Enclosure 1

Denver Water's Lead Reduction Program Plan

Denver Water Variance From Optimal Corrosion Control Treatment Requirements Under the Safe Drinking Water Act's Lead and Copper Rule

LEAD REDUCTION PROGRAM PLAN

Submitted to EPA, September 2019

DENVER WATER

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Introduction

Denver Water is committed to delivering safe water to 1.4 million people in the metro area, which is why Denver Water is working to significantly reduce lead exposure risks for customers with lead service lines and plumbing. The water we deliver to homes and businesses is lead-free, but lead can get into the water as it moves through customer-owned service lines and lead-containing plumbing.

This Lead Reduction Program Plan has been prepared in support of Denver Water's request to the Environmental Protection Agency for a variance from the optimal corrosion control treatment requirements under the Safe Drinking Water Act's Lead and Copper Rule.

Currently, Denver Water maintains a pH of 7.8 to reduce corrosion of lead service lines and plumbing. Denver Water conducted a study on multiple treatment options to reduce the potential for lead to enter drinking water from lead service lines and household plumbing. Based on the results, the Colorado Department of Public Health and Environment, the state regulatory agency that oversees drinking water regulations, required Denver Water to begin adding orthophosphate by March 2020, in accordance with regulatory requirements.

Despite its benefits, orthophosphate added to drinking water can increase phosphorus levels in wastewater and stormwater, resulting in adverse impacts to wastewater treatment plants and downstream reservoirs, streams and rivers. Once started, orthophosphate cannot easily be discontinued without causing an increase in corrosion, making orthophosphate a potentially permanent treatment method.

Due to these concerns, Denver Water, along with the Colorado Department of Public Health and Environment and other stakeholders, convened working groups in 2018 to further evaluate the benefits and risks of orthophosphate alongside other options to reduce lead exposure. As part of this process, Denver Water investigated whether a lower dose of orthophosphate, a higher pH of 9.2 with alkalinity adjustment or a multi-faceted approach including pH/alkalinity adjustment to 8.8 combined with the accelerated replacement of lead service lines and the provision of filters to customers could achieve the same or greater reduction in lead exposure risk. Based on this analysis, and as highlighted in Figure 1, Denver Water seeks to implement the multi-faceted Lead Reduction Program in place of adding orthophosphate to drinking water because the Lead Reduction Program provides the greatest benefit to public health and the environment.

FIGURE 1: LEAD REDUCTION PROGRAM PLAN BENEFITS

Protects Future Generations
The Lead Reduction Program permanently removes the largest source of lead within 15 years through accelerated lead service line replacement versus more than 50 years of using orthophosphate.

Focuses on Health Equity and Environmental Justice
The components of the Lead Reduction Program provide equal access for everyone to benefit from reducing overall lead exposure.

Provides Better Water Quality
For customers with lead service lines, Denver Water will provide filters that reduce lead by 97% until their lead service line can be replaced.

Creates a Regional Solution
The Lead Reduction Program prevents additional phosphorous loading at regional wastewater treatment plants, which is costly to remove.

Protects Infants and Children
The Lead Reduction Program prioritizes filter distribution and lead service line replacement in areas at greatest risk to lead exposure, namely areas with young families, child care providers and schools.

Protects Environmental Health
Upon implementation, the Lead Reduction Program will prevent introduction of a new source of phosphorous into reservoirs, rivers and streams. Nutrients can impair water for aquatic life as well as downstream wastewater and water utilities.

The Lead Reduction Program includes multiple elements, the most essential of which involve:

- Development of a lead service line inventory to identify and track lead service line replacement.
- A filter program.
- An accelerated lead service line replacement program.
- Corrosion control treatment with pH/alkalinity adjustment.
- Communications, outreach and education plans.

Overall, as compared to orthophosphate, the Lead Reduction Program provides a holistic and permanent lead reduction approach that is as effective at protecting public health, more efficient in reducing lead exposure, less harmful to the environment, more equitable in its public health benefits and more cost-effective with fewer regional risks.

History

How does lead enter drinking water?

Lead exposure, whether from paint, soil, air or water, is a significant public health concern because it has the potential to adversely affect some of our most vulnerable populations, especially children. When it comes to lead in drinking water, no levels are considered safe. That is why Denver Water is working with the Colorado Department of Public Health and Environment, the Environmental Protection Agency and Denver Water's customers to reduce the risks of lead exposure as drinking water moves through homes and businesses with lead service lines and lead plumbing.

While Denver Water delivers safe, lead-free water to customers' homes, lead can enter the water through three sources: (1) a customer's lead service line, which conveys water from the water main in the street to the customer's home, (2) a customer's household plumbing that contains lead solder and (3) a customer's plumbing fixtures that contain lead (e.g., faucets, valves). Figure 2 highlights the sources of lead in drinking water.

Denver Water studies show that lead service lines, typically found in homes built before 1951 within the Denver Water service area, are the primary source of lead in drinking water.

What has Denver Water done historically to control lead and reduce lead exposure?

For decades, Denver Water has been working to reduce lead in drinking water. Figure 3 highlights the history of lead in drinking water and provides an overview of Denver Water's activities to reduce lead exposure. Since 1992, Denver Water has tested water from inside customer homes with known lead service lines or lead solder as part of the Safe Drinking Water Act's Lead and Copper Rule. Additionally, Denver Water has provided corrosion control treatment in the form of pH adjustment of the water delivered to customers' homes to minimize the corrosion of customer-owned lead service lines and plumbing.

FIGURE 2: SOURCES OF LEAD IN DRINKING WATER

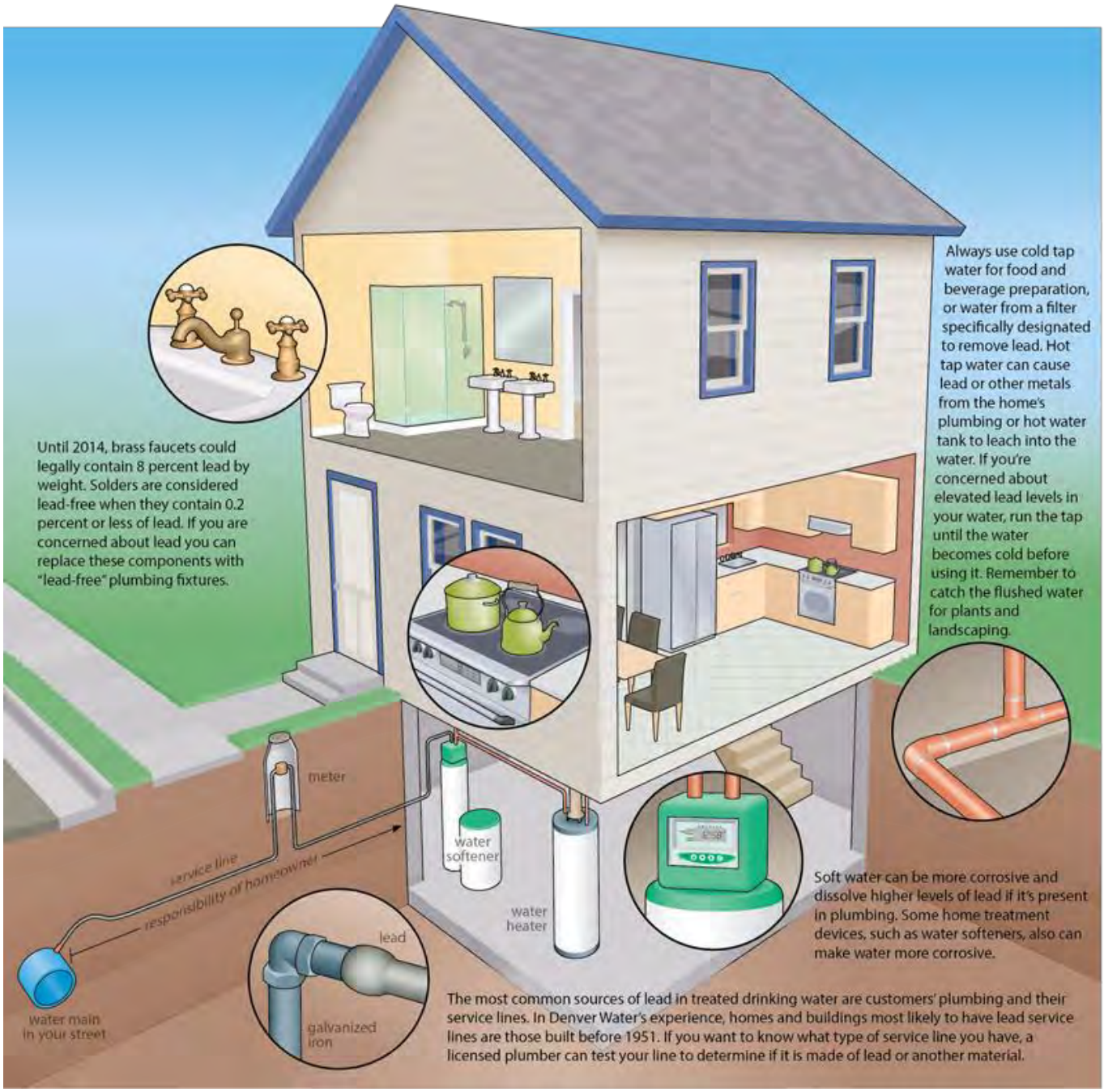


FIGURE 3: HISTORY OF LEAD IN DRINKING WATER

Since 1994, Denver Water has been authorized to maintain a minimum pH/alkalinity of 7.5. In accordance with this authorization, in recent years, Denver Water has sought to consistently maintain a pH of 7.8. This approach has resulted in the following lead concentrations measured from Tier 1 homes as defined in the Lead and Copper Rule. A Tier 1 home is a sample site that is a single-family structure built between 1983 and 1987 that (1) contains copper pipes with lead solder, (2) contains lead pipes and/or (3) is supplied by a lead service line.

Category	Lead Concentration Range (1997-2019 data) (expressed in units of ppb – parts per billion)
Average lead concentrations for Tier 1 homes	4 to 8
90th percentile lead concentrations for Tier 1 homes	7 to 17*

* Lead and Copper Rule action level is 0.015 mg/L = 15 ppb; 17 ppb was reported once in 2012.

Although these treatment efforts were largely effective for many years, in 2012, the 90th percentile value for sample results of lead concentrations in tap water was 17 ppb, exceeding the Lead and Copper Rule action level of 15 ppb. Since the Lead and Copper Rule was adopted in 1992, the 2012 exceedance of the lead action level was Denver Water's first and only exceedance.

As a result of this one exceedance, Denver Water was required to investigate the cause and evaluate alternative treatment solutions. These studies included a lead service line pipe rack study that required the harvesting of lead service lines from homes in the distribution system. These studies, especially the pipe rack study, required a significant investment of time and resources by Denver Water and resulted in the submittal of an Optimal Corrosion Control Treatment Report in late 2017. Based on the data in the report, in March 2018, the Colorado Department of Public Health and Environment designated orthophosphate be added to drinking water as the optimal corrosion control treatment and directed Denver Water to prepare to implement orthophosphate treatment by March 2020.

Corrosion Control

What is corrosion control?

When water interacts with metal, the metal can oxidize, resulting in corrosion. By adjusting the chemistry of the water, it is possible to cause a buildup or coating on pipe walls, which reduces the amount of lead released from lead-containing pipes and fixtures. This protective coating, however, requires the maintenance of a delicate chemistry in the water. To reduce corrosion and maintain the coating, the Lead and Copper Rule requires drinking water systems to maintain "optimal corrosion control treatment," which means a corrosion control treatment that minimizes the lead and copper concentrations at customers' taps. This can be done through orthophosphate addition, pH/alkalinity adjustment or calcium hardness adjustment. Depending on the chemistry of the water, some corrosion control treatment methods can be more effective than others.

What is orthophosphate?

Orthophosphate is a phosphate-based corrosion control inhibitor that changes the chemistry of water to create a protective coating on service lines and plumbing that, in turn, reduces the corrosion that causes lead releases. Although orthophosphate is effective at reducing lead exposure, it can increase phosphorus levels in wastewater and add excessive nutrients to surface water, adversely affecting rivers, streams and lakes in our region. To remove phosphorus, wastewater treatment plants would need to invest in facility upgrades. In addition, once Denver Water begins to treat with orthophosphate, it will likely need to continue treatment indefinitely to avoid upsetting the delicate chemistry of the water that maintains the protective coating on service lines and plumbing.

Are there effective alternatives to orthophosphate?

Because of concerns about the negative impact of orthophosphate on wastewater treatment plants and the environment, Denver Water engaged stakeholders to assess alternatives to using orthophosphate that may provide even greater protection to Denver Water customers.

These studies investigated two treatment approaches: (1) the lowest effective dose of orthophosphate (3, 2 or 1 mg/L as orthophosphate) required to minimize lead at drinking water taps in Denver Water's system and (2) the effects of a higher pH of 9.2 as a corrosion control treatment method on lead releases. Denver Water and stakeholders also analyzed the costs to remove phosphorus from the watershed as well as the costs to counter the potential effects of increasing pH. In addition, Denver Water developed a lead control model, demonstrating the efficiency of replacing lead service lines in combination with both use of lead removal filters and pH/alkalinity adjustment, as compared with orthophosphate corrosion control treatment alone.

Based upon these studies, Denver Water is proposing an alternative, holistic approach that directly tackles the biggest issue, customer-owned lead service lines, at its source by accelerating the replacement of those lines through a Lead Reduction Program. The Lead Reduction Program would reduce the risk of public exposure to lead beyond what can be achieved by adding orthophosphate to the drinking water by:

- Developing a lead service line inventory so our customers can investigate the likelihood of having a lead service line.
- Implementing the Filter Program, a program that would distribute filters to all homes with a known, suspected or possible lead service line, reducing lead by 97% or more.
- Implementing an accelerated lead service line replacement program that would replace the major source of lead decades ahead of the current rate of replacement: approximately 63,955 lead service lines would be replaced within 15 years versus 50 years or more under current practices.
- Adjusting pH from 7.8 to 8.8 and maintaining alkalinity above 30 mg/L as $CaCO_3$ for corrosion control treatment to reduce corrosion of lead service lines, household plumbing

and fixtures (note: treatment objectives for pH/alkalinity adjustment will be approved by the Colorado Department of Public Health and Environment).

- Enhancing the communications, outreach and education program to help customers understand the Lead Reduction Program and ways that they can reduce their exposure to lead.

How will this change my water quality?

The proposed pH/alkalinity adjustment to improve corrosion control will have little-to-no noticeable impacts to Denver Water customers, their plumbing, and appliances. Results from internal and external taste tests show that changes in taste and odor are not anticipated to be an issue with either proposed corrosion control treatment alternatives. Further, there is no evidence that the effectiveness of fluoride would be impacted.

For customers with chemistry dependent uses (pools, fish tanks, breweries, etc.), the customers will be informed of the change and prepare accordingly. Proper maintenance of appliances to prevent excessive scale build-up should be part of general maintenance practices regardless of the water quality that enters premise plumbing.

Variance Request and Lead Reduction Program

How does the Environmental Protection Agency determine whether an alternative treatment method is as effective or better than orthophosphate?

To implement the Lead Reduction Program, Denver Water must apply for a variance from the Environmental Protection Agency. Under 42 U.S.C. § 300g-4(a)(3) and 40 C.F.R. § 142.46, the Environmental Protection Agency may grant a variance from the optimal corrosion control treatment requirements under the Safe Drinking Water Act's Lead and Copper Rule *"upon a showing from any person that an alternative treatment technique not included in such requirement is at least as efficient in lowering the level of the contaminant with respect to which such requirements was prescribed."*

Is Denver Water proposing the Lead Reduction Program on a voluntary basis?

Denver Water is proposing the Lead Reduction Program on a voluntary basis as an alternative to orthophosphate treatment under the Lead and Copper Rule. Denver Water cares about the 1.4 million people it serves and the safety of the water at their taps. Denver Water wants to provide the best short- and long-term solution to prevent lead exposure. In addition, Denver Water is concerned about the adverse impact that orthophosphate could have on the downstream reservoirs, rivers and streams, the quality of the source of supply and the costs wastewater treatment and stormwater management providers would incur to remove phosphorus. For these reasons, Denver Water is proposing the Lead Reduction Program as a proactive measure to permanently replace lead service lines from its service area as efficiently as possible, provide additional public health protection that cannot be achieved through orthophosphate treatment alone, protect the watersheds and help reduce regional costs that would be incurred to remove phosphorus from wastewater.

What commitments is Denver Water making?

Denver Water will actively engage its customers within the City and County of Denver and the service areas of its distributors that collectively make up Denver Water's "integrated system." The Lead Reduction Program will aim to reduce lead concentrations by distributing filters to customers with known, suspected or possible lead service lines, replacing 7.0% of the lead service lines annually and replacing all lead service lines within 15 years. Denver Water's commitments are described in more detail in Table 1.

TABLE 1: DENVER WATER'S PROPOSED LEAD REDUCTION PROGRAM COMMITMENTS

Communications, Outreach and Education
Denver Water is committing to: • Educate and engage with residents, customers, distributors, local public health agencies and government stakeholders about lead awareness and reduction efforts. • Educate the public on measures they can take to reduce their exposure to lead in water used for drinking, cooking and infant formula preparation. • Tailor and support a communications, outreach and education program focused on expecting and existing families with formula-fed infants/children up to age 2, at homes with copper piping with lead solder, with special emphasis on homes built 1983-1987. • Seek feedback from residents and other stakeholders to learn best practices and effective ways to implement program activities. • Strive for 100% participation in the Filter Program.
Lead Service Line Inventory
Denver Water is committing to: • Research, investigate and document the presence of customer-owned lead service lines. • Help customers identify if they have a lead service line. • Maintain a current lead inventory and map. • Confirm materials at properties with a suspected or possible lead service line. • Use the inventory to target communications, outreach and education efforts at areas with the greatest risk.
Filter Program
Denver Water is committing to: • Provide filters and filter cartridge replacements to properties with known, suspected and possible lead service lines for up to 15 years during the life of the Lead Reduction Program. • Educate and inform residents on the importance of using filters for drinking water. • Denver Water is striving for 100% adoption in the Filter Program; if filter adoption is less than 75%, Denver Water will increase outreach and education efforts in low adoption areas to improve filter use.
Accelerated Lead Service Line Replacement Program
Denver Water is committing to: • Replace all known lead service lines in 15 years. • Replace 7.0% of the lead service line inventory each program year, based on a cumulative annual average. • Use the predictive model to help prioritize lead service line replacements, taking into consideration public health/toxicology concerns, child care providers, primary schools, neighborhoods with a high density of young families and socioeconomic and environmental factors. • Follow up with residents and provide filters until the service line is confirmed as non-lead or until six months after the lead service line is replaced.
Corrosion Control Treatment
Denver Water is committing to: • Maintain water quality by implementing corrosion control treatment through pH/alkalinity adjustment. • For homes built from 1983 to 1987 with copper piping with lead solder where water quality tests exceed 3 ppb, provide equivalent treatment by offering free filters and replacement cartridges for expecting and existing families with formula-fed infants/children up to age 24 months, per CDPHE guidance.

