifth liter for samples with a greater volume of water between the faucet and the distribution system. Similar to Chicago data, Philadelphia data indicate high variability in the sample with highest WLL and that the sample with highest WLL is usually later in the profile than the 5th liter.

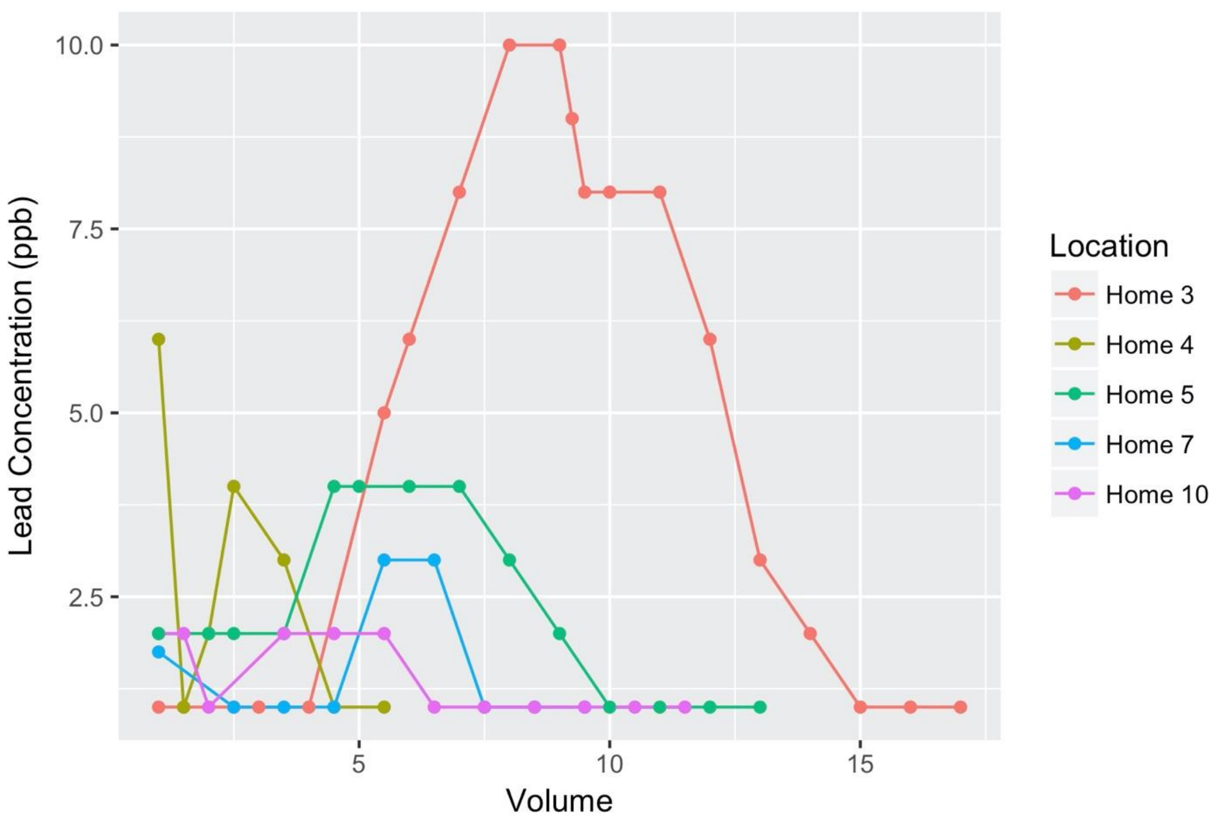


Figure 4. Profile sampling data from Philadelphia, PA.

Variability and Sample Size for 5th Liter Samples

Irrespective of the liter collected (first-draw, fifth-liter, etc.), the sample size (number of Tier 1 homes to sample) required for a reliable determination of 90th percentile WLL depends on the variability in WLL for that liter. Variability in first-draw, fifth-liter and the maximum of the first-draw and fifth-liter samples is shown for Chicago, IL, and Cincinnati, OH, in Figure 5. For Chicago, which is in compliance but with little margin for safety, variability (width of the interquartile range) is much greater for the fifth-liter than the first-draw, whereas for Cincinnati (a highly-stable system with low WLL), the variability in first-draw and fifth-liter samples is more comparable. Higher variability in fifth-liter samples indicates that 90th percentile WLL estimates for fifth-liter samples would be less accurate and less precise for many systems than 90th percentile WLL estimates for first-draw samples, assuming the number of samples were not changed. Adjusting the number of samples for compliance monitoring for fifth-liter samples would require collection and analysis of a large quantity of fifth-liter sample data for diverse systems.