Learning by Doing
Denver Water is committing to: • Evaluate the performance of the Lead Reduction Program to improve outcomes. • Establish an Advisory Committee to inform Denver Water on more efficient and effective ways to implement the Lead Reduction Program to achieve the variance goals.
Health Equity and Environmental Justice
Denver Water is committing to: • Create equitable access for all communities within the integrated system so that all residents will benefit from the reduction in lead exposure. • Prioritize the integration of health equity and environmental justice principles by measuring the community needs and tailoring outreach efforts to reach vulnerable populations. • Consult and collaborate with community organizations and members, health equity and environmental justice experts, stakeholders and customers to continually improve upon the Lead Reduction Program.

How will the performance of the Lead Reduction Program be evaluated?

Denver Water will use the criteria shown in Table 2 to evaluate the performance of the Lead Reduction Program. An annual report will detail the program's success and provide regulators with clear criteria to determine when to require correction or take enforcement action.

TABLE 2: LEAD REDUCTION PROGRAM EVALUATION FOR COMPLIANCE

Element	Definition of Compliance	Correction Active	Failure to Meet Condition
Lead Service Line Inventory	Must investigate a minimum of 1.4% of total LSLs in inventory per year.	• Achieve compliance by following year. • Provide notice of corrective action to customers with filters.	If less than 1.4% investigations occur for three program years: • Notice to all customers.
Filter COE	Outreach and education materials provided each year to at least 95% of households enrolled in the Filter Program.	• Must achieve compliance by following year. • Notice to customers with filters.	If Denver Water fails to provide outreach and education materials to at least 95% of households enrolled in the Filter Program for three years: • Notice to all customers.
Filter Program	Achieve minimum filter adoption rate of 65% per year.	• If filter adoption rate is less than 65% in a year, increase outreach and education efforts to improve filter use. • Notice of corrective action to customers with filters.	If failure to achieve 65% adoption rate for three years: • Termination of variance. • Notice to all customers.
Accelerated Lead Service Line Replacement	Must achieve 7.0% cumulative annual average replacement rate each year.	• Achieve compliance by following year. • Notice to customers with filters.	If less than 7.0% of lead service lines are replaced for three years: • Termination of variance. • Notice to all customers.
Corrosion Control Treatment	Lead and Copper Rule sampling results remain below action level for lead.	• Must adjust corrosion control and distribution management. • Customer education and notice.	If action level exceeded for two monitoring periods: • Must provide customer notice. • Termination of variance unless CDPHE requires otherwise.

What is the estimated cost of each alternative?

Denver Water estimated the life cycle cost for each alternative. This effort included incorporating cost data from other water and wastewater utilities, stormwater entities, watershed authorities and recreational entities. CDPHE requested a summary of costs to support the implementation of, or resulting from, the variance or orthophosphate alternatives, and excluding costs related to Denver Water's existing lead service line replacement work. Denver Water also calculated the costs including the costs for the existing lead service line replacement work because these efforts will continue under either alternative. As seen in Table 3, under either assumption, the variance alternative is more cost effective.

TABLE 3: LIFE CYCLE COSTS IN TERMS OF NET PRESENT VALUE

Assumption	Orthophosphate (at 2 mg/L as PO_4)	Variance
Excluding Existing Service Line Replacement Efforts	$322M to $506M	$265M to $362M
Including Existing Service Line Replacement Efforts	$376M to $582M	$319M to $439M

How will Denver Water fund the Lead Reduction Program?

Denver Water will fund the Lead Reduction Program through rates, loans, grants and donations. In addition, as a show of support for the Lead Reduction Program Plan, Metro Wastewater Reclamation District committed $22.5 million in funding in a resolution adopted on July 16, 2019.

"The Metro Wastewater Reclamation District strongly supports the Lead Reduction Program because it is a permanent and holistic solution that benefits both public health and the environment across the unique arid west region. In furtherance of its support, the Metro Wastewater Reclamation District Board of Directors has made a commitment of up to $22.5 million to the Lead Reduction Program if the variance is approved by Environmental Protection Agency."

What if the variance request is not approved or the variance criteria are not met?

Following the Colorado Department of Public Health and Environment's designation of orthophosphate for optimal corrosion control treatment, Denver Water initiated design and construction of chemical feed systems to dose orthophosphate at 3 mg/L at Denver Water's three treatment plants. If the variance request is not approved, these systems will begin introducing orthophosphate on March 20, 2020.

If the variance is granted and certain criteria in Table 2 are not met during the 15-year period of the Lead Reduction Program, Denver Water might also be required to implement orthophosphate using the chemical feed systems.

More details on the optimal corrosion control treatment designation of orthophosphate can be found at: www.colorado.gov/cdphe/lead-dw-treatment

Public comment period for the Lead Reduction Program Plan

Denver Water conducted a public comment period from July 12 to August 7, 2019 to gather feedback on the program benefits, filter input, communication preferences and overall support. The information was distributed through a variety of different engagement channels such as newsletters, targeted emails to stakeholders and customers who have expressed an interest in Denver Water's lead reduction efforts, TAP news site distribution, social media, distributors, neighborhood groups, etc. During this four-week period, 406 comments were received from unique IP addresses that have indicated that more than 98% of respondents support the Lead Reduction Program, emphasizing benefits for future generations, environmental health and protecting infants and children. Public feedback has been incorporated throughout the plan. Full results can be found in Appendix I.A.

Denver Water also received letters of support from various public health agencies, copies of which can be found in Appendix I.B.

How to navigate through this Lead Reduction Program Plan

This executive summary introduces the Lead Reduction Program Plan, the variance request and Denver Water's commitments if the variance is approved by the Environmental Protection Agency.

Section I presents the history of lead occurrence and control in the Denver Water system, from the single exceedance of the action level for lead in 2012 until the designation of orthophosphate for optimal corrosion control treatment by the Colorado Department of Public Health and Environment in March 2018.

Section II provides a summary of the investigations undertaken by Denver Water since March 2018 to demonstrate that the Lead Reduction Program is as effective as the alternative of orthophosphate at reducing lead concentrations in drinking water. An overview of the elements that together make up the Lead Reduction Program is presented.

Section III describes how Denver Water will implement all six elements of the Lead Reduction Program.

Section IV details how Denver Water will evaluate the performance of the Lead Reduction Program and ultimately maintain regulatory compliance with the Lead and Copper Rule.

Section V describes how Denver Water will address health equity and environmental justice needs through the Lead Reduction Program.

Section VI presents the implementation schedule for the Lead Reduction Program.

Section VII presents the estimated costs of the Lead Reduction Program.

A series of technical memoranda were prepared during the development of the Lead Reduction Program and are included in the appendices to this plan.

What is Denver Water asking of the customer?

- Understand that lead can get into water as it moves through customer-owned lead service lines and lead solder and what you can do to reduce lead exposure.
- Help us identify if you have a lead service line – learn more at denverwater.org/Lead
- If you have a lead service line:
  - Allow Denver Water to replace the lead service line at no cost to the property owner.
  - Use a filter until the lead service line can be replaced.
- If you have sources of lead in premise plumbing inside the home:
  - Replace faucets and indoor plumbing with lead-free components.

To minimize exposure to lead when using water for drinking, cooking and making beverages, ice and infant formula:

- Use a filter certified by NSF International to remove lead for drinking and cooking. Replace the filter cartridge according to the manufacturer's instructions.
- Use only cold water for drinking, cooking and making baby formula. Remember, boiling water does not remove lead from water and hot water often contains higher levels of lead than cold water.
- If water has not been used in the home for a few hours, such as first thing in the morning or when getting home from work or school, run the kitchen or any bathroom faucet for five minutes (remember to capture the water and reuse it!). You can also run the dishwasher, take a shower or do a load of laundry to help flush water in your internal plumbing before drinking or cooking.
- Regularly clean your faucet's screen (also known as an aerator).
- Consider replacing faucets and indoor plumbing with lead-free components.

I. DENVER WATER'S HISTORY OF LEAD OCCURRENCE AND CONTROL

From the late 1800s to the mid-1900s, lead service lines were installed in the Denver metro area to deliver water from the main into customers' homes. This was a common practice in the industry across North America, as lead service lines offered significant durability and protection from leaks and subsequent contamination of household water supplies. In 1949, Denver Water's engineering standards were amended to allow the use of other materials, such as copper, for service line installations. By 1986, the state of Colorado had banned lead in pipes, solder and other plumbing materials.

Lead in Denver Water's service area

Denver Water's service area consists of the City and County of Denver and its outlying distributors, as depicted in the map in Figure 4. The service area shown in the map includes adjacent distribution systems that are physically connected to and provided with water from Denver Water's system.[1]

Lead service lines are known to exist in Denver and in approximately half of the service areas of Denver Water's distributors.

Within Denver, customers own and have historically been responsible for their service lines. Since Denver Water did not install and does not own service lines, it has few records about the location or type of material (copper, lead or other) of service lines. However, the year of service line installation provides some indication of whether the service line is likely to be made of lead.

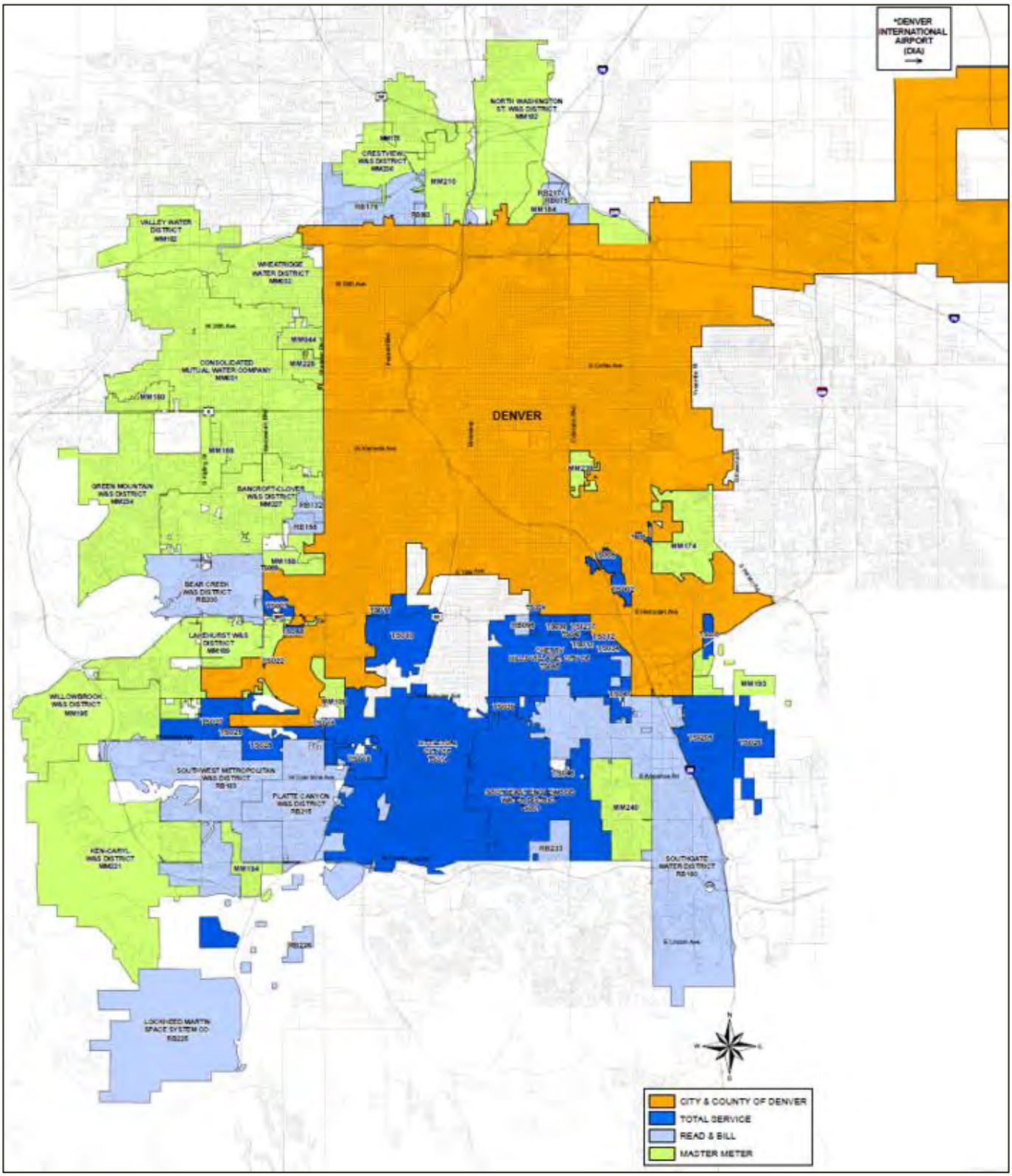
In 1949, the Denver Water Board added copper to its list of approved materials for service lines. Although Denver Water's engineering standards did not eliminate lead as an acceptable material for service lines until 1971, data collected during construction and repair work and from water quality tests for homes built after 1950 indicate that the use of lead as a service line material sharply decreased after 1950.

Actions taken by Denver Water to protect customers from lead in drinking water

Since 1992, Denver Water has tested water from customers' faucets per the Environmental Protection Agency's Lead and Copper Rule and the Colorado Department of Public Health and Environment's Primary Drinking Water Regulations. The results from the last twenty years are shown in Figure 5. Additionally, Denver Water has studied corrosion control and modified treatment processes to improve corrosion control.

[1] See Rule 11.42(1), 5 CCR 1002-11 and Appendix III.B.1.

FIGURE 4: DENVER WATER SERVICE AREA INCLUDING INTEGRATED SYSTEMS

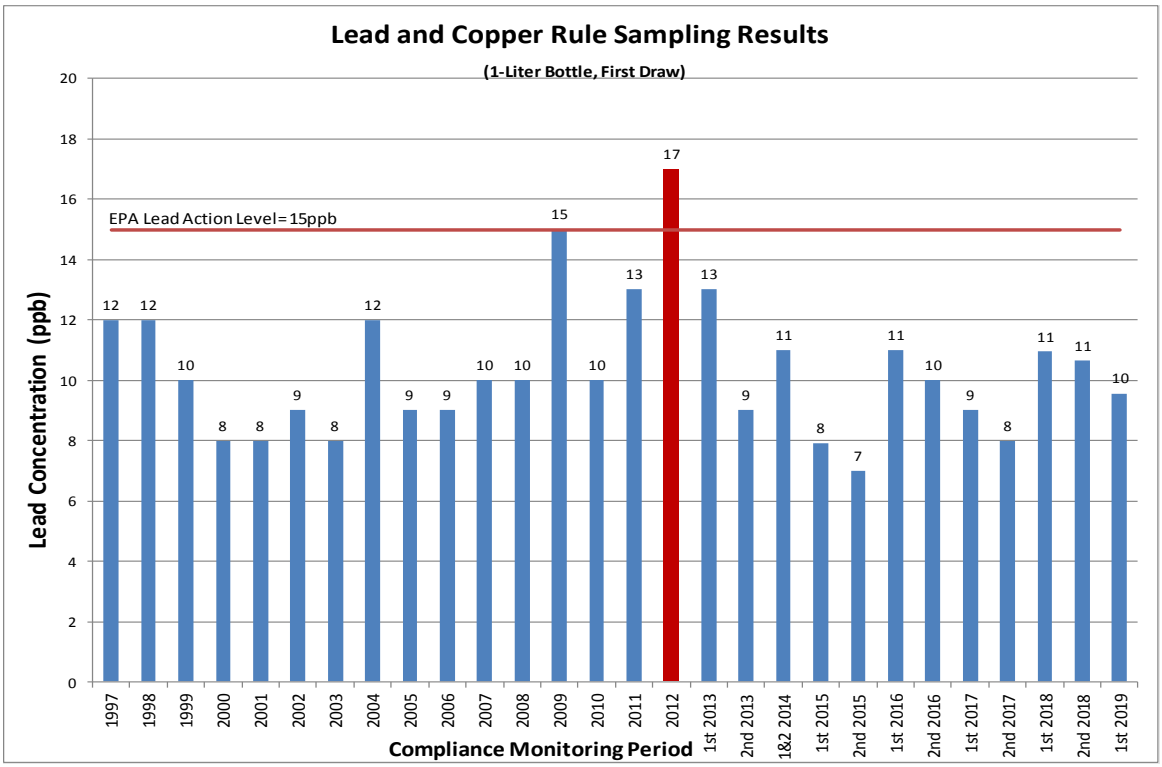


A corrosion control study completed in 1994 recommended that Denver Water adjust the pH of the water produced from its treatment plants to a range of 7.5 to 8.3 standard units. CDPHE issued a letter following the study indicating that to comply with the Lead and Copper Rule,

Denver Water must produce water with a minimum pH of 7.5 and minimum total alkalinity of 15 mg/L as $CaCO_3$ before the water enters the distribution system. In 1994, Denver Water implemented the changes to meet these regulatory requirements.

Through 2011, Denver Water's LCR sample results for Tier 1 lead service lines and Tier 1 copper piping with lead solder were under the lead action level of 15 parts per billion (ppb). In 2012, Denver Water's LCR sample results exceeded the lead action level. As seen in Figure 5, sample results from homes indicated a monitoring value of 17 ppb for the 90th percentile (meaning that the concentrations of lead were above 15 ppb in more than 10% of the homes tested). This exceedance prompted Denver Water to implement its largest public health education campaign and study options for improving corrosion control treatment. (Note that water testing has demonstrated that corrosion of copper has always been well under the action level for copper, which is 1.3 parts per million.)

FIGURE 5: 90TH PERCENTILE LEAD CONCENTRATIONS BETWEEN 1997 AND 2019



What steps did Denver Water take after exceeding the lead action level in 2012?

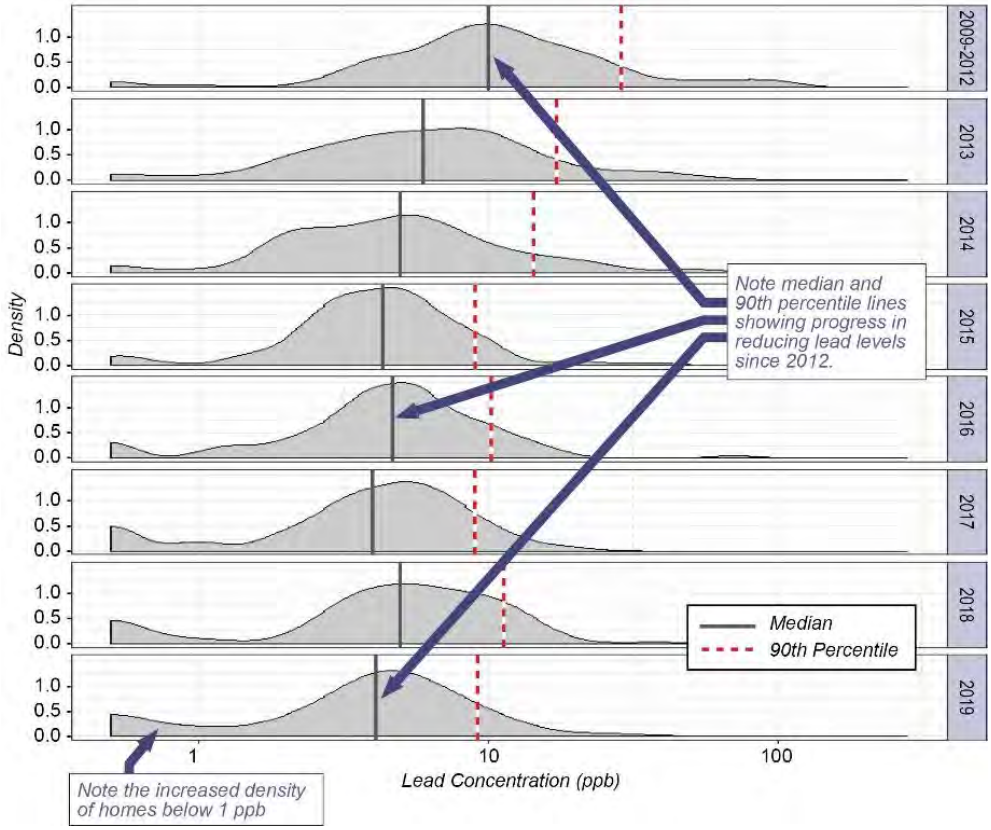
After the 2012 samples exceeded the lead action level, Denver Water implemented a multi-faceted approach to create awareness and protect customers from lead in drinking water, which included:

- Adoption of proactive and ever-adapting communications strategies that included direct customer mailings, bill inserts, sharing information at community gatherings, working with traditional media on coverage of lead issues and social media, including educational and call-to-action posts on Denver Water's Facebook page and messages via Twitter.
- Offer of free lead water quality testing kits to customers.
- A program to replace customer-owned lead service lines when encountered during water main or major road construction work.
- New policies enforcing replacement of lead service lines during building redevelopment.
- A partnership with the Denver Urban Renewal Authority on a pilot program to make low- or no-interest financing available to homeowners to replace their lead service lines.

These changes resulted in the replacement of approximately 1,200 lead service lines per year as compared to the previous rate of approximately 500 per year between 2000 and 2012.

Additionally, as seen in Figure 6, Denver Water has continued to optimize its existing corrosion control system through improved pH and alkalinity monitoring and adjustment at the treatment plants. Denver Water has also made chemical adjustments in the last year to maintain alkalinity levels above 40 mg/L as $CaCO_3$ at all plants and decrease the chloride-to-sulfate mass ratio to further improve corrosion control.

FIGURE 6: LEAD CONCENTRATION DISTRIBUTION FOR HOMES WITH LEAD SERVICE LINES (2009-2019)



Denver Water studied ways to improve corrosion control treatment

In 2013, Denver Water proceeded to examine all possible causes of the 2012 exceedance and was required to conduct a desktop study to identify potential corrosion control changes to plant operations including increasing pH and alkalinity or adding corrosion control inhibitors such as orthophosphate and silicates. The optimal corrosion control treatment from the study concluded that a pH/alkalinity adjustment could result in lead reductions of between 40% and 53%, while orthophosphate would likely reduce lead concentrations between 67% and 76%, depending on water source and temperature. However, the report suggested further studies were necessary to confirm that theoretical calculations could be replicated in a real-life scenario. The report also recommended additional studies to determine the best way to make a water quality change without causing a period of poor water quality and identify the time required for the scales to adapt to the new water quality.

The 2013 desktop study also concluded that:

- Adjusting pH/alkalinity would require higher pH levels, which might impact disinfection by-product formation in the distribution system or cause copper pitting. Copper pitting is not well understood, and Denver Water's chloride levels are on the low end of the range where pitting has shown to be an issue.
- Adding orthophosphate might contribute to increased biological growth in the distribution system and result in the precipitation of phosphate compounds that show up as turbidity in water heaters. Orthophosphate would increase the amount of phosphorus at regional wastewater treatment facilities (loading), which are tasked with removing residual phosphorus prior to discharge. Operating costs would increase not only for Denver Water but also for regional wastewater treatment plants.

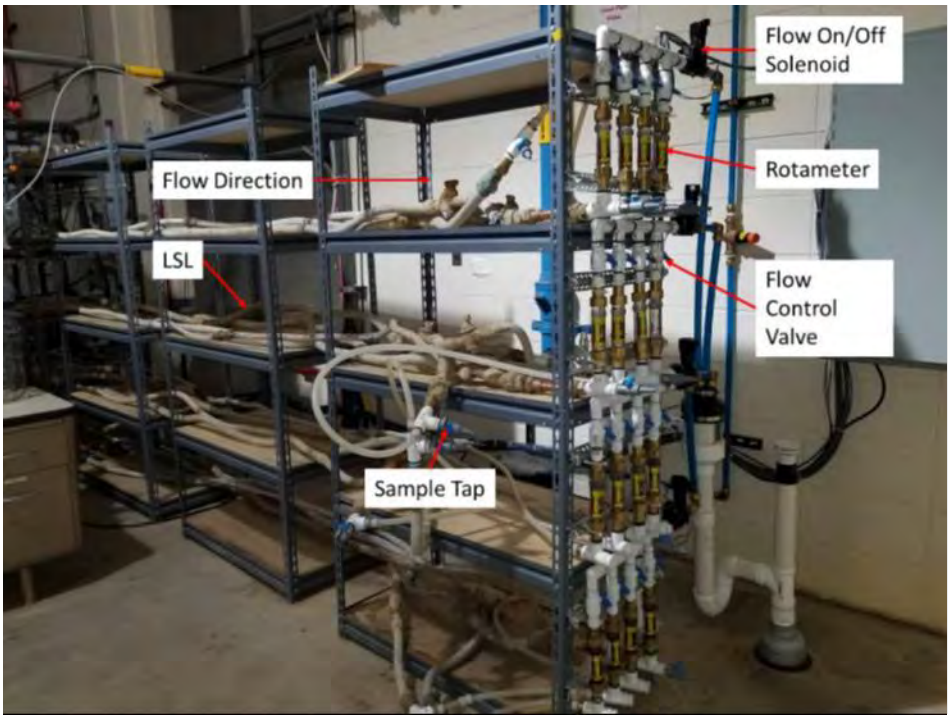
As a result of the 2013 desktop study, Denver Water was required to conduct a corrosion control study. Denver Water collected 32 lead service lines from customers' homes and initiated a pipe rack study using sections of the 32 lines. Figure 7 shows the lead pipe rack at the Marston Treatment Plant. The study included:

- Development of a CDPHE-approved pilot testing protocol.
- Construction and operation of two lead pipe rack pilot skids in 2015 and 2016 to accommodate the two different sources of supply that provide water to Denver Water customers.
- Testing of three forms of corrosion control additives: silicates, pH/alkalinity and orthophosphate.

Dosing for corrosion control began mid-2016 and continued through late 2017 to gather enough data to produce statistically meaningful results. Early in the study, silicates were dropped as an alternative because adding silicates failed to demonstrate significant reductions in lead

concentrations. Variability in the results for individual lead pipe racks would suggest that changes in corrosion control may disturb existing scales for either orthophosphate or pH/alkalinity adjustment; however, in both cases lead concentrations did decrease with time.

FIGURE 7: LEAD PIPE RACK AT THE MARSTON TREATMENT PLANT



The Optimal Corrosion Control Treatment Report was submitted to CDPHE in September 2017, and while the study found that orthophosphate provided greater lead reduction than pH/alkalinity adjustment, as seen in Table 4, Denver Water recommended pH/alkalinity corrosion control treatment due to concerns that orthophosphate would require improvements at downstream wastewater treatment plants to remove the additional phosphorus to meet discharge permit requirements. Furthermore, orthophosphate changes the scale composition on all pipelines in the distribution system, including service lines and household plumbing. Once the phosphate-based scales are formed, Denver Water would likely be committed to adding orthophosphate in perpetuity or until another treatment technique is proven to be as effective as orthophosphate at minimizing lead releases. Discontinuing orthophosphate would cause the pipe scales to dissolve, potentially releasing lead, iron and other metals that are both aesthetic and public health issues.

TABLE 4: SUMMARY OF RESULTS FROM LEAD PIPE RACK STUDY

Pilot Plant Location	pH 8.8	Orthophosphate
Marston Treatment Plant (representing 80% of Denver Water's supply)	Median Reduction: 35% to 51%*	Median Reduction: 66% to 72%*
Moffat Treatment Plant (representing 20% of Denver Water's supply)	Median Reduction: 57% to 72%*	Median Reduction: 64% to 81%*

*Three pipes were dedicated to each treatment type at each pilot plant. The range here represents the low and high results from the three pipes.

CDPHE designated orthophosphate for OCCT in March 2018

On March 20, 2018, CDPHE designated orthophosphate as the optimal corrosion control treatment based on evidence that orthophosphate would reduce lead concentrations at customers' faucets by up to 74%, as compared to 50% using pH/alkalinity adjustment. Per the Lead and Copper Rule as set forth in Regulation 11 of Colorado's Primary Drinking Water Regulations, Denver Water treatment plants must be equipped with and ready to implement orthophosphate by March 20, 2020.

Denver Water proceeded with the design and construction of additional chemical feed systems at each treatment plant to support corrosion control treatment using orthophosphate by March 2020. These systems can also support pH and alkalinity adjustment for corrosion control.

Denver Water pursues an alternative to corrosion control with orthophosphate

In response to concerns about introducing a new source of phosphorus into the watershed and the downstream impacts, Denver Water sought an alternative approach to reduce the risk of lead exposure for its customers. The development of the alternative lead reduction strategy is discussed in Section II.

II. LEAD REDUCTION ALTERNATIVES ANALYSIS

While Denver Water's 2017 study, along with results from other water utilities, demonstrated the effectiveness of orthophosphate in reducing lead exposure, Denver Water and other stakeholders raised concerns about relying on orthophosphate as a long-term treatment strategy, such as:

(1) Detrimental Impacts to the Watershed: orthophosphate would increase phosphorus loading in wastewater, stormwater and regional waterbodies. Phosphorus is a key food source for algae, especially blue-green algae, and these microorganisms compete for the same oxygen in water that other aquatic life, like fish, need to survive. Additionally, algae in large numbers release compounds that cause taste and odor problems in raw water, which are very difficult and expensive to remove and often make potable drinking water unpalatable. On occasion, blue-green algae can grow quickly and release toxins in what are known as harmful algal blooms, as seen in Salem, Toledo, the Great Lakes and the Gulf of Mexico. These toxins are detrimental to aquatic life and humans, impacting recreation and drinking water supplies if local potable water treatment plants are not equipped to remove them.

(2) Long Term Impacts to the Watershed: to avoid upsets in corrosion control, orthophosphate dosing must continue until all known lead service lines are replaced and Denver Water can prove that corrosion control is no longer needed. Denver Water estimates that at the existing rate of 1,200 replacements per year it will take 50 years or more to replace all lead service lines and stop orthophosphate dosing.

(3) Potential Impacts in Drinking Water: the protective coatings begin to dissolve when orthophosphate is turned off. Long-term disruptions (a month or longer) in the supply chain for orthophosphate could result in significant lead releases into the drinking water of homes with lead service lines. Orthophosphate can also increase the likelihood of nitrification occurring in the distribution system, which can lead to an increased formation of disinfection by-products.

Because of these concerns and a commitment to protect public health, Denver Water, along with CDPHE, EPA and other stakeholders, embarked on a process to explore whether alternative approaches might be as or more effective at reducing lead exposure while also reducing the potential adverse impacts associated with orthophosphate.

This section describes the stakeholder process, the alternative studies specific to reducing lead in drinking water and the conclusions derived therefrom. Studies related to the impact of orthophosphate on the environment are described in a white paper released by CDPHE.[2]

[2] See https://www.colorado.gov/pacific/cdphe/OCCT-Stakeholder-Information

The regulatory framework for alternative treatment approaches

The Lead and Copper Rule is based on a treatment technique consisting of four key pillars: public education, source water treatment, lead service line replacement and corrosion control - *Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper*, 56 F4 26460-01, P. 26477 (June 7, 1991). These pillars are highly prescriptive in the sense that the LCR defines specifically when each pillar is triggered and exactly what must be done to fulfill each pillar of the treatment technique. For example, once the lead action level is exceeded, a drinking water provider is required to engage in public education efforts for as long as the lead action level is exceeded. If the lead action level is exceeded after corrosion control treatment has been installed, and the drinking water provider owns the service line, then the drinking water provider is required to begin lead service line replacement in a prescriptive manner. Lead service line replacement activities must continue until the drinking water provider is able to meet the 90th percentile lead action level requirements for two consecutive monitoring periods. In addition, with regard to corrosion control treatment, specific treatment requirements must be studied and the optimal form of treatment must be implemented, with little opportunity to pursue alternative approaches.

For EPA to approve any "alternative treatment technique" under 42 U.S.C. § 300g-4(a)(3), the alternative approach must be "at least as efficient in lowering" lead concentrations:

> The [EPA] Administrator may grant a variance from any treatment technique requirement of a national primary drinking water regulation upon a showing by any person that an alternative treatment technique not included in such requirement *is at least as efficient in lowering the level of the contaminant* with respect to which such requirement was prescribed. A variance under this paragraph shall be conditioned on the use of the alternative treatment technique which is the basis of the variance.

See also 40 C.F.R. § 142.46.[3]

Because Denver Water does not own any part of customers' lead service lines, historically, it has focused on education and optimal corrosion control efforts and was not required to conduct lead service line replacement after the 2012 lead exceedance. The analyses described in the following sections explore alternatives to this approach.

Denver Water's role in the alternatives analysis

In July 2018, Denver Water, CDPHE and regional stakeholders entered into a memorandum of understanding to study alternative approaches to orthophosphate (at 3 mg/L) for lead reduction while assessing impacts to downstream watersheds and utilities. Stakeholders included

[3] Under 40 C.F.R. § 142.46, EPA may approve the variance "whether or not the public water system for which the variance is requested is located in a State which has primary enforcement responsibility…."

representatives from federal and state agencies, member municipalities, utilities, environmental and watershed advocacy groups and Denver Water distributors.

Stakeholders were tasked by executive leaders from CDPHE, Denver Water, Metro Wastewater, Aurora and the Greenway Foundation to "*work collaboratively to seek long-range regional solutions that maintain public trust and protect public health and the environment per the Safe Drinking Water Act and the Clean Water Act, while additionally minimizing impacts to water supplies, wastewater treatment plants, and watersheds.*" Specific areas of interest included:

- **Reducing impacts to downstream wastewater treatment plants.** Sixty percent of Denver Water's supply is reclaimed at Metro Wastewater, Broomfield, South Adams County, South Platte Water Renewal Partners (Littleton/Englewood) and at utilities in the Water Infrastructure and Supply Efficiency or WISE Program. The addition of orthophosphate increases the amount of phosphorus that must be removed during treatment and requires an investment in new infrastructure and/or increased chemical dosing to meet the discharge limits for phosphorus.
- **Reducing impacts to the watershed, stormwater and nearby waterbodies.** Forty percent of Denver Water's supply reaches irrigated areas from as far south as Littleton to as far north as Broomfield. Orthophosphate may require investment in new treatment infrastructure and/or increases in the number and types of management practices needed to reduce the additional phosphorus loading. Alternatives may also include phosphorus offsets, such as banning phosphorus fertilizers, to further reduce the amount of phosphorus in the watershed.
- **Mitigating water quality impacts in distribution systems.** Potential water quality impacts in the distribution system, such as higher disinfection by-product formation or the increased occurrence of nitrification, may be experienced in both Denver Water and its consecutive water systems (Broomfield, South Adams County and East Cherry Creek Valley) that blend Denver Water's treated water with their water supplies.
- **Understanding impacts of transitioning between corrosion control treatment techniques.** Transitioning from orthophosphate to pH/alkalinity and vice versa can disrupt the protective coatings and result in lead releases. Denver Water studied the impact of these transitions to determine the feasibility of implementing a different corrosion control treatment in the future.

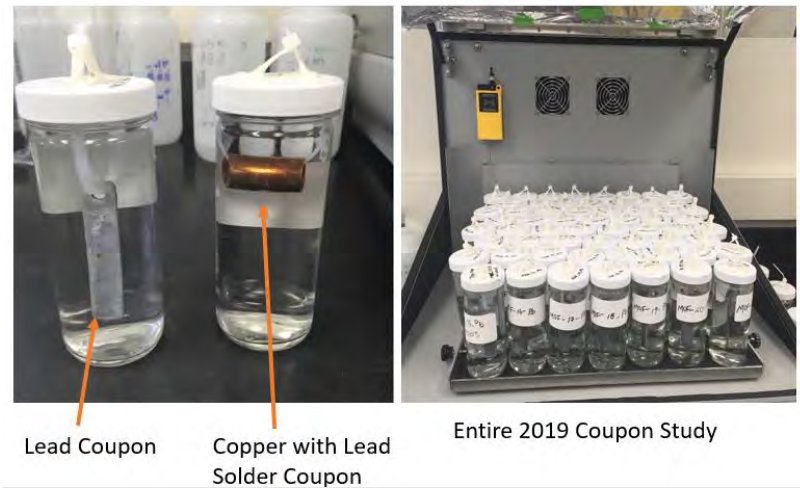
For its part in the alternatives analysis, Denver Water investigated the effects of the following alternative corrosion control strategies:

1) A lower dose of orthophosphate;
2) Higher pH adjustment; and
3) Combined alternatives including accelerating lead service line replacement, a filter program and pH adjustment.