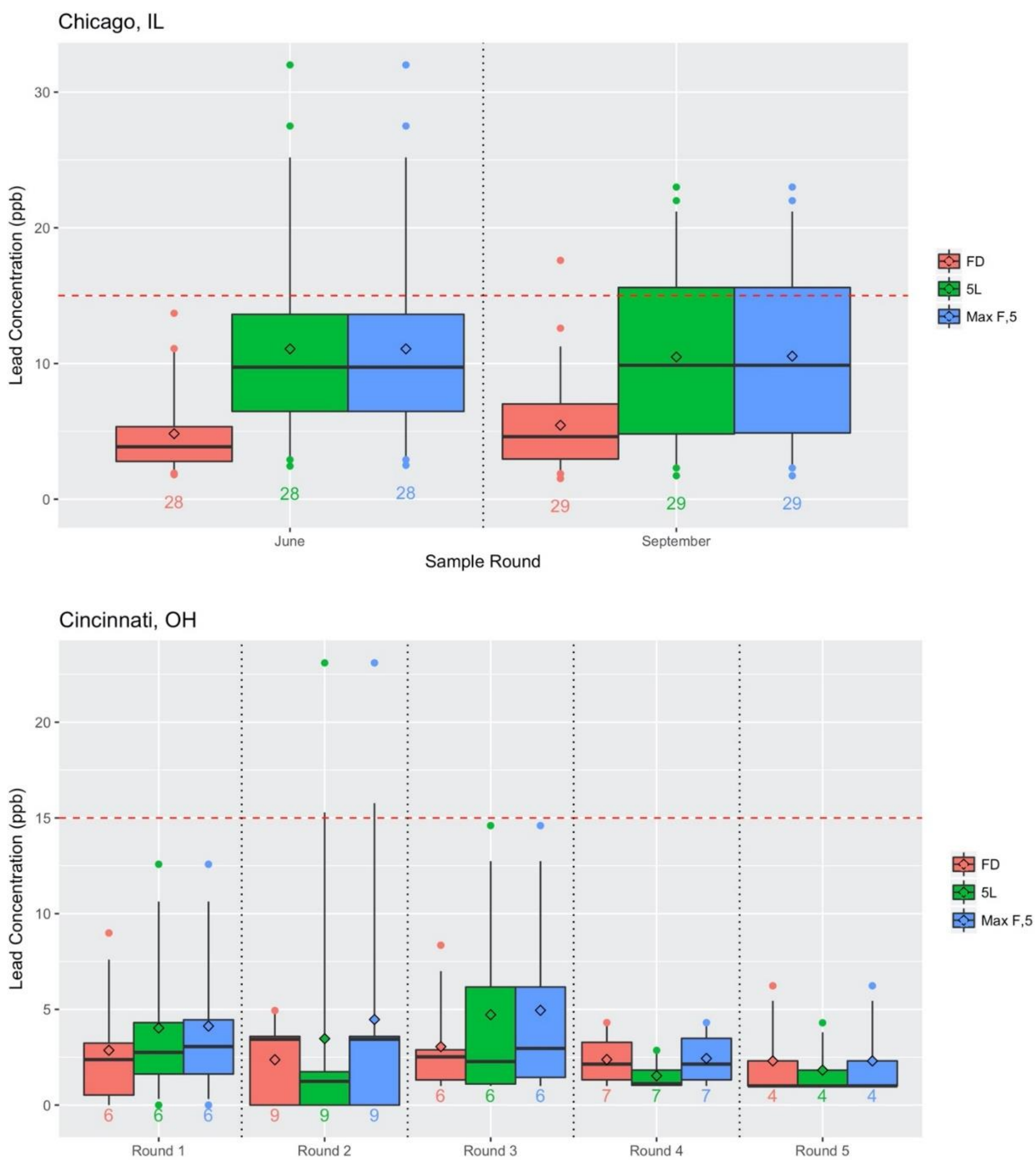


Figure 5. Variability in WLL for first-draw, fifth-liter and maximum of first-draw and fifth-liter for Chicago and Cincinnati

Challenges Associated with 5th Liter Sampling

In addition to the limitations outlined above, the fifth-liter sampling presents several challenges within the revised LCR related to interpretation of data for fifth-liter samples:

- The current first-draw sample action level was set based on feasibility. For some systems, fifth-liter 90th percentiles will be higher than first-draw 90th percentiles, yet there is no proposed basis for an action level for fifth-liter samples that is similarly based on feasibility. That is, fifth-liter data would be collected but could not be appropriately assessed.
- A regulatory program based on fifth-liter samples would be complex to implement. For example, fifth-liter sample collection logistics would add significant additional effort to utilities and their customers who agree to conduct sampling. The additional complexities relate to (i) developing and following guidance of reliably capturing the fifth liter of water, (ii) recruiting the additional sample sites that would be required for developing a sufficiently precise statistical characterization of WLL (e.g., a fifth-liter 90th percentile estimate) and (iii) additional analysis and interpretation of data. The revised LCR draft provides no indication of how data could or would be analyzed. No matter how the data are analyzed, the assessment and explanation of compliance/noncompliance will be more complex and a greater communication challenge than utilities and regulators currently face.

APPENDIX 6.n

6. Additional Changes to the Proposed Revisions are Needed to Move the Nation Forward in Successfully Reducing Exposure to Lead Through Drinking Water.

n. Homes with leaded solder and brass should be part of the LCR monitoring as they provide important data for CCT effectiveness (§ 141.86 Monitoring Requirements for Lead and Copper in Tap Water and (a) Sample Site Location).

Basis for Recommendations: On p 61725, EPA requested comment on the change in lead concentrations that occur in homes without LSLs when CCT changes occur. EPA is seeking additional data on non-LSL homes. See the following technical brief for data on these homes and how they have reduced lead levels as CCT has improved.

Technical Brief: Changes in Lead Levels in non-LSL Homes After Implementation of CCT