The effects of lower doses of orthophosphate or higher targets for pH adjustment on lead release from lead service lines

As part of the alternatives analysis, Denver Water evaluated whether lower doses of orthophosphate, higher levels of pH or a combination of high pH and very low doses of orthophosphate could achieve an equivalent reduction in lead concentrations as the designated optimal corrosion control treatment (studied at 3 mg/L). To test effectiveness, Denver Water conducted additional pipe rack studies with harvested lead service lines[4] and initiated coupon studies to measure the effectiveness of different corrosion control strategies on lead release.[5] The coupon study arrangement is shown in Figure 8.

FIGURE 8: STUDY OF LEAD RELEASE USING A) LEAD COUPONS AND B) COPPER WITH LEAD SOLDER COUPONS



Denver Water tested lower doses of orthophosphate (2 mg/L, 1 mg/L and 0.5 mg/L) to determine if a lower dose could achieve the same level of lead reduction as the 3 mg/L dose used in the 2017 study. Both the lead pipe rack studies and lead coupon studies concluded that 2 mg/L was the lowest effective dose for orthophosphate, reducing lead concentrations by 74% over the existing corrosion control treatment method using a pH of 7.8 standard units. The 2 mg/L dose equates to a one-third reduction in the amount of phosphorus that would otherwise be contributed to the watershed under a 3 mg/L orthophosphate condition.

Denver Water also evaluated increasing pH to 9.2 standard units as an alternative corrosion control approach. The 2017 lead pipe rack study examined the effect of increasing pH to 8.8 standard units: lead concentrations were reduced 50% more than the existing corrosion control treatment using a pH of 7.8 standard units. At pH 9.2, lead concentrations increased and hard water deposition was observed on plumbing fixtures. Data from downstream utilities and stormwater entities suggested that a pH adjustment of 8.8 has less of a financial impact and does not impact the environment to the same degree as orthophosphate at doses of 1 mg/L or higher.

[4] See Appendix II.B for pilot testing results with the lead pipe racks.
[5] See Appendix III.E.2 for coupon testing results.

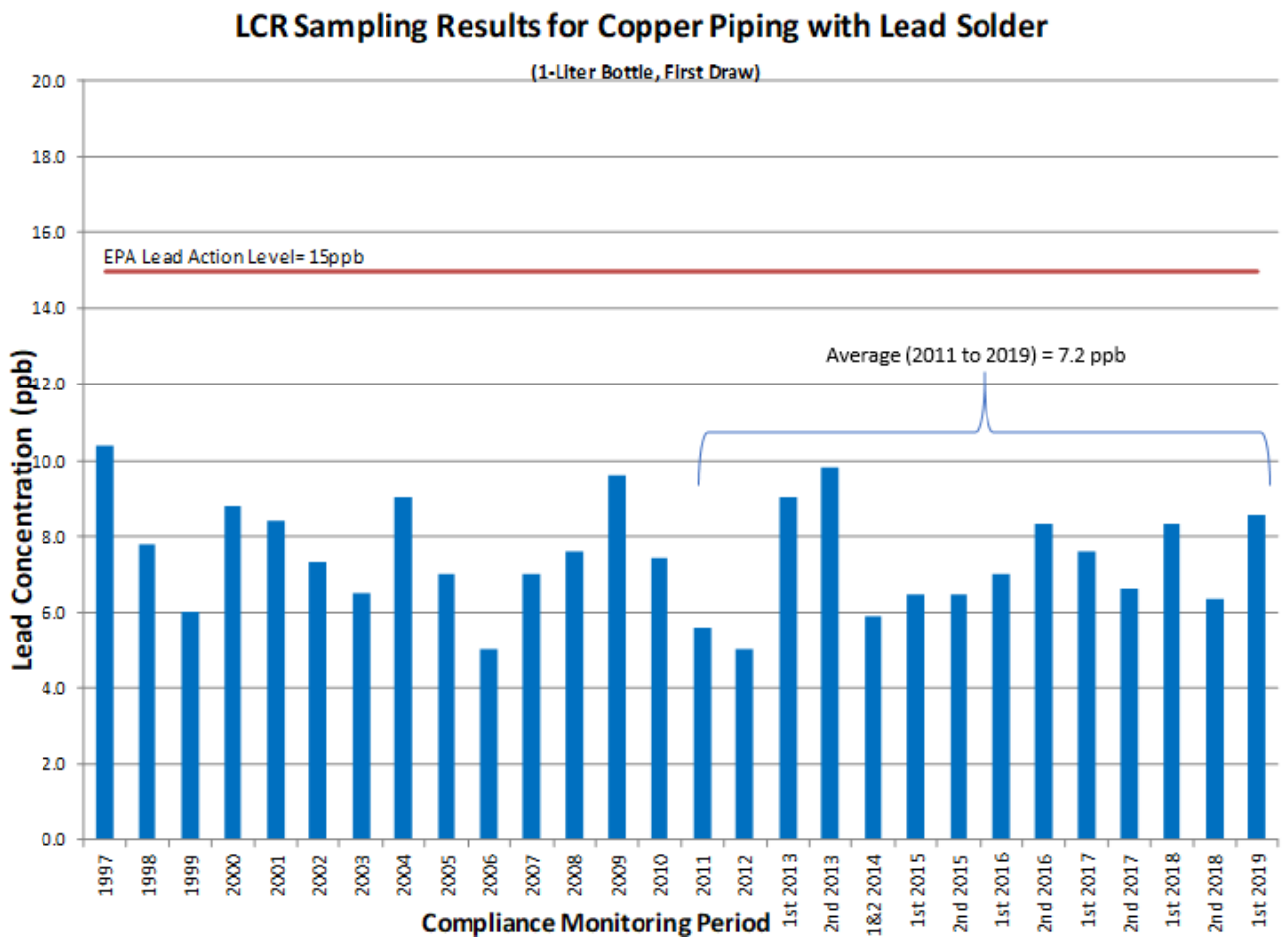
The results from a combined approach, using a high pH (8.8) and a low dose of orthophosphate (0.5 mg/L) also proved to be less effective than orthophosphate alone and was removed from further study. Of all the pH and orthophosphate doses tested, only the 2 mg/L dose proved to be as effective as the previously studied 3 mg/L dose.

The effects of 2 mg/L orthophosphate or pH of 8.8 standard units on copper piping with lead solder

CDPHE and EPA asked Denver Water to demonstrate the effectiveness of both pH/alkalinity adjustment and orthophosphate in reducing lead release from copper pipes with lead solder.

A review of LCR historical data shows that the average of the 90th percentiles for each monitoring period reported between 2011 and 2019 was 7.2 ppb, as shown in Figure 9. Denver Water has never exceeded the action level for copper piping with lead solder.

FIGURE 9: DENVER WATER'S 90TH PERCENTILE LEAD CONCENTRATIONS FOR TIER 1 HOMES (BUILT 1983-1987) WITH COPPER PIPING WITH LEAD SOLDER



Denver Water initiated copper with lead solder coupon testing in March 2019 using water from the supply feeds to the lead pipe racks at the Marston Treatment Plant and Moffat Treatment Plant. This testing was conducted to evaluate the effectiveness of the different corrosion control treatments. Table 5 shows the results from the coupon testing.[6]

TABLE 5: PERCENT REDUCTION IN LEAD AS OBSERVED FROM TESTING WITH COPPER COUPONS WITH LEAD SOLDER

Sample Location	pH 8.8	Orthophosphate (2 mg/L as PO_4)
Marston Treatment Plant (representing 80% of Denver Water's supply)	41% (32% - 61%)	70% (66% - 80%)
Moffat Treatment Plant (representing 20% of Denver Water's supply)	43% (29% - 71%)	68% (54% - 84%)

Using the percent reductions from Table 5 above, Denver Water calculated the following ranges of 90th percentile lead concentrations based on the initial average 90th percentile lead concentration of 7.2 ppb representative of homes built between 1983 and 1987:

- After treatment with orthophosphate: 2.2 to 2.3 ppb.
- After treatment with pH/alkalinity adjustment: 4.1 to 4.2 ppb.

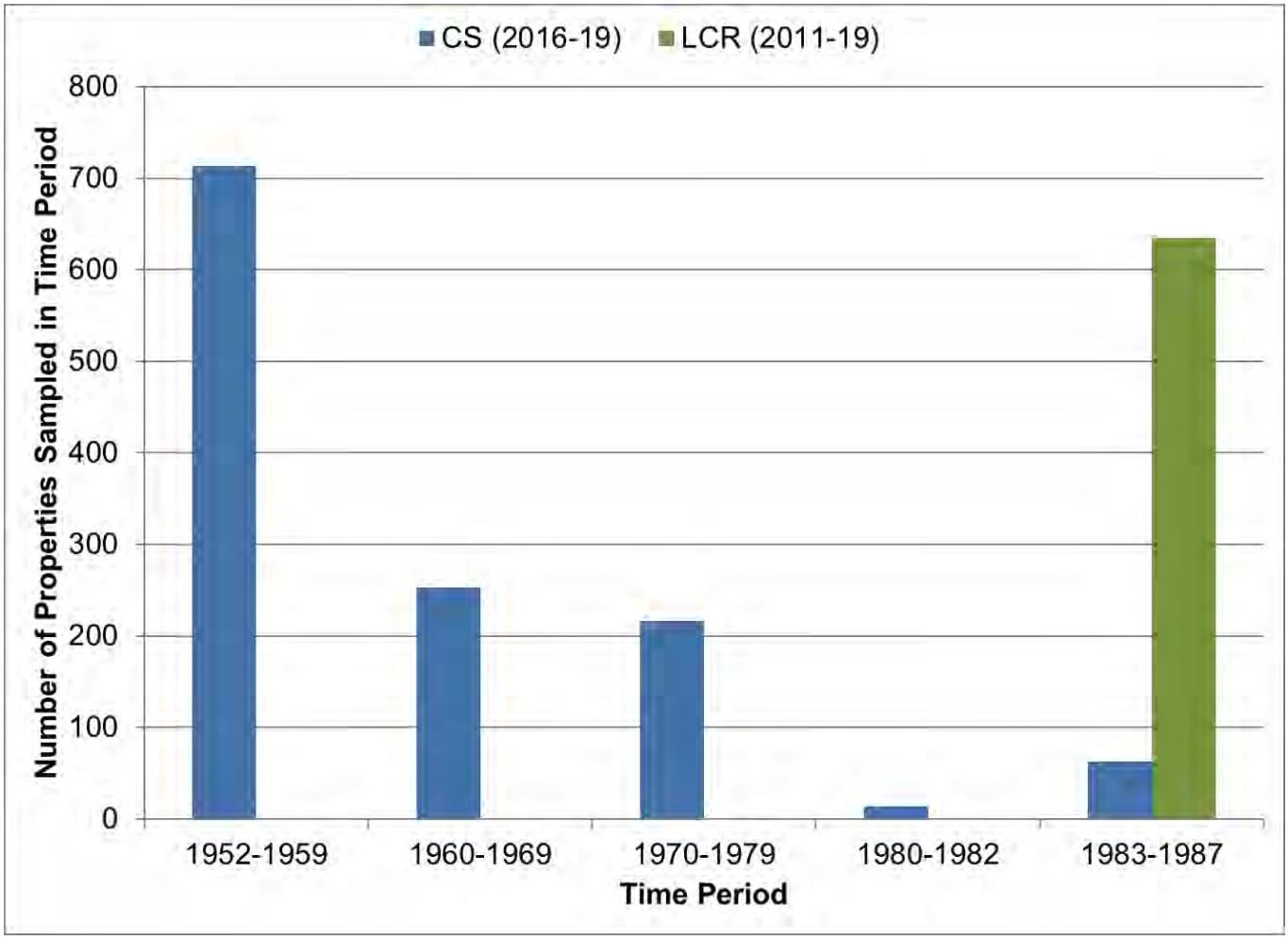
Although orthophosphate demonstrated better lead reduction than pH/alkalinity adjustment, the relative difference in reduction is small when applied to already low levels of lead coming from copper piping with lead solder (an approximately 2 ppb difference).

Is the difference between the two corrosion control treatments meaningful when applied to copper piping with lead solder?

Denver Water applied the percent lead reductions from Table 5 above to 1,831 water quality samples from homes served by copper piping with lead solder. Figure 10 represents the number of samples included in the analysis based on the build date, with blue bars representing customer requested samples and green bars representing LCR compliance samples.

[6] Based on median reduction (interquartile range) between the control and treated samples from the post conditioning phase (weeks 11-17 of the study). A detailed overview of the coupon testing, including results for lead coupons, is presented in Appendix III.E.2.

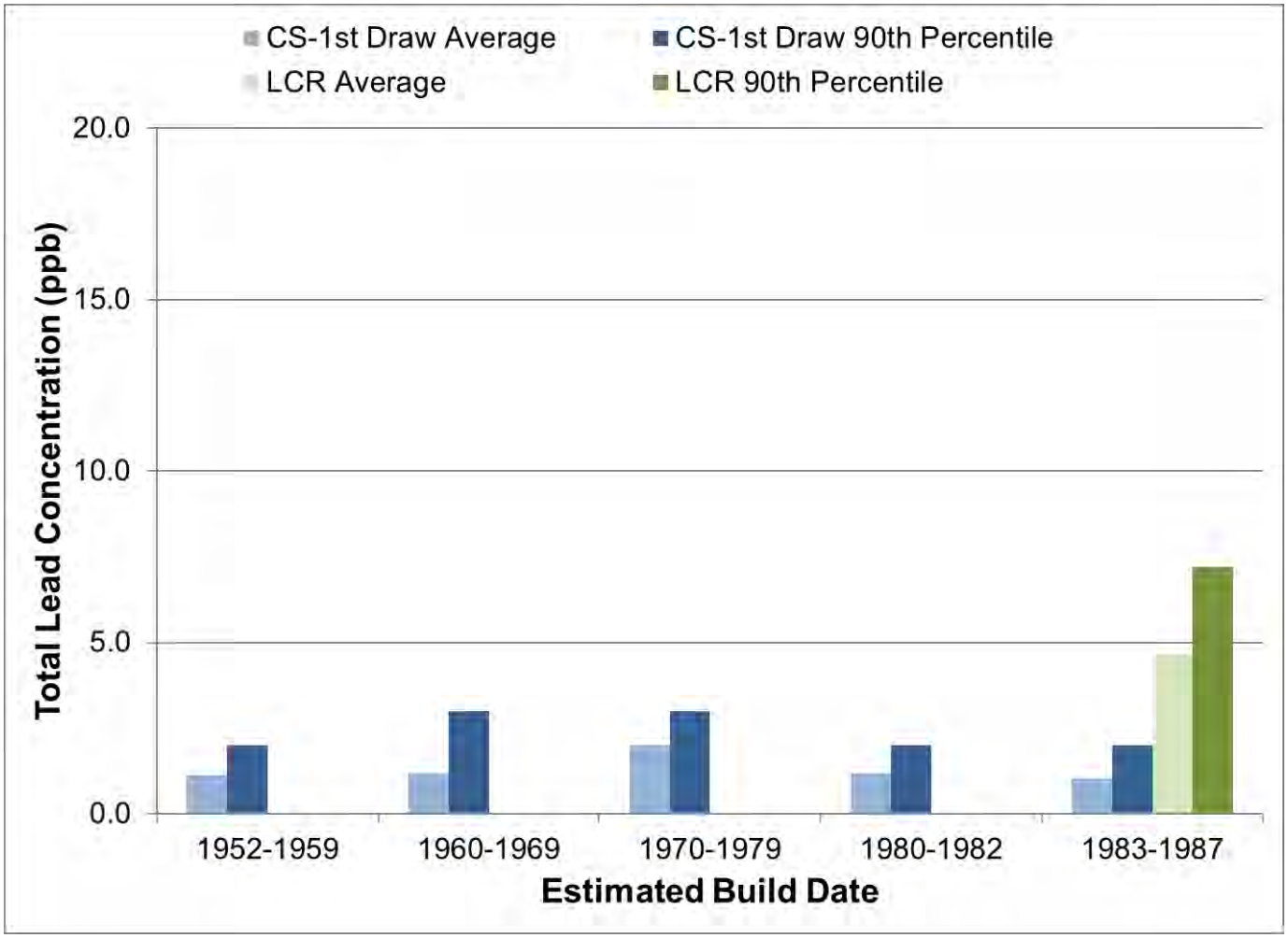
FIGURE 10: DISTRIBUTION OF AVAILABLE WATER QUALITY SAMPLES BY DECADE OF BUILD DATE (COPPER PIPING WITH LEAD SOLDER)



Although Denver Water has data from LCR compliance sampling dating back to 1997, only results from samples collected since 2011 were included in the analysis. Results from sampling prior to 2011 were considered to be less robust: Denver Water may have used different analytical methods with different detection limits, Denver Water's own procedures may have varied, and/or treatment objectives (and the resulting performance) at the three water treatment plants may have changed between 1997 and 2011.

The analysis by decade of lead concentrations measured at homes with copper piping with lead solder are presented in Figure 11. The majority of lead concentrations are relatively low and typically below 5 ppb, although higher lead release (7 ppb) is observed from homes constructed between 1983 and 1987.

FIGURE 11: DECADE ANALYSIS OF LEAD RELEASE FROM COPPER PIPING WITH LEAD SOLDER WITH EXISTING CORROSION TREATMENT



Note: Only results from the first draw from the 3-bottle test (blue bars) are used in Figure 11 due to its similarity with the Lead and Copper Rule sampling protocol for compliance sampling.