Prepared By: Tyler Bradley, Philadelphia Water Department

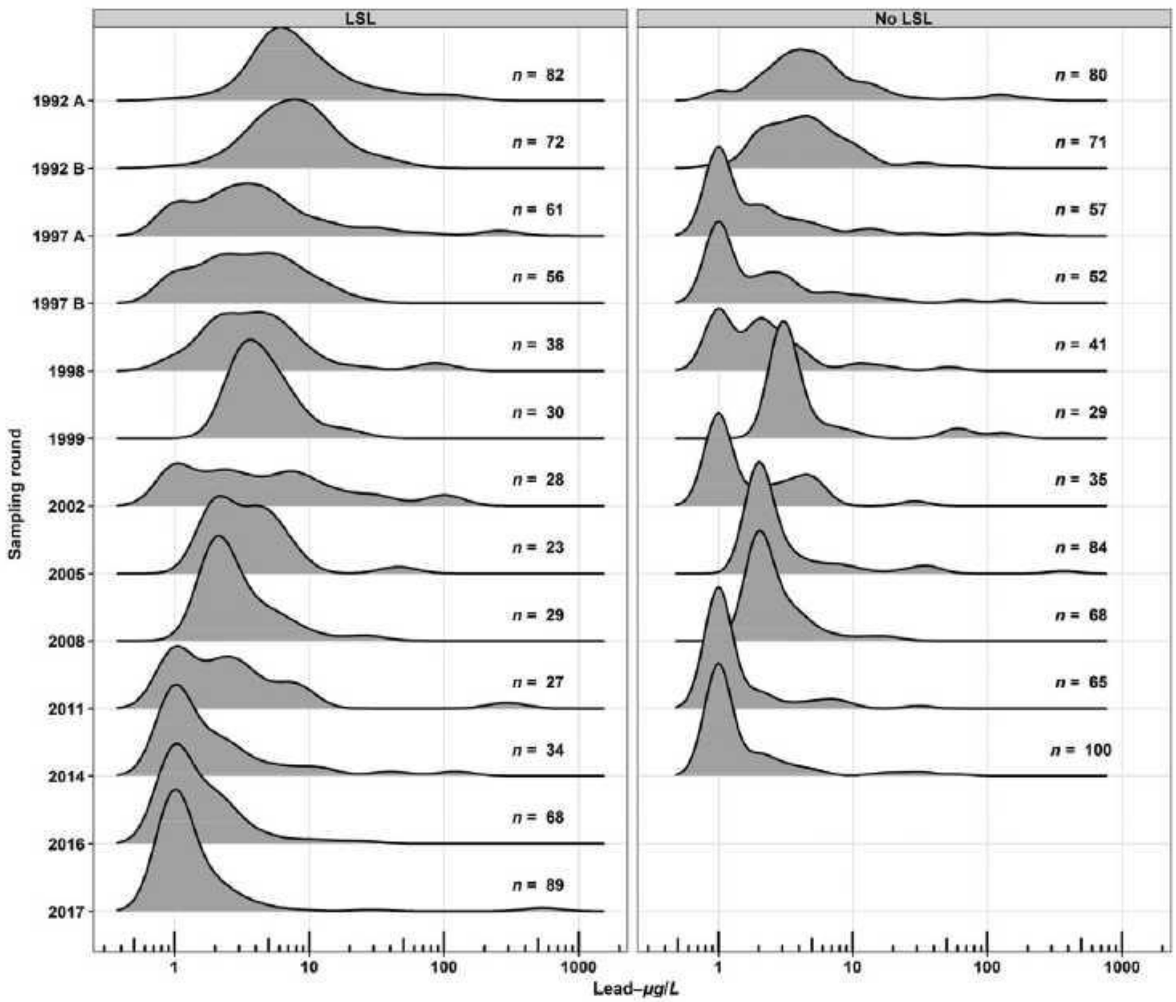
11/19/19

In the Oct 2018 *JAWWA* article "Using Historical LCR and WQ Data to Evaluate CCT" (Bradley, T. and N. Horscroft. 2018. Using Historical LCR and Water Quality Data to Evaluate Corrosion Control Treatment. *JAWWA* https://doi.org/10.1002/awwa.1143) PWD demonstrated in Figure 4 that homes that do not have a LSL experienced similar reductions in lead levels as seen in homes with LSL. These non-LSL homes all had copper pipes with leaded solder, and possibly other sources of lead.

The general distribution of lead levels over the course of 25 years of monitoring showed continued decreases for both LSL and non-LSL homes as CCT was implemented and improved, as shown in Figure 4 (also shown below). PWD sampled from non-LSL homes through the 2014 LCR sampling round. As shown in this image, the distribution of lead levels in non-LSL homes shifted closer and closer around the reporting limit for lead (1 ppb). Note also that as CCT was uniformly applied and improved over time, the distribution of lead concentrations narrowed around the median values, showing less variation and occurrence of higher concentrations.

Figure 6 of this article also demonstrates that between PWD's 1992 and 1997 sampling rounds, during which time uniform CCT was being implemented, 65% of non-LSL homes sampled during both sampling periods saw a decrease in lead levels. While this is lower than the number of LSL homes seeing a decrease in lead levels between the rounds, it still showed that the initial implementation of CCT had a positive impact on lead levels in a majority of the non-LSL homes sampled.

FIGURE 4 Distribution of lead results for each LCR sampling round based on whether the homes have an LSL

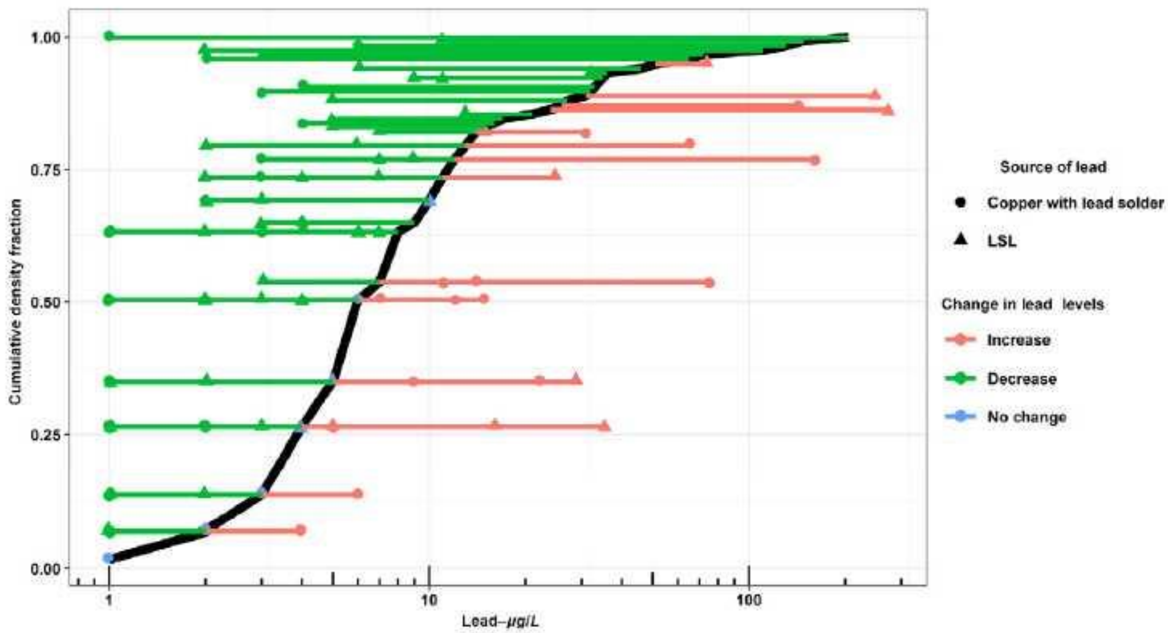


LCR—Lead and Copper Rule, LSL—lead service line, PLSL—plumbing LSL

PLSLs were classified as having LSLs in this figure, and homes with no data for service-line type were not included in this figure.

Reference: Bradley, T. and N. Horscroft. 2018. Using Historical LCR and Water Quality Data to Evaluate Corrosion Control Treatment. *JAWWA*
https://doi.org/10.1002/awwa.1143

FIGURE 6 ECDF for 1992 lead results sampled from homes that were also sampled in 1997



ECDF—empirical cumulative density function, LSL—lead service line

Horizontal lines represent the change in lead levels between 1992 and 1997.

Reference: Bradley, T. and N. Horscroft. 2018. Using Historical LCR and Water Quality Data to Evaluate Corrosion Control Treatment. *JAWWA* https://doi.org/10.1002/awwa.1143

7. PWD Joins and Incorporates by Reference a List of Comments Submitted to this Docket by the American Water Works Association

PWD has been and continues to be a supporter of the American Water Works Association (AWWA) and participates on AWWA's committees including those to address lead contamination and related regulations or guidance. PWD has reviewed AWWA's comments (ID: EPA-HQ-OW-2017-0300-1012) and joins and incorporates selected ones by reference. PWD has not joined nor incorporated by reference all of AWWA's comments because PWD has not performed an appropriate review of every comment, and some comments do not pertain directly to Philadelphia. However, there are specific comments that directly pertain to PWD's comments and are being joined and incorporated by reference herein. These comments listed below, but not repeated in their text, are listed according to AWWA's table of contents and are joined and incorporated by reference:

> "Comments on the National Primary Drinking Water Regulations: Proposed Lead and Copper Rule Revisions" submitted on February 5, 2020 by the American Water Works Association, Washington, DC