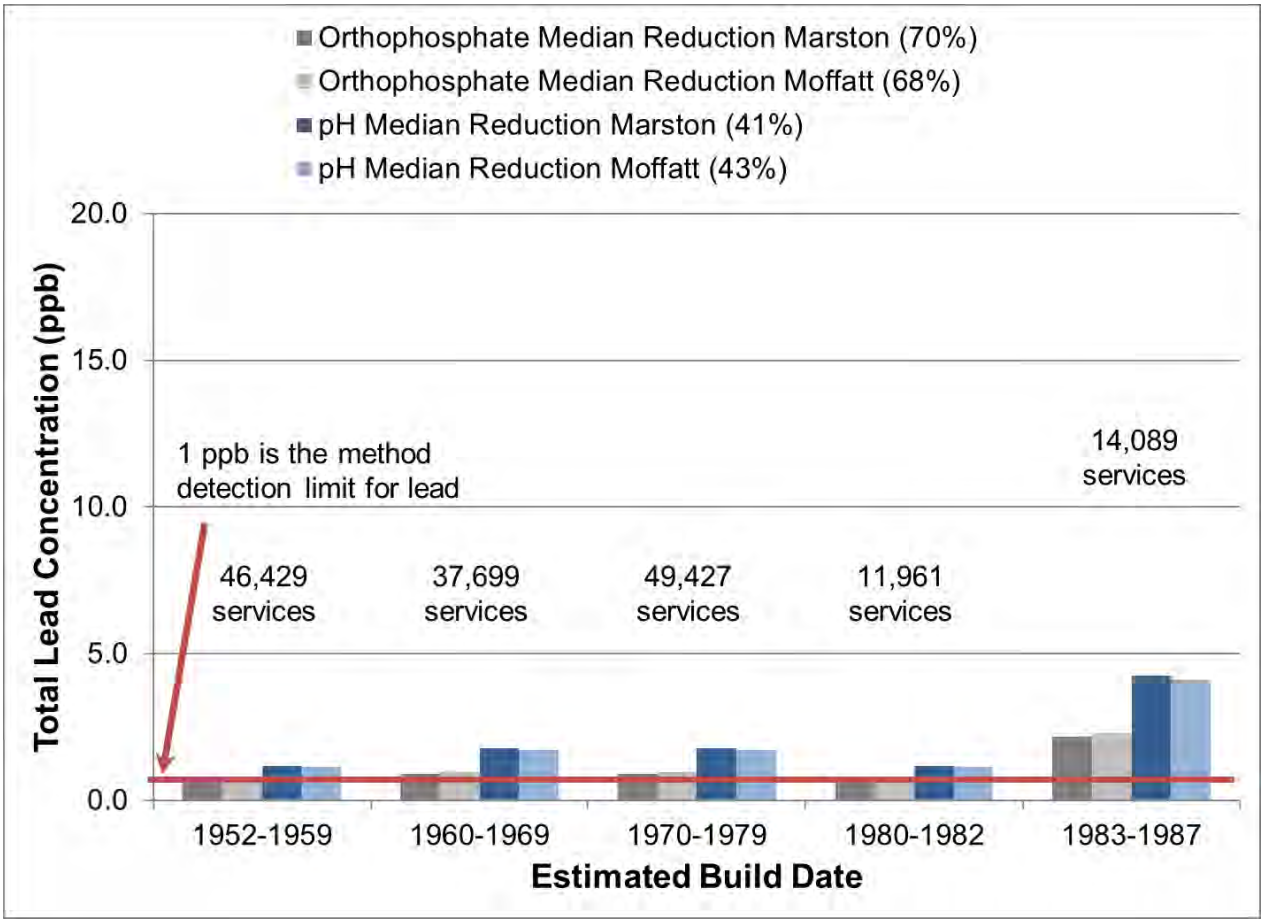
The data included in Figure 11 were reviewed to identify sites where lead concentrations were higher than would be expected from a property with copper piping with lead solder. Potential outliers were identified based on: i) lead above 5 ppb in at least five samples at a property included in the monitoring pool on multiple occasions; or ii) lead above 15 ppb in at last one sample.[7] Some results were clearly outliers (i.e., at one property, one value out of 15 was 100 times higher than all other results at the property) and some properties had results available both before and after lead service line replacement. Approximately 4% of the properties were identified as potential outliers and 1% were considered to have a lead service line and have been added to the lead service line inventory for replacement. Where no obvious explanation could be identified for variable lead results observed, additional field investigations were recommended to confirm the material of the service line (3% of properties).

[7] See Appendix II.C for details.

Regardless of whether a result was an outlier, all results from the 2011 to 2019 LCR compliance sampling set were included in the lead reduction analysis and therefore provide a conservative estimate of lead concentrations at homes constructed between 1983 and 1987.

The lead reduction percentages from the coupon tests from Table 5 were applied to the data included in the decade analysis of all homes with copper piping with lead solder, as seen in Figure 12. In some cases, the lead concentrations are below method detection limits (red line = 1 ppb). The decade analysis demonstrates that more than 45% of all of Denver Water's customers—and most customers served by copper piping with lead solder—will experience very similar lead concentrations whether Denver Water uses pH/alkalinity adjustment or orthophosphate. For the less than 5% of Denver Water properties built from 1983 to 1987, lead concentrations are projected to be less than 5 ppb and the difference in performance between pH adjustment and orthophosphate is approximately 2 ppb.

FIGURE 12: DECADE ANALYSIS OF LEAD RELEASE FROM COPPER PIPING WITH LEAD SOLDER AFTER TREATMENT



According to a Health Impact Partners report on policy making to achieve equity in lead poisoning prevention,[8] a difference of 2 ppb in lead concentration corresponds to a change in

[8] Adapted from the Human Impact Partner's "Achieving Equity in Lead Poisoning Prevention Policy Making: Proceedings from a Consensus Conference," May 2019. See HumanImpact.org/LeadPolicyEquity

blood lead level[9] of less than 0.1 ug/dL. For comparison, the Centers for Disease Control and Prevention defines elevated blood lead level at 5 ug/dL.

Based on the evidence above, Denver Water would assert that the difference in effectiveness of orthophosphate and pH adjustment is not meaningfully different for most customers served by copper piping with lead solder. Because the difference in lead concentrations is slightly greater for homes built from 1983 to 1987, Denver Water has proposed additional measures to reach equivalency, specifically targeted at existing and expecting families with formula-fed infants/children up to age 2. Details about these measures can be found in Sections III.

Effects of a comprehensive strategy to reduce lead concentrations in homes served by lead service lines

Because neither alternative corrosion control approach on its own (pH adjustment or orthophosphate) achieved the equivalency for reduction in lead concentrations while also reducing adverse impacts to downstream wastewater treatment plants and watersheds, Denver Water evaluated other strategies to achieve an equivalent or better reduction in lead exposure as the designated optimal corrosion control treatment.

This evaluation was prompted by CDPHE and EPA's request to provide an effective and comprehensive solution to protect individual customers as well as the population as a whole. Denver Water evaluated coupling pH adjustment with lead service line replacement, interim filter distribution and public education to meet this challenge. Below is a summary of the individual studies that supported the final recommendation and request for variance for the holistic approach.

Sources of lead

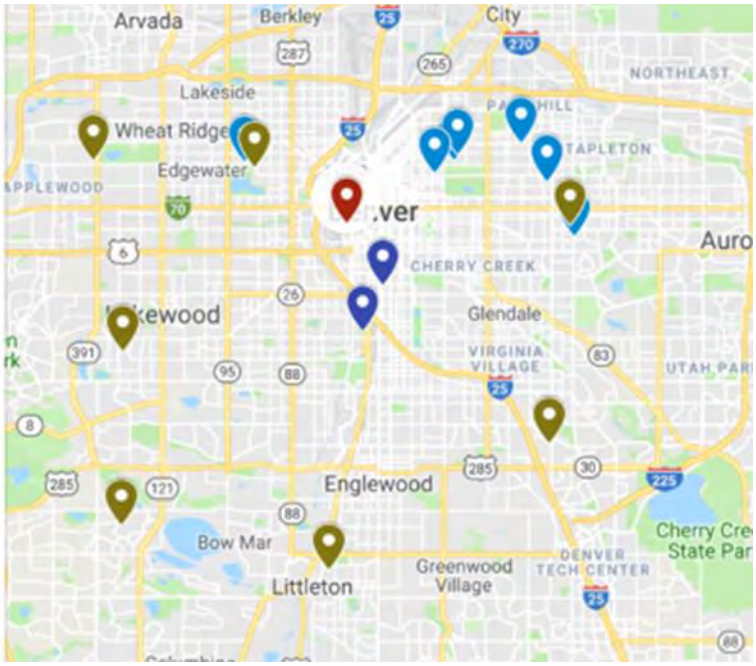
In conducting the studies, Denver Water had to determine the relative contributions of lead from lead service lines as compared with other sources, such as copper piping with lead solder and premise plumbing. In 2018 and 2019, Denver Water sampled water from volunteer Denver Water employee households to generate lead concentration profiles extending from the sink out to the water main in the street. Following EPA protocols, more than 20 sequential sample bottles of different sizes (from 125 mL to 1 L) were used in the sampling protocol.

In the initial round of sampling, Denver Water collected data from ten homes with known lead service lines; seven of these were sampled in subsequent rounds (see Figure 13). For comparison, lead profiles were also generated for eight homes with known copper piping with lead solder, with six homes being included in subsequent rounds of profiling. Customers self-selected whether to remain in the study for each subsequent sampling round. The water samples from these homes are representative of different neighborhoods within Denver Water's service area.

[9] The concentration of lead (in micrograms) in blood (deciliters), ug/dL, is used to quantify blood lead level.

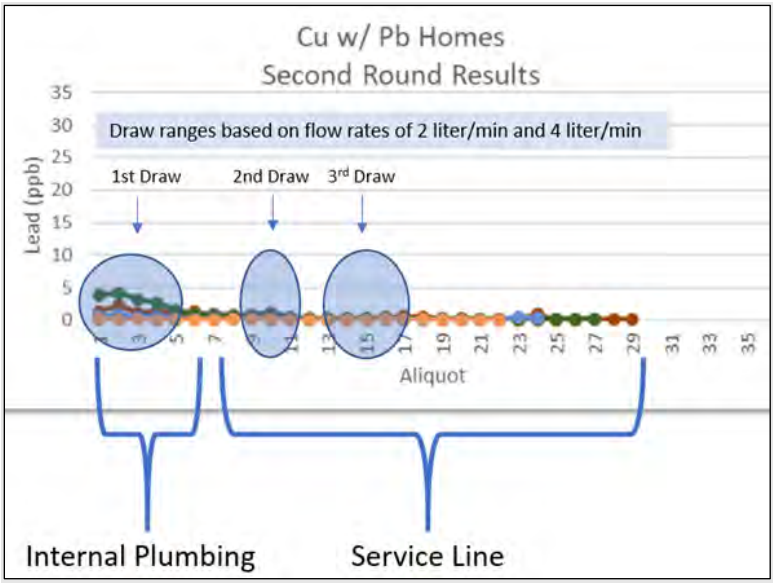
FIGURE 13: HOUSEHOLDS FROM ACROSS THE DENVER WATER SYSTEM INCLUDED IN PROFILE SAMPLING

(Blue denotes households with a known lead service line and green denotes households with a known copper piping with lead solder as included in the first round of sampling in 2019)



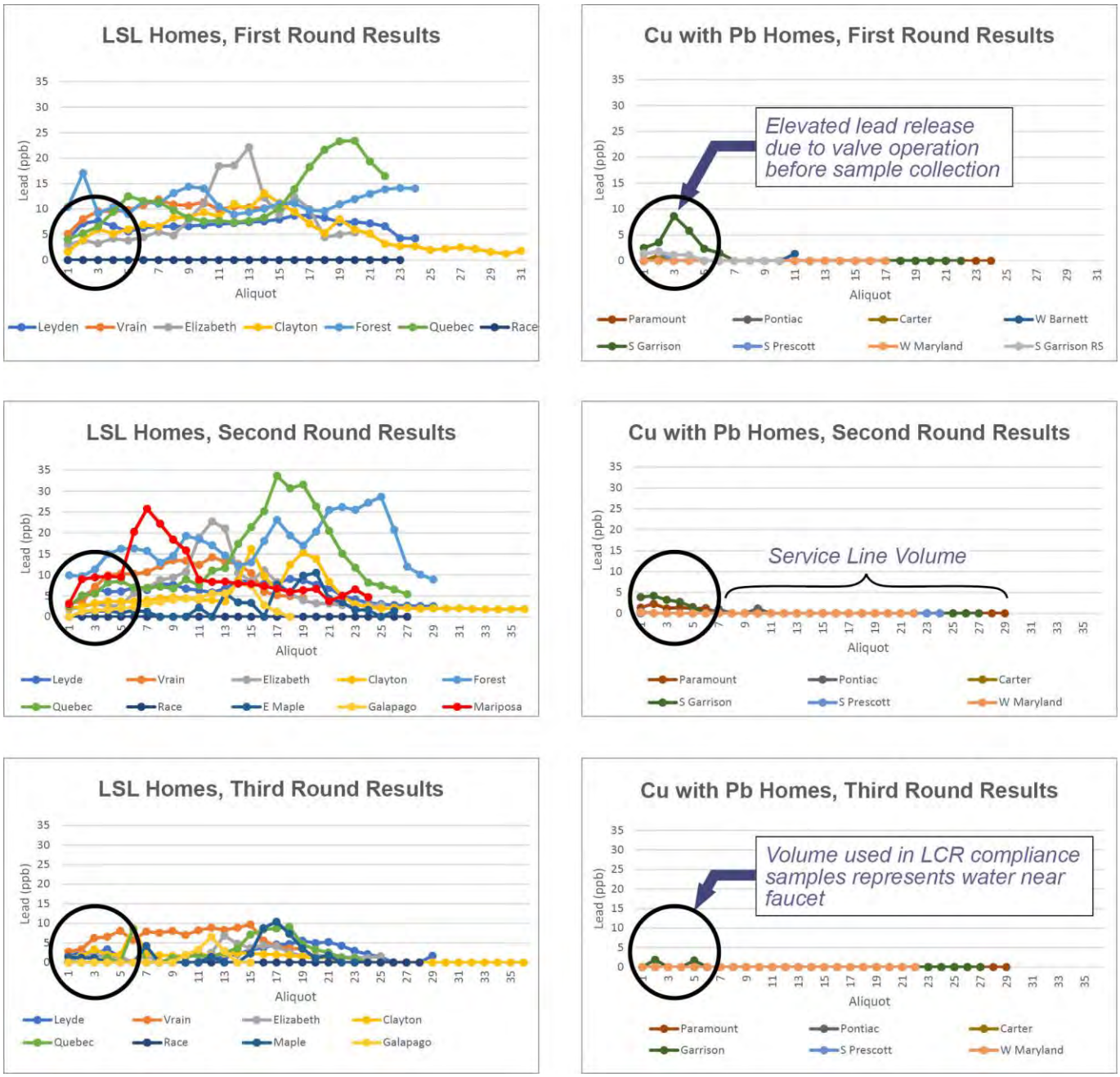
Results of this analysis show a higher concentration of lead in homes with lead service lines across the length of the profile (sink to water main). At households with verified copper piping with lead solder, lead release is typically characterized by a small increase in lead concentrations closest to the sink faucet, followed by a decrease to non-detect lead concentrations shortly thereafter, as shown in Figure 14.

FIGURE 14: LEAD PROFILE FROM SINK FAUCET TO WATER MAIN



Side-by-side results from the three rounds of lead profile sampling are shown in Figure 15; the lead concentration profiles of households with lead service lines are shown in the graphs on the left and the profiles of households with copper piping with lead solder are shown in the graphs on the right.

FIGURE 15: LEAD PROFILE RESULTS FROM VOLUNTEER DENVER WATER HOUSEHOLDS
(Lead service lines on the left, copper piping with lead solder on the right)



Results from profile testing at homes with copper piping with lead solder, as shown in the right column of Figure 15, demonstrate that lead concentrations are consistently maintained below 5 ppb and near non-detect levels with the existing corrosion control treatment. Simple flushing in the morning or after getting home from work or school would remove most of the lead captured during the sampling of water from these homes.[10]

Evaluation of the benefits of lead service line replacement

After the single exceedance of the action level for lead in 2012, Denver Water offered free water quality testing to all Denver Water users and more than 3,000 samples have been returned and analyzed since then. See Figure 16 for an overview of the 3-bottle sampling kit used by Denver Water.

FIGURE 16: DENVER WATER'S 3-BOTTLE SAMPLING KIT

Denver Water's 3-Bottle Sampling Protocol
Three 1 L water quality samples (i.e., 1st, 2nd and 3rd draw) were collected before and after lead service line replacement to provide insight into lead release from the faucet to the service line. Customers receive a sample kit with three 1 L bottles and are asked to sample from a cold-water faucet in a bathroom or sink that is not connected to a home water treatment system. Customers must avoid using water for a minimum 6-hour stagnation period before collecting samples. After the stagnation period, the customer turns on the cold water faucet and fills up the first bottle, allows the water to run for 30 seconds, fills up the second bottle, allows the water to run for 30 seconds and fills the third bottle. Results indicate the relative contribution to lead measured at the faucet from fixtures, in home plumbing and the service line. Per Figure 14, the first bottle captures water from internal plumbing and the second and third bottle capture water from the service line. Over 3,000 households have participated in the customer requested water quality sampling program. Denver Water offers water quality sampling for lead for free to all Denver Water households, visit: denverwater.org if you would like to participate.

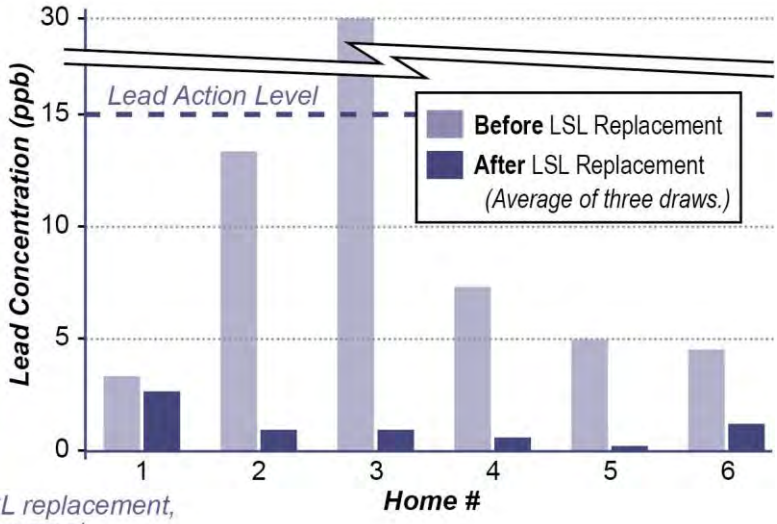
Six of the households who had previously sampled their water subsequently replaced their lead service lines between 2016 and 2018 with non-lead lines and followed up with recommended water sampling. A comparison of the before and after water quality results allowed Denver Water

[10] Information on the profiling study can be found in Appendix III.E.1.

to evaluate the impact of lead service line replacement on reducing lead concentrations. The results in Figure 17 demonstrate the potential public health benefit of permanently removing the dominant source of lead contributing to drinking water: lead was measured at 2.2 ppb or lower after lead service line replacement, regardless of the lead concentrations before replacement, which were measured as high as 30 ppb. These results align with the lead profile testing results in demonstrating the benefit of replacing lead service lines.

FIGURE 17: LEAD REDUCTION AFTER LSL REPLACEMENT MEASURED AT SIX HOUSEHOLDS

Home #	Before LSL Replacement			After LSL Replacement		
	1st Draw	2nd Draw	3rd Draw	1st Draw	2nd Draw	3rd Draw
1	5	0	5	5.1	1.3	0.2
2	9	14	30	3	0	0
3	29	31	30	1	1	1
4	8	12	2	2	0	0
5	2	2	11	1	0	0
6	3.5	5.3	5.7	2	2	0
Avg.	9.4	10.7	14.0	2.4	0.7	0.2



Lead is reduced to near non-detect levels after LSL replacement, regardless of the lead measured before LSL replacement.