2.1	p 6	Reflecting NDWAC recommendations
2.2	pp 6-7	Incentivizing success
3.5.9	pp 22-23	Find-and-fix
3.5.9.1	p 23	Applicability limited to required compliance monitoring
3.5.9.2	pp 23-24	Duty to "fix"
3.5.10	pp 24-25	Adding water quality parameter monitoring sites after individual high lead observations
3.5.11	p 25	Appropriate components of assessing tap sample sites that exceed the lead action level
3.6.1	pp 26-27	Basis for inventory
3.6.6	p 28	Achievable expectation for property owner engagement
3.6.8	p 30	Lead service line replacement and associated public education
3.6.9	p 30	Provision of pitcher filters
3.6.9.1	p 30	Specifying point-of-use devices is a source of concern
3.6.12	pp 34-35	Sampling following lead service line replacement
3.7	pp 35-36	Public education and supplemental monitoring requirements
3.7.1	p 36	Utilize existing communication tools
3.7.7	pp 40-41	24-Hour notification of customer after single lead result > 15 ppb
3.8.3	pp 43-44	Sample pool
3.8.5	p 44	LCR compliance tap sample protocol
3.8.6	pp 45-46	Customer requested samples
4.10	pp 73-74	Is the proposed trigger level appropriate?
4.11.16	p 86	Are pitcher filters appropriate after lead service line replacement or disturbances?
4.20	p 104	Is required outreach to local health departments appropriate?

Final Note of Explanation:

AWWA Standard C810, Replacement and Flushing of Lead Service Lines as released in November 2017, does not reflect industry-wide agreement. When the standard was approved for release it was on the condition that a more thorough review would follow, and that the standard would be revised in a short time frame. Philadelphia provided comments prior to its release and is still in the process of working with the standard committee to address the comments for the revision.

The following practices were not resolved at the time of the standard's release:

- Items to use for prioritizing lead service line replacements.
- Using water quality sampling to identify the existence of a lead service line.
- Use of filters or bottled water following a partial replacement until a sample for lead is acceptable.
- Testing of water following replacement, one month later.
- The use of profile sampling when lead levels are elevated.

Therefore, the EPA should not consider these items to be supported by the water industry at this time.

REFERENCES:

Batterman, S., S. McGinnis, A.E. DeDolph, and E.C. Richter. 2019. Evaluation of changes in lead levels in drinking water due to replacement of watermains: a comprehensive study in Chicago, Illinois. *Environmental Science & Technology* 53: 8833-8844.

Bradley, T. and N. Horscroft. 2018. Using Historical LCR and Water Quality Data to Evaluate Corrosion Control Treatment. *JAWWA* https://doi.org/10.1002/awwa.1143

Burlingame, G. and A. Sandvig. 2004. How to mine your lead and copper data. *Opflow* 30:6:16-19.

Burlingame, G.A. Letter dated March 3, 2016 to Peter Grevatt, Eric Burneson, Rick Rogers, and Lisa Daniels. *Questions regarding sampling practices under the Safe Drinking Water Act's Lead and Copper Rule*. Philadelphia Water Department, Philadelphia, PA.

Burlingame, G.A., C. Bailey, J. Nelson, V.J. Arnette, S. Bradway, A. R. H. Putz, A. Stark, P. Schwer, L.H. Sanborn, J.E. Tobiason, and S. Via. 2018. Lessons learned from helping schools manage lead in drinking water to protect children's health. 2018. *JAWWA* 110(10) 44-53.

Burlingame, G.A., S.V. Masters, and J. Przybylowicz "Rinse the Tap" Advisories are a Refreshing Measure. *Opflow* 45:5:22-24, May 2019.

Masten, S.J., S. H. Davies, S.W. Haider, and C.R. McPherson. 2019. Reflections on the Lead and Copper Rule and lead levels in Flint's water. *JAWWA* 111(9) 43-55.

Triantafyllidou, S., Parks, J. and Edwards, M. 2007. Lead Particles in Potable Water. *JAWWA* 99:6: 107-117.

U.S. Environmental Protection Agency, 2015. *NDWAC Recommendations to the Administrator for the Long Term Revisions to the Lead and Copper Rule (LCR) and Past Meeting Summaries* [WWW Document]. US EPA. URL https://www.epa.gov/dwstandardsregulations/ndwac-recommendations-administrator-long-term-revisions-lead-and-copper-rule (accessed 2.7.18).

US EPA, 2018. *3Ts for Reducing Lead in Drinking Water in Schools and Child Care Facilities: A Training, Testing, and Taking Action Approach*. Office of Ground Water & Drinking Water.

USEPA. 2019 (October). *Economic Analysis for the Proposed Lead and Copper Rule Revisions.*