Evaluation of a Filter Program

Although the replacement of lead service lines provides significant and permanent reductions in lead concentrations, it may take several years to remove all lead service lines. CDPHE was concerned about the customers who would not receive a lead service line replacement until year 10 or 15, for example. During that time, these customers would be subject to higher levels of lead with Denver Water's use of pH/alkalinity adjustment versus orthophosphate. Hence, filters were added to the LRP approach.

Filters can provide immediate protection from lead in drinking water when properly used and cartridges are replaced. They can also provide an interim barrier to remove lead from a customer's drinking water until the presence or absence of a lead service line can be confirmed. Pitcher filters can remove more than 97% of lead from drinking water.[11] At the same time, filters are only effective to the extent they are used.

To evaluate the potential filter adoption rate, Denver Water reviewed results from a past study of filter use by its customers. Based on a 2017 customer survey (1,432 responses) by Denver Water, 54% of customers reported that their households typically drink unfiltered tap water, 37% of respondents used filters (the type of filter used was not confirmed) and 9% drank bottled water regularly.

[11] See Appendix III.C.2.

More recently, in July 2019 Denver Water conducted a Filter Pilot Program of 300 customers with known or suspected lead service lines. Participants were surveyed two weeks after receiving a pitcher filter.[12] Based on lessons learned from the pilot, Denver Water will include the following steps as part of the full-scale Filter Program:

1. Provide advance targeted communications, outreach and education prior to filter distribution to introduce the Filter Program and explain the importance of filter use.
2. Reinforce the importance of using the filter for cooking and infant formula preparation, in addition to drinking water.
3. Inform participants that the filters and replacement cartridges are provided at no cost to the customer for the duration of the program.
4. Explore alternative filter types.

Participants of the Filter Pilot Program were randomly selected in seven neighborhoods that are representative of the general Denver Water customer population. The participants included a range of income levels and a mix of English-speaking and Spanish-speaking households. All household in the Filter Pilot Program were asked to complete a filter use survey and by August 13, 2019, 27% of all participants had completed the survey. Of the surveys completed, 13% were completed in Spanish. Filter use survey responses indicated a 91% filter adoption rate for drinking water and a 60% filter adoption rate for cooking.

Evaluation of comprehensive approach: pH/Alkalinity adjustment combined with accelerated lead service replacement and Filter Program

Based on the analysis of alternative corrosion control treatments and exploration of other strategies to reduce lead exposure, a multi-faceted approach that includes corrosion control using pH/alkalinity adjustment, the accelerated replacement of customer-owned lead service lines within 15 years and a Filter Program, which will provide immediate protection will offer the highest public health benefit in both the short and long term. This approach is the foundation for the Lead Reduction Program.

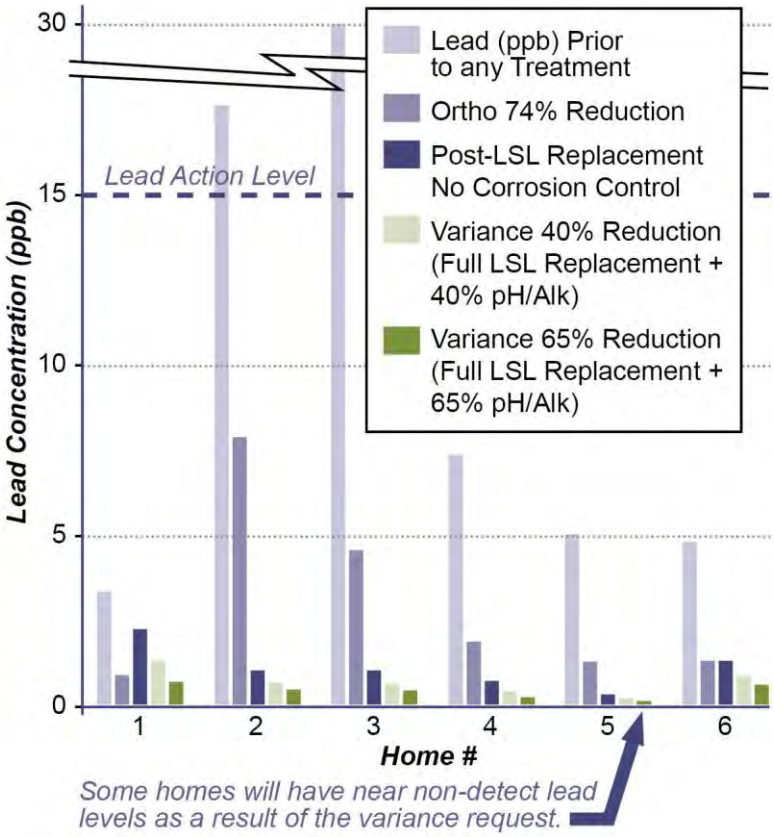
As shown in Figure 18, in the long-run, replacing lead service lines and adjusting the pH/alkalinity of the water will be far more effective at reducing lead exposure compared with continued treatment with orthophosphate. For the six households sampled, lead concentrations are predicted to be less than 5 ppb with the variance alternative.

[12] The Filter Pilot and survey are described in Appendix III.C.2

FIGURE 18: EXPECTED LEAD CONCENTRATIONS UNDER ORTHOPHOSPHATE AS COMPARED TO THE VARIANCE APPROACH AT SIX HOUSEHOLDS WITH A LEAD SERVICE LINE

Home #	Lead (ppb) Prior to any Treatment	Lead (ppb) After Treatment			
		Orthophosphate 74% Reduction	Post-LSL Replacement No Corrosion Control	Variance 40% Reduction (Full LSL Replacement + 40% pH/Alk)	Variance 65% Reduction (Full LSL Replacement + 65% pH/Alk)
1	3.3	0.9	2.2	1.3	0.8
2	17.7	4.6	1.0	0.6	0.4
3	30.0	7.8	1.0	0.6	0.4
4	7.3	1.9	0.7	0.4	0.2
5	5.0	1.3	0.3	0.2	0.1
6	4.8	1.3	1.3	0.8	0.5
Avg.	11.4	5.0	1.1	0.7	0.4

Based on actual sample test results pre- and post-LSL replacement, using the average of the three bottles collected from each home.



Evaluation of lead concentrations in water for households that do not adopt filters

Until the lead service line can be replaced, all customers with known, suspected or possible lead service lines will be given a filter that is NSF-certified to remove lead. If a household does not use a filter to remove lead for drinking and cooking, the household will still receive the benefit of a 40% to 65% reduction in lead concentrations from pH/alkalinity adjustment (yellow columns in Table 6) but will not benefit from the 97% reduction provided by the filters (purple column in Table 6). The success of the Lead Reduction Program depends on the cooperation of the customer, particularly during the period when all known lead service lines are being replaced. Without the interim use of filters until the lead service line can be replaced, the orthophosphate alternative will outperform the Lead Reduction Program for that home. The number of customers required to use filters to achieve equivalent performance to orthophosphate alone is discussed in Section III; however, Denver Water will strive for 100% filter adoption to reduce lead exposure for all customers with a known, suspected or possible lead service line.

TABLE 6: COMPARISON BETWEEN FILTER USE AND PH/ALKALINITY ADJUSTMENT DURING THE VARIANCE TERM (2020 TO 2034) AT SIX HOUSEHOLDS

Homes that use a filter (purple column) and homes that do not use a filter (yellow columns)
(The lead service line has not been replaced in either scenario)

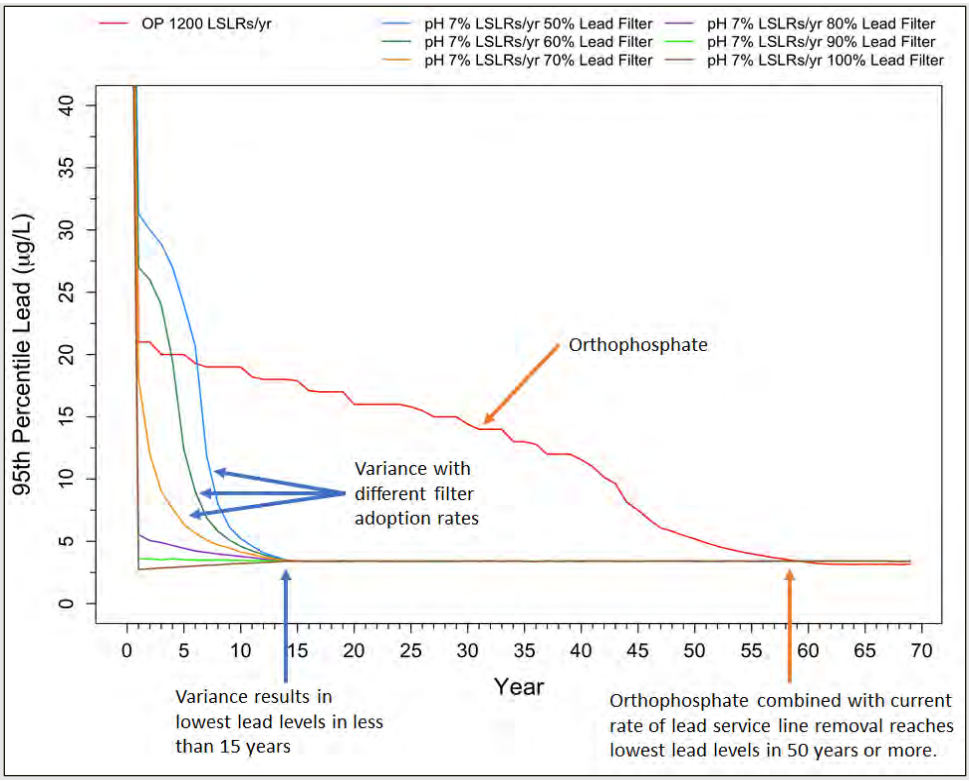
Household Number	Lead (ppb) Prior to Any Treatment Pre-LSLR*	Lead (ppb) After pH/Alkalinity Treatment with and without Filter prior to lead service line replacement		
		Filter** 97% Reduction	Variance 40% Reduction no filter/no LSLR	Variance 65% Reduction no filter/no LSLR
1	3.3	0.1	2.0	1.2
2	17.7	0.5	10.6	6.2
3	30.0	0.9	18.0	10.5
4	7.3	0	4.4	2.6
5	5.0	0	3.0	1.8
6	4.8	0	2.9	1.7
Average	11.4	0.3	6.8	4.0

An equivalency model was developed to compare orthophosphate and the variance alternative on lead exposure to all Denver Water customers. The model conservatively estimates lead concentrations using data from LCR and customer inquiry sampling, the lead service line pipe rack study and the copper with lead solder coupon study to predict lead concentrations at all connections in the Denver Water service area every year.

The equivalency model was used to evaluate the effectiveness of different filter adoption rates combined with other variance elements in reducing lead exposure as compared to orthophosphate, as shown in Figure 19.[13] The model does not do any averaging, but in order to display the model results in a digestible way, Figure 19 shows the 95th percentile lead concentration for all service lines in the Denver Water service area, including lead, copper and non-lead materials.[14] The y-axis scale of Figure 19 is adjusted for clarity. As a result, the lead concentrations for year 0 (existing condition) are not shown, and all the modeled scenarios begin at about 90 ppb. Based on this analysis, Denver Water must increase the filter adoption rate for customers with known, suspected and possible lead service lines from 37% (2017 survey) to 65% to provide equivalent protection when used in combination with accelerated lead service line replacement and pH/alkalinity adjustment. Denver Water will strive for 100% filter adoption using lessons learned from other large-scale lead reduction programs.[15]

[13] For a description of the equivalency model see Appendix II.A.
[14] Full results are available in Appendix II.A.
[15] See Appendix III.C.3.

FIGURE 19: PROJECTED LEAD CONCENTRATIONS (95TH PERCENTILE) COMPARING ORTHOPHOSPHATE (RED LINE) WITH DENVER WATER'S PROPOSED VARIANCE APPROACH (ALL OTHER COLORED LINES)



Final evaluation of the expected results of the Lead Reduction Program

Another way to compare the performance of the Lead Reduction Program (using pH or filters, before the lead service line is replaced) to orthophosphate is to evaluate the expected 90th percentile lead concentrations. The following four scenarios based on service line material and filter adoption were considered (see Table 7):

- Property with a lead service line and using a filter for drinking and cooking.
- Property with a lead service line and not using a filter.
- Property with copper piping with lead solder.
- All other properties with no lead service line and no lead solder.

Using results from pipe rack testing, lead concentrations in drinking water for customers who use filters are expected to decrease to non-detect levels. Customers who have lead service lines and do not use filters will experience a reduction in lead concentrations due to pH/alkalinity adjustment of approximately 50%, reducing 90th percentile lead concentrations to 7 ppb.

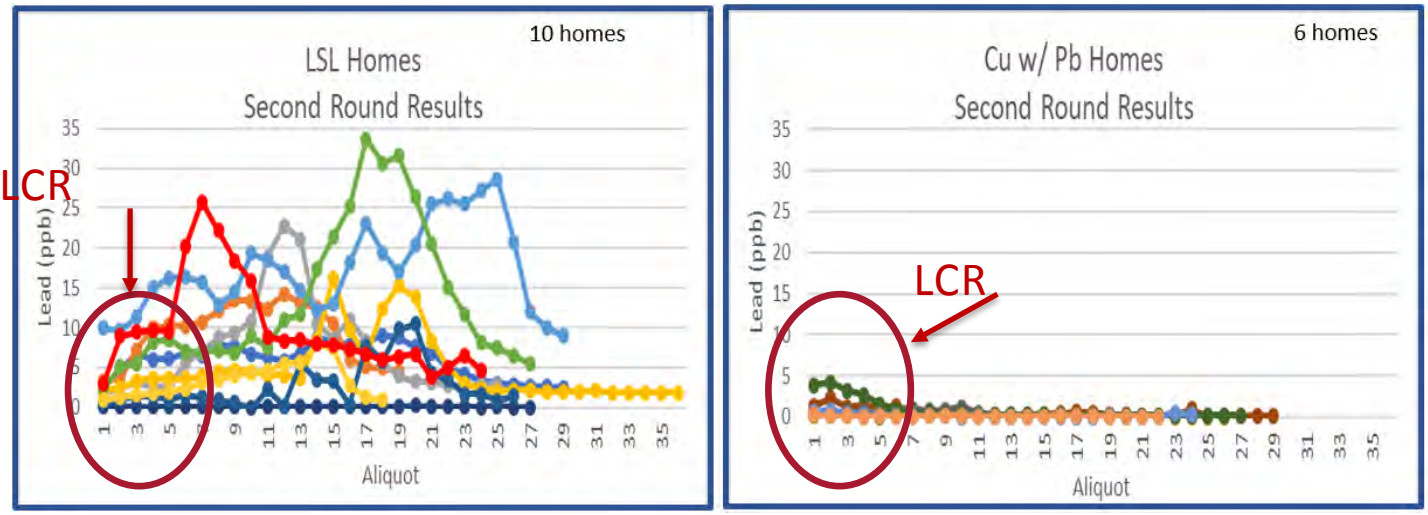
TABLE 7: ESTIMATED 90TH PERCENTILE LCR LEAD CONCENTRATIONS AS A FUNCTION OF SERVICE LINE TYPE

Scenario	Estimated 90th Percentile Lead Concentration			
	LSL + Filter	LSL no Filter	Lead Solder	Non-lead**
Number of Services	63,955		159,605	96,140
Historic LCR Lead Concentration	14.0		7.2	3.0
Lead Concentration with pH/Alkalinity (ppb)*	< 1	7.0	4.1 - 4.2	1.7 - 1.8
Lead Concentration with Orthophosphate (ppb)*	N/A	3.6	2.2 - 2.4	0.9 – 1.0

*Based on percent lead reduction observed from pipe rack testing of 50% for pH/alkalinity adjustment and 74% for orthophosphate (per March 2018 designation for optimal corrosion control treatment by CDPHE).
**LCR does not apply to non-lead service lines.
N/A = not applicable

For the approximately 160,000 customers in homes built from 1952 to 1987 with copper piping with lead solder, 90th percentile lead concentrations in the first liter of water are expected to range from non-detect to 4.2 ppb with pH/alkalinity adjustment where the occupants do not flush their water line before using water for drinking, cooking and formula preparation. Lead concentrations in the subsequent liters of water will drop to near non-detect levels based on existing data, as presented in Figure 20. Lead concentrations in all other non-lead service lines are expected to be near non-detect levels under either pH/alkalinity or orthophosphate application.

FIGURE 20: PROFILING DATA FOR COMPARISON TO LCR SAMPLING PROTOCOL WITH FIRST LITER



While the expected lead concentration results are low in the pH/alkalinity and orthophosphate approaches, the historic lead concentrations assumed for the initial concentration may not be the best representation of the lead exposure to Denver Water customers. Data from profiling indicate that the first draw sample underestimates the lead released from lead service lines and overestimates the lead released from copper piping with lead solder, as shown in Figure 19. To confirm this observation, data available from customer requested sampling from homes constructed between 1952 and 1987 with copper piping with lead solder were analyzed to understand typical lead concentrations in each bottle or draw included in the 3-bottle test. Results are shown in Table 8 and demonstrate that there is very little lead measured in the second and third draws from lead solder homes. This also supports the hypothesis that the bulk of the lead exposure comes from the estimated 63,955 lead service lines and not the estimated 159,605 copper pipes with lead solder. Lead service line replacement provides a multi-generational benefit of significantly reduced lead exposure to Denver Water customers.

TABLE 8: LEAD CONCENTRATIONS MEASURED IN CUSTOMER SAMPLES OBTAINED FROM HOMES WITH LEAD SOLDER BY BUILD DATE

Decade of Home Construction	Customer Requested Sampling 3-Bottle Test		
	90th Percentile Lead (ppb)		
	1st Draw	2nd Draw	3rd Draw
1952-1959	2.00	0.50	0.50
1960-1969	3.00	0.50	0.50
1970-1979	3.00	1.50	0.50
1980-1982	2.00	1.16	0.50
1983-1987	2.00	0.50	0.50

Conclusions

In summary, Denver Water evaluated three different approaches separately and combined, to determine if they provide equivalent public health protection when compared with orthophosphate added to drinking water at 2 mg/L. The studies show that the comprehensive approach of accelerated lead service line replacement, filter distribution and pH/alkalinity adjustment will be more efficient at reducing lead releases compared with the use of orthophosphate alone while reducing impacts to wastewater treatment plants and the environment.

III. PROPOSED LEAD REDUCTION PROGRAM

The proposed Lead Reduction Program is a holistic and permanent lead reduction approach that will reduce lead concentrations to under 5 ppb and near non-detect levels in less than 15 years. The LRP is generally more effective at reducing lead exposure than adding orthophosphate to Denver Water's drinking water and will protect public health and the environment. The essential elements of the program are:

- Execution of a **communications, outreach and education program** to help customers understand the program and ways they can reduce their exposure to lead.
- Creation of a **lead service line inventory** to inform the accelerated replacement of LSLs and to allow customers to investigate the likelihood of having an LSL.
- Implementation of a **lead removal filter program** to all homes with known, suspected or possible LSLs, reducing lead by 97%.
- Implementation of an **accelerated lead service line replacement program** that would remove the major source of lead decades ahead of the current rate of replacement (approximately 63,955 lead service lines within 15 years versus 50 years or more under current practices).
- Adjustment of pH and alkalinity for **corrosion control treatment** to reduce corrosion of lead service lines, household plumbing and fixtures.

The following sections describe how each of these LRP elements will be implemented.

III.A Communications, Outreach and Education Plans

Communications, outreach and education are the critical foundation for successful implementation of the LRP. As recognized by the EPA when adopting the Lead and Copper Rule in 1991, "the more frequently an individual is provided with information on lead in drinking water, the more likely he or she will take some action to reduce his or her exposure." 56 FR 26460-01, 26501 (June 7, 1991).

In addition to ongoing efforts since 2012, Denver Water has been working with regional community networks to begin the communications, outreach and education program during the summer of 2019. During this time, Denver Water informed and engaged the public on the variance process, including the broader topic of lead in drinking water, and supported the pilot Filter Program. Lessons learned during this initial phase will be used to inform the communications, outreach and education programs that will go into effect in 2019 or early 2020.

Detailed communications and outreach plans for the pre-variance phase laid the foundation for

Denver Water has a youth education program that reaches thousands of local families and Denver youth by directly engaging with schools in the area every year.

As a part of the communications, outreach and education efforts, Denver Water has tested more than 15,000 samples of water from schools within its service area for lead and is working with the school districts on their remediation efforts.

the development of future communications and outreach plans. Objectives and strategies for the LRP, including each of its elements, are outlined in the following sections.

COE objectives and strategies:

The overarching goals for communications will be to scale up education and outreach efforts to achieve the following:[16]

- Inform customers and stakeholders of EPA's final decision.
- Raise awareness among all customers of the change and its impacts.
- Emphasize the outcome of implementation of the LRP, namely improved water quality and reduced risk of exposure to lead in drinking water for those with lead service lines and plumbing.
- Provide clear and consistent messaging and branding.

Upon approval of the variance, Denver Water will further aim to:

- Build a platform for communitywide education and engagement regarding the Lead Reduction Program that includes communications and outreach and gathers feedback to improve the program as it moves forward.
- Facilitate training for contractors, employees and vendors to educate these groups on where to direct customer inquiries and to support consistent communications on the program.
- Provide clear, accurate and timely information and messaging about the Lead Reduction Program to target audiences.
- Educate and engage with customers, residents, families and communities in order to create a common understanding of and instill confidence in the Lead Reduction Program.
- Support a specific communications, outreach and education program targeted at expecting and existing families with formula-fed infants/children up to age 2 living in homes with copper piping with lead solder built 1983-1987.
- Educate customers to encourage consistent, proper and ongoing filter usage, and develop materials that easily demonstrate how to use the filters.
- Encourage customers to consider in-home plumbing updates.
- Encourage customers to flush the tap before drinking, cooking or preparing infant formula after prolonged periods during which water is not used, such as first thing in the morning or when returning home from work or school.
- Seek feedback from customers and others about the Lead Reduction Program to learn best practices and effective ways to implement program activities.
- Incorporate the Learning by Doing approach to improve outcomes during the life of the Lead Reduction Program.

[16] For further details regarding the COE Plans, see Appendix III.A.

Detailed communications plans will be developed for each element of the LRP: the Lead Service Line Inventory, the Filter Program, the Accelerated Lead Service Line Replacement Program and Corrosion Control Treatment. The communications plans will include an analysis of target audiences; key messaging developed in tandem with CDPHE and EPA to inform all core communications collateral and materials; and training and resources for Denver Water employees and contractors, with an emphasis on those who interact directly with customers.

Lead Service Line Inventory objectives and strategies:

The LSL Inventory is an inventory of lead service lines in Denver Water's service area, which will inform the ALSLR Program. The LSL Inventory will be regularly updated over the 15-year period of the LRP.

The communications plan for the LSL Inventory will have the following objectives:

- Inform and educate customers about their service lines – ownership, material types and plumbing.
- Engage distributors to assess lead services lines within Denver Water's integrated system.
- Work with municipalities to develop better records regarding service line material.

Denver Water employees and contractors working to educate and inform customers, assist customers with inquiries and collect data for the LSL Inventory will follow the LSL Inventory communications plan. The plan will include a variety of communications methods to reach targeted audiences, including direct mail marketing and outreach, mapping tools, water quality tests, websites with links to educational information about LSL verification methods and training resources for plumbers.

Filter Program objectives and strategies:

The Filter Program will provide filters and educational materials to customers with known, suspected or possible lead service lines and encourage consistent, ongoing and proper filter use.

The communications plan for the Filter Program will have the following objectives:

- Inform and educate customers about the Filter Program.
- Engage with customers with known, suspected or possible LSLs to ensure they receive a filter.
- Work with property owners, local housing authorities and tenants to share information and encourage filter use with residents in rental and multi-family properties.
- Encourage filter use for drinking, cooking and when preparing infant formula.
- Encourage changing the filter cartridge according to the manufacturer's instructions.
- Educate customers about flushing and provide flushing instructions to encourage flushing the tap before drinking, cooking or preparing infant formula after prolonged periods during which water is not used, such as first thing in the morning or when returning home from work or school.

The Filter Program communications plan will focus on target audiences that include customers in homes with lead service lines, local governments, distributors, elected officials, public health agencies and health providers. Communications, outreach and education will also target expecting and existing families with formula-fed infants/children up to age 2 in homes with copper piping with lead solder built from 1983 to 1987, per CDPHE guidance. It will also provide information for Denver Water staff and contractors who are distributing filters to help them direct customers to appropriate resources and channels for answers to their questions. Implementation of the communications plan will begin with notification to affected residents of the Filter Program. Communications channels will include door-to-door communications, a customer tracking system, how-to videos and local opportunities to engage residents.

Denver Water's Filter Program will target expecting and existing families with formula-fed infants/children up to age 2 in homes with copper piping with lead solder built from 1983.

Accelerated Lead Service Line Replacement Program objectives and strategies:

The ALSLR Program will replace customer-owned lead service lines and provide information on post-replacement flushing procedures.

The communications plan for the ALSLR Program will target both property owners and residents and have the following objectives:

- Inform and educate customers about their service lines – ownership, material types and plumbing.
- Inform and educate customers about their premise plumbing – sources of lead, known potential health risks and options or strategies to reduce the risk of lead exposure from premise plumbing.
- Obtain property-owner consent to replace their lead service line and share information with the owner and residents of the property on what to expect from service line replacement.
- Provide support and information on post-replacement filter use and flushing.
- Provide customers with appropriate education and resources on water quality testing and the results of testing following lead service line replacement.
- Offer Denver Water staff and contractors strategies to obtain the consent of property owners who have refused to have their lead service line replaced.

Corrosion control treatment objectives and strategies:

Corrosion control treatment of the water will help minimize the release of lead into water from lead service lines and household plumbing and fixtures that contain lead.

The communications plan for corrosion control treatment will have the following objectives:

- Provide information on the Lead and Copper Rule and metal corrosion for general audiences.
- Inform and educate residential and commercial customers about the sources of lead in plumbing.
- Raise awareness among customers of the upcoming water treatment change and its potential impacts to water aesthetics, if any.
- Emphasize the outcome of increasing the pH — improved water quality and reduced risk of lead exposure in drinking water for customers with lead service lines and lead plumbing.
- Educate customers about flushing and provide flushing instructions to encourage flushing the tap before drinking, cooking or preparing infant formula after prolonged periods during which water is not used, such as first thing in the morning or when returning home from work or school.
- Provide clear and consistent messaging and branding.

What if the COE Plans do not generate the desired awareness and engagement?

Outreach and engagement will evolve and be refined over the life of the LRP. With each year of the LRP, Denver Water staff will have an increased understanding and awareness of the engagement strategies that have been effective. Denver Water is committed to conducting ongoing assessments and annual reporting of its COE metrics to determine if corrective action needs to be taken. Additionally, Denver Water will incorporate qualitative findings from ongoing stakeholder input to identify opportunities for improvement through the Learning by Doing element described later in this section.

How will Denver Water reach all of its customers?

Denver Water will focus much of its communications efforts on households in single-family and multi-family residences that have known, suspected or possible lead service lines. These households include occupants of apartments who normally do not have a direct customer relationship with Denver Water. Communications efforts are best targeted toward this group of customers because they will also be enrolled in the Filter Program.

Denver Water recognizes that it is important to communicate with all types of customers, including critical, commercial and industrial customers, and the communications, education and outreach strategies outlined in this plan will include them as audiences, as well.

By working closely and frequently with this broad group of customers, Denver Water can better foster filter adoption and use, partner with its customers in identifying and locating lead service lines and obtain valuable input from its customers.

A key focus of the COE Plans and the targeted communications plans for each element of Denver Water's LRP is equity and accessibility. Considerations will include health equity and environmental justice and creating systems where all customers have the opportunity to thrive.

Table 9 summarizes the strategies Denver Water will use to implement the COE Plans.

TABLE 9: STRATEGIES USED TO IMPLEMENT COE PLANS

- **Develop and incorporate key messages and talking points for Denver Water, CDPHE, EPA and stakeholders.**
- **Develop external communication strategies and tools to include, at a minimum:**
  - Digital communications (customer emails, social media, DenverWater.org/Lead webpage).
  - Printed collateral (fact sheets, FAQs, direct mailers).
  - Presentations to Registered Neighborhood Organizations.
  - Community meetings and listening sessions.
  - Integration into existing Denver Water communications and outreach (water trailers, TAP news site).
  - Traditional media engagement.
  - Other tactics to be identified through discussions with neighborhood leaders and community members and in ongoing coordination with partners.
- **Subject matter conveyed to include, at a minimum:**
  - Variance process and Lead Reduction Program.
    - Potential next steps after the EPA's final decision is made.
    - Lead service line identification.
  - Corrosion control treatment.
  - Accelerated lead service line replacements.
  - Filter distribution and use.
  - How lead can get into drinking water.
  - How customers can have their water tested.
  - How customers can manage their exposure to lead.
  - Where to get more information, including on other sources of lead.
- **Support staff training:**
  - Meet with internal staff to discuss communication needs.
  - Develop and implement training for customer support.
  - Identify clear channels for customer inquiries, feedback and questions specific to the variance and Filter Program.
- **Brief regulators, elected officials, utility managers and local health departments.**
- **Create lists of special audiences per anticipated impacts of each potential treatment method (e.g., industrial/commercial customers).**
- **Share customizable outreach materials to support distributors' customer communications.**
- **Focus and prioritize education and engagement to high-risk community members (e.g., expecting and existing families with formula-fed infants/children up to age 2) such as:**
  - Leverage existing stakeholder relationships/communication channels established by Denver Department of Public Health and Environment and Denver Water.
  - Target messaging for various community organizations, doctor offices, etc.
  - Partner with community health clinics, daycare/child care providers, social service programs for women and families.
- **Provide multiple, accessible ways for all community members to engage, with an eye toward:**
  - Providing all program materials in Spanish and other languages as needed.
  - Grassroots, on-the-ground outreach that directly engages with people in the comfort of their community (e.g., existing community events, gathering places and forums).
  - Partnering with local community leaders and non-profits with established relationships and credibility in the community.
  - Scheduling and executing public events in a manner that makes them accessible (e.g., providing child care, interpretation services).

III.B Lead Service Line Inventory

Because Denver Water does not own its customers' service lines, its database of known lead service lines is limited. The existing inventory is compiled from historical records of observations made during water main replacements, leak repairs and meter installations. Past water quality test results suggest that homes built prior to 1951 are likely to have lead service lines, but some of those service lines may have been replaced over time. Denver Water will undertake a rigorous investigative effort, especially in the early years of the LRP, to build a more accurate lead service line inventory for customers, regulators and other stakeholders.

Developing a comprehensive lead service line inventory to support the program

Over the last year, Denver Water developed a comprehensive lead service line inventory using a logic-based methodology. In addition, Denver Water is using a predictive model to further refine the inventory. The inventory groups service lines into five categories, assigning each a probability score that is based on the likelihood that a service connection is made of lead. The probability score for each property is developed using known construction practices, historical records, expert judgement and data interpretation.[17]

The following three categories represent service lines most likely to consist of lead:

- Known LSL – 100% direct evidence documenting lead.
- Suspected LSL – 80% or higher likelihood of lead, based upon available data (i.e., homes built prior to 1951).
- Possible LSL – 50% or higher likelihood of lead, as some data may be conflicting or missing but there is not enough information to confirm a non-lead service line.

The following two categories represent service lines that either are unlikely to contain lead or contain no lead:

- Unlikely LSL – <10% very low likelihood of lead.
- Non-lead – 100% direct evidence or statistically defensible factors supporting categorization as a non-lead service line.

These categories enable Denver Water to:

1. Identify candidate properties for inclusion in the Filter Program and the ALSLR Program. Providing filters to all properties with a known, suspected or possible lead service line is fundamental to demonstrating the efficiency of the LRP when compared with the alternative of orthophosphate.
2. Pinpoint geographic areas or individual properties for investigation of suspected or possible lead service lines. Through subsequent water quality testing and/or field investigations, these properties will be moved to the known LSL or non-lead categories.

[17] The process used to assign a given property to one of the categories is described in Appendix III.B.2 and Appendix III.B.3.

3. Quantify and prioritize the known and suspected LSLs for efficient and targeted replacement during the ALSLR Program, focusing early on areas and homes with our most vulnerable populations and where economies of scale and opportunity can be achieved in conjunction with road projects and main replacements.

What factors help Denver Water identify the likelihood of a lead service?

As noted in Section I, Denver Water anticipates that most lead service lines in Denver will be found at properties built before 1951. Typical service line materials include copper, lead, galvanized steel and other non-lead materials. Service lines comprised of either full or partial sections of lead or galvanized steel will be documented and counted in the inventory as a lead service line.

Denver Water may use the following factors to refine the lead service line inventory:

- Historic records of observed service materials, tap sizes, water main replacements and LCR plumbing materials surveys.
- Knowledge of the materials that were used at certain periods and other likely identifiers; for example, lead concentrations in Denver Water's system drop off significantly in homes built after 1950 and lead service lines were prohibited in Denver starting in 1971.
- Information from the redevelopment of existing homes from City and County of Denver records and other entities that are subject to Denver Water's operating rules.
- Information from the entire integrated system; Denver Water will work with its distributors to identify the addresses of known or verified lead service lines and the dates when lead service lines were allowed or not allowed.

Denver Water's service area has approximately 319,700 customer service lines, including schools, businesses and multi-family units. Table 10 lists the estimated number of service lines by category (as of August 2019).

TABLE 10: PROBABILITY ESTIMATE OF SERVICE LINES

Service Line Category	Estimated Number of Services	Properties to be Enrolled in Filter Program
Known LSL*	1,066	**84,546 service lines assumed to be included as candidate properties for the Filter Program and further investigation.**
Suspected LSL	61,374	
Possible LSL	22,106	
Unlikely LSL	89,388	
Non-Lead	145,766	
Total	**319,700**	

*LSL = Lead Service Line

The service line categories shown in Table 10 were further refined to compute the expected number of lead service lines and non-lead service lines using the assigned inventory probabilities, census and other data (Table 11).

TABLE 11: OVERVIEW OF THE DIFFERENT CATEGORIES OF SERVICE LINES

	Basis	Lead Service Lines	Non-Lead Service Lines	Total
Census	Direct Evidence	316	10,244	10,560
	Evidence from Distributors	180	30,562	30,742
	Post 1972 Build Date and Tap Date	0	102,461	102,461
	Pre 1952 Property & Water Quality Results	625	7	632
Estimate	Build & Tap Dates	62,325	108,854	171,179
	Service Size	0	1,129	1,129
	Presumed Replacement	0	967	967
	Water Sales Manual Review	509	1,521	2,030
	Totals	**63,955**	**255,745**	**319,700**

As of August 2019, the estimated number of lead service lines is 63,955. Denver Water is currently engaged in a field investigation involving potholing approximately 200 service lines within the City and County of Denver to confirm the material used for service lines. The results will be used to verify the logic used in the LSL Inventory and predictive model.[18] Responses from the integrated systems will also be used to inform future inventory estimates.

The number of service lines categorized as suspected, possible and unlikely will diminish over time, while the number categorized as known and non-lead will increase. This is especially likely to occur in the first five years of the LRP as further research of historical data, results from observations during the annual replacement of lead service lines and additional field and water quality investigations inform and improve the accuracy of the numbers and factors in the inventory model.

What more will Denver Water do to improve the certainty of the LSL Inventory?

Denver Water has expanded the lead service line inventory to incorporate a predictive model[19] that integrates data from investigations and ALSLR Program results to increase the efficiency of lead service line identification within Denver Water's service area. Additional investigation methods may include:

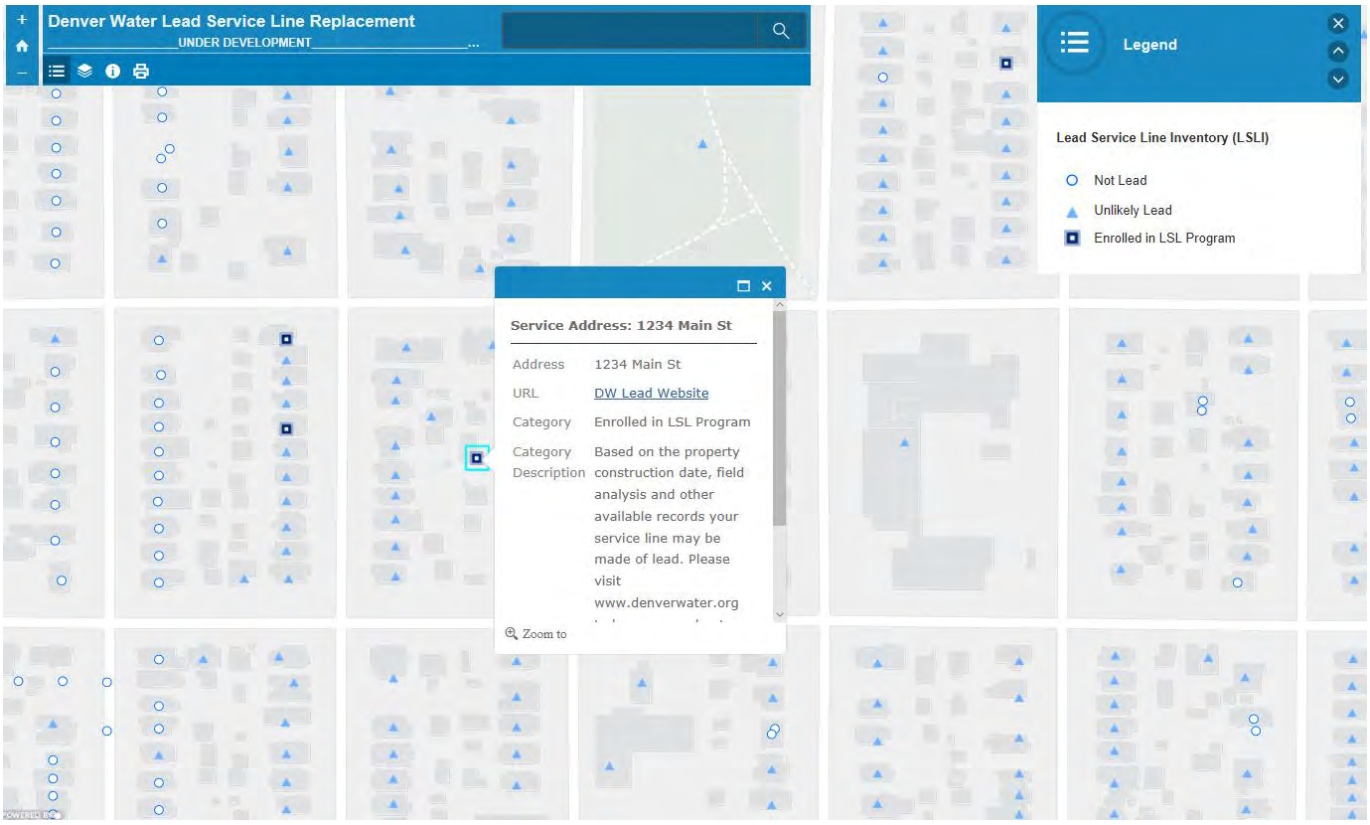
[18] As discussed in later in Section III.B.
[19] Please see Appendix III.B.3 for details.

- Water quality sampling using the 3-bottle test to establish the service line profile. Denver Water's research shows that water quality assessed from the second and third bottles is indicative of the service line material, especially lead.
- Historical data review to improve the knowledge of a given property and assess the likelihood of having a lead service line (ongoing effort).
- Visual inspection of the service line material where the line enters the meter pit and/or home, if accessible.
- Potholing to visually inspect for the presence of lead.
- Contact with property owners to determine the history of any updates to the property.

How will customers know if they have lead service lines?

To aid property owners and residents, Denver Water will maintain an interactive and user-friendly map using a GIS platform to denote service line type as documented in the LSL Inventory. The goal is to provide information for each property within Denver Water's integrated system. Denver Water expects to update the map frequently to illustrate new information gathered from its field investigations. An example of what the map of the LSL Inventory could look like is shown in Figure 21.

FIGURE 21: LEAD SERVICE LINE IDENTIFICATION MAP (EXAMPLE)



How can predictive modeling be used to better identify the location of lead service lines?

The predictive model will be used to triangulate the results of investigations completed to date and to guide future investigations, without having to undertake an excavation at every property. This will improve the overall efficiency of LSL identification and the replacement process at the properties described as having a suspected or possible LSL. In addition, investigation results will fine-tune or improve the confidence in the lead service line inventory as a whole.[20]

The predictive model, through water quality sampling, potholing and information gained from the ALSLR Program, improves its logic rules (i.e., build date or tap date) that are used to assign the likelihood of finding a lead service line at a given property. Information from the field allows the predictive model to extrapolate (or predict) the likelihood of finding lead at similar locations using logic rules and field investigation results. The field investigations may include visual inspection, water quality sampling and potholing to determine the probability of lead. Field results generated at a representative number of properties in an area of uncertainty can provide greater confidence in the model's ability to predict the service line materials used elsewhere in the water system.

How will predictive modeling be used in prioritizing replacements?

Continued refinement and utilization of the predictive model will inform Denver Water's approach to targeting communications as part of the COE Plans, enrolling customers in the Filter Program and prioritizing LSL replacements. Denver Water's annual efforts to plan the ALSLR work will focus efforts on the properties or areas with a higher risk of lead exposure. The following factors that may inform the prioritization schedule include:

- Public health considerations (i.e., relative risk–odds ratio for childhood lead poisoning per EPA and health department toxicology experts).
- Critical customers (i.e., locations of child care providers and primary schools).
- Filter adoption rates by geographic and/or demographic area.
- Age-related considerations (children under the age of six, neighborhoods with a high density of young and expecting families).
- Socio-economic and environmental factors.

The location of vulnerable populations will help inform the selection of work locations on a yearly basis. Each property associated with the LSL Inventory will be incorporated into the prioritization analysis to identify the potential risk of lead exposure.

Criticality factors associated with each property are provided a set of values (referred to as a criticality co-efficient) that are adjusted by a weighting factor (referred to as a criticality weight). The weighted criticality factor can be defined by analysis tools and/or stakeholder consensus, as shown in Figure 22. The overall criticality score for an individual property is the result of multiplying the criticality factors by the respective criticality weightings.

[20] For details, please see Appendix III.B.3.

FIGURE 22: CRITICALITY WEIGHTING PROCESS

Once the likelihood and criticality scores are generated for each property, the total risk score is calculated for a geographic area (i.e., a common spatial boundary as identified in census blocks from the American Census Records). This analysis provides both an individual and accumulated geographic risk score that can then be considered with other logistical considerations, such as planned paving schedules and water main replacement work.

The total risk density scores by geographic area will be used to sequence work to address the (high) risk of lead exposure at a property and the efficiency of working through an area of properties to relative to the risk posed to a broader portion of the community. Additionally, properties that are of high risk and consequence that are not incorporated in a census area for production will be evaluated for sequence of constructions.

What happens to properties that are reclassified as part of the inventory updates?

Depending on their location in the integrated system, properties initially classified as having a low possibility for a lead service line (and therefore not enrolled in the Filter Program) may be reclassified by the predictive model as having a higher likelihood for lead. Similarly, as the predictive model is refined with results from the field, a property initially identified as having a suspected lead service line may be reclassified as being unlikely to have a lead service line.

When a property is identified as having a possible or suspected lead service line, the resident will be enrolled in the Filter Program. If a property is initially identified as having a possible or suspected lead service line and is subsequently reclassified as being unlikely to have a lead service line, further investigation will be undertaken to confirm the service line material. If upon further investigation non-lead is confirmed, a letter will be mailed notifying the customer of the change and their participation in the Filter Program will be discontinued within six months of the change in status.

What if a lead service line is found after Denver Water completes the LRP?

Any property found to have a lead service line after the end of the program will receive a filter and be scheduled for service line replacement within six months of identification.

III.C Filter Program

The Filter Program is an interim protection measure that will supply filters that remove lead from customers' drinking water.[21] As part of the Filter Program, households with known, suspected or possible LSLs, whether owner-occupied or tenanted, will receive a filter and replacement

[21] The Filter Program Plan is included in Appendix III.C.3.

cartridges until either the service line is confirmed to be non-lead or six months after the lead service line is replaced, as shown in Table 10. Through the duration of the LRP, Denver Water will provide filters that will remove nearly all the lead but leave other important minerals like fluoride.

Multi-family properties are included in the 84,546 service lines that are part of the Filter Program, as shown in Table 10. A multi-family property has multiple household units. A household unit is an individual residence that receives a filter. Using available data, Denver Water estimates that Filter Program participants consist of 119,250 Denver Water household units, with each household unit receiving a filter.

How and when will filters be distributed?

Filter distribution to all households with known, suspected or possible LSLs will start within 90 days of the variance approval. In accordance with the COE Plans, each eligible customer will receive education/outreach material, a pitcher filter and a six-month supply of replacement filter cartridges that are NSF-certified for lead removal. A pitcher filter and six-month supply of replacement filter cartridges will be provided for each individual unit at multi-family dwellings.

Denver Water is testing the lead removal performance of multiple filter products before filters are distributed to customers in the Filter Program.

Denver Water's integrated system will be divided into sub-areas for consolidated communications and distribution of the filters. Filters will be distributed to neighborhood residents in sub-areas during the same time period to reinforce filter use, consolidate outreach and answer questions within a specific community using local community organizations and resources. The intent is to intensely target the sub-areas or neighborhoods with filter distribution using various methods:

- Primary – Direct mail to the eligible resident unit with delivery confirmation.
- Secondary – Hand delivery via door-to-door canvasing (in person or drop-off).
- Exceptions – Resident preference only: pick up at Denver Water facility, mobile unit, at community meetings or other locations and events.

Vulnerable populations, including expecting families, children and those of low socioeconomic standing, will be identified, contacted and tracked as sub-populations within the sub-areas. The criteria for vulnerable population will be used to help prioritize the order of geographic sub-population distribution within a sub-area and associated community outreach.

Replacement filter cartridges will be distributed every six months using the same methodology identified for the distribution of pitcher filters.

A property will be removed from the Filter Program six months after replacement of the lead service line or if a non-lead service line is confirmed at the property.

Communications and the Filter Program

The notification methods that will be used for customers that are eligible to receive a filter include:

- Delivery of detailed instructions regarding the Filter Program, water filter cartridge use and replacement on Denver Water's website.
- Delivery of detailed instructions regarding the Filter Program, water filter cartridge use and replacement during door-to-door campaigns, neighborhood meetings and additional strategic community outreach in identified areas as part of the overall Lead Reduction Program.
- Distribution of letters informing customers of the Filter Program with:
  - Detailed instructions regarding the Filter Program, water filter cartridge use and replacement requirements.
  - Denver Water's customer care call center phone number.
  - A link to Denver Water's Lead Reduction Program website.
- Information customized for tenants in rental properties (i.e., directed to local housing authorities and property management companies).
- Robocalls to impacted customers with:
  - Detailed information regarding the Filter Program.
  - Denver Water's customer care call center phone number.
  - A link to Denver Water's Lead Reduction Program website.
- Direct mail of water filters to select impacted customers with:
  - Information regarding filter cartridge replacement.
  - Denver Water's customer care call center phone number.
  - A link to Denver Water's Lead Reduction Program website.
  - A mail in response survey/response form (in multiple languages).
  - A quick response code for access to Denver Water's digital registration page (in lieu of mail in survey/response).
- Hand deliver water filters to select impacted customers including multi-family housing, with:
  - Information regarding filter cartridge replacement.
  - Denver Water's customer care call center phone number.

- A link to Denver Water's Lead Reduction Program website.
- A quick response code for access to Denver Water's digital registration page (in lieu of mail in survey/ response).
- A mail in response survey/response form (in multiple languages).

- Conduct follow-up communications using mail, phone or a door-to-door survey during the first six months of filter use to determine practices and preferences.

Verifying filter adoption – how will Denver Water know filters are being used?

Filter adoption assumes customers are accepting, installing (if applicable), using and maintaining the filter properly, including replacing the filter cartridge at the appropriate time.

The distribution of filters and replacement cartridges will be documented and tracked during the life of the LRP using an electronic database and GIS. A survey of randomly selected customers enrolled in the Filter Program will be conducted annually to measure the filter adoption rate. Responses from a minimum of 1,059 randomly selected customers each year will be required to estimate the filter adoption rate with at least 95% confidence and no more than 5% error, at adoption rates greater than 65% (from Figure 19 in Section II). This is referred to as the threshold for the filter adoption rate—the minimum percentage of households that use filters such that the LRP achieves results that are equivalent to those of using orthophosphate. Denver Water will complete the adoption survey each year (on a calendar year basis) using internal resources and community outreach services to generate the minimum 1,059 responses.[22]

In the last years of the Lead Reduction Program, the number of remaining lead service lines may approach the minimum required number of respondents. In this case, the survey approaches a census rather than a sample, which may cause difficulty in attaining high survey response rates. Because this can only happen near the close of a successful replacement program, it is not expected to cause issues. Any issues that do arise will be best addressed by the Learning by Doing approach.

Additionally, a customer survey will be implemented during the ALSLR Program (surveys will be distributed based on the number of completed lead service line replacements each year). The results of the ongoing surveys, including lack of responses, will be evaluated and used to estimate and improve adoption rates, develop communications, outreach and education activities for sub-area populations and make improvements to the Filter Program (Learning by Doing).

The results will also be parsed and evaluated based on geography and/or demographics to address health equity and environmental justice concerns. If certain areas are not responding to the survey, then additional COE activities would be designed and carried out to understand the issue and improve survey response.

[22] Details and assumptions used to design the survey to evaluate filter adoption are provided in Appendix III.C.1 and Appendix III.C.3.

What if Denver Water does not achieve the threshold filter adoption rate?

Increasing filter use at customer homes to 100% is the goal of the Filter Program. It is reasonable to expect that communications, outreach and education efforts to customers will help to increase the filter adoption rate. Compliance is based on a minimum filter adoption rate of 65%, and failure to remedy persistently low filter adoption rates will trigger actions, as described in Section IV.

However, to maintain filter adoption above the minimum rate of 65%, Denver Water has identified 75% as an operating target to increase outreach and education activities before non-compliance occurs. If customer use falls below 75% for filter adoption, Denver Water will:

- Increase and modify its communications, outreach and education efforts with particular attention to any sub-populations with below-average adoption rates.
- Evaluate possible modifications to the ALSLR Program.

III.D Accelerated Lead Service Line Replacement Program

Through the ALSLR Program, Denver Water will replace all identified lead service lines within 15 years. To achieve this, the Denver Water ALSLR Program will perform LSL replacements as efficiently as possible. At the same time, Denver Water will engage with and educate customers so that they understand the benefits of LSL replacement and consent to participate.

What is Denver Water committing to as part of the accelerated lead service line replacement program?

Denver Water is committing to replace all lead service lines within 15 years at a cumulative program year average replacement rate of 7.0%. Lead service lines will be replaced from the main to the first fitting inside the dwelling (defined as a full lead service line). Any partial lead service line or galvanized steel service line material downstream of an existing or previously existing lead service line will also be replaced up to the first fitting inside the dwelling. The ALSLR Plan describes in greater detail the process by which Denver Water will undertake the 7.0% cumulative program year average replacement rate over the life of the ALSLR Program.[23]

What constitutes an LSL replacement?

The following types of LSL replacements will count as credit for an entire LSL replacement:

- Full LSL replacement of a single service line.
- Replacement of an existing partial lead service line that results in a non-lead service line from the main to the first fitting inside the dwelling.
- Replacement of a galvanized service line downstream of an existing or previously existing lead service line.

[23] The ALSLR Plan is provided in Appendix III.D.1

- LSL replacements completed by property owners or third parties and inspected by Denver Water.

Summary of the LSL replacement process

Denver Water customers might notice a greater level of construction activity in their neighborhoods over the next 15 years, especially in neighborhoods with high concentrations of lead service lines. In addition to continuing to replace approximately 400 lead service lines per program year through water main replacement projects and approximately 300 leaking lead service lines per program year, Denver Water will also target the replacement of thousands of lead service lines per program year through systematic, prioritized replacements, focusing on:

- Replacing lead service lines in geographic areas with cumulative opportunities to reduce lead exposure and/or provide project delivery efficiencies. These areas may include blocks with a high density of lead service lines or neighborhoods undergoing a municipal paving or road improvement project.[24]
- Replacing lead service lines at individual properties with lead concentrations consistently above the action level and/or at properties demonstrating a significant demographic risk (for example daycares).
- Monitoring the estimated individual LSL replacement volume from redevelopment and leaks to address a potential shortfall in the overall 7.0% cumulative annual average goal.
- Coordinating with the City and County of Denver Public Works and other area municipal, utility and public sector agencies to ensure that a framework is in place to optimize construction and related activities.

Currently, 1,200 lead service lines are replaced annually through various activities by Denver Water, developers and other third parties. At this rate, it will take 50 years or more to replace all known and suspected lead service lines in Denver Water's service area

See Table 12 for a summary of this approach.

Additionally, crews will conduct investigations at properties, with suspected and possible lead service lines to identify the service line material to improve the lead service line inventory. The identification of service line material will inform the predictive model. This process will assist in future annual ALSLR planning.

[24] The ALSLR Plan is provided in Appendix III.D.1

TABLE 12: EXAMPLE OF GROUPINGS FOR LEAD SERVICE LINE REPLACEMENTS AND INVESTIGATIONS

Group/Type		Est. Annual LSL Replacements and LSL Investigations	Group Subtotals for Est. Annual LSL Replacements and LSL Investigations
GROUP A – LSLR by GEOGRAPHIC AREA	Water main Replacement	400	3,850*
	Block by Block or Street by Street	3,000*	
	Municipal Pavement and Road Improvement Programs	450	
GROUP A – LSLR by INDIVIDUAL	Leaks	300	1,400*
	Individual & High Priority LSLR	600*	
	Scrape Off and Redevelopment Properties	500	
GROUP B - INVESTIGATION	Investigations for areas with suspected and possible LSL	500*	2,000*
	Water Quality Testing of areas with expected or somewhat expected to have LSL	1,500*	

(*) asterisk indicates the values are subject to change but are provided as an example based on replacing 5,250 lead services in one program year.

Approximately 20% of the properties included in the predictive model described as having a suspected or possible lead service line will be investigated to confirm the service line material (see Table 12). This, in turn, will be used to predict the likelihood of having a lead service at all the remaining 80% of properties. Divided over 14 years of the LRP duration, this works out to investigating 1.4% per program year of the properties categorized as having a suspected or possible lead service line.

To maintain the efficiency of the ALSLR Program, completing a higher number of investigations in the early years of the program will be necessary. Investigations at 10% of all properties with a suspected or possible lead service line will occur within the first five years of the LRP, or approximately 2,000 investigations per program year. This percentage of investigations was selected based on the statistical needs of the predictive model.

The geographic area work for Group A, defined by streets or blocks, focuses on a relatively high density of properties with lead service lines that can be replaced quickly and efficiently. The geographic area is displayed on the left side of Figure 23. The properties are marked with different shapes and colors to indicate the likelihood of having a lead service line. A property identified for an individual replacement (Group B in Table 12) is represented by the right side of Figure 23. Individual replacements will not be spatially concentrated, rather the properties (known or suspected colored symbols) may be located in various areas across the Denver Water service area. The properties included in Group B were identified based on having lead concentrations consistently above the action level and/or demonstrating a significant demographic risk.[25]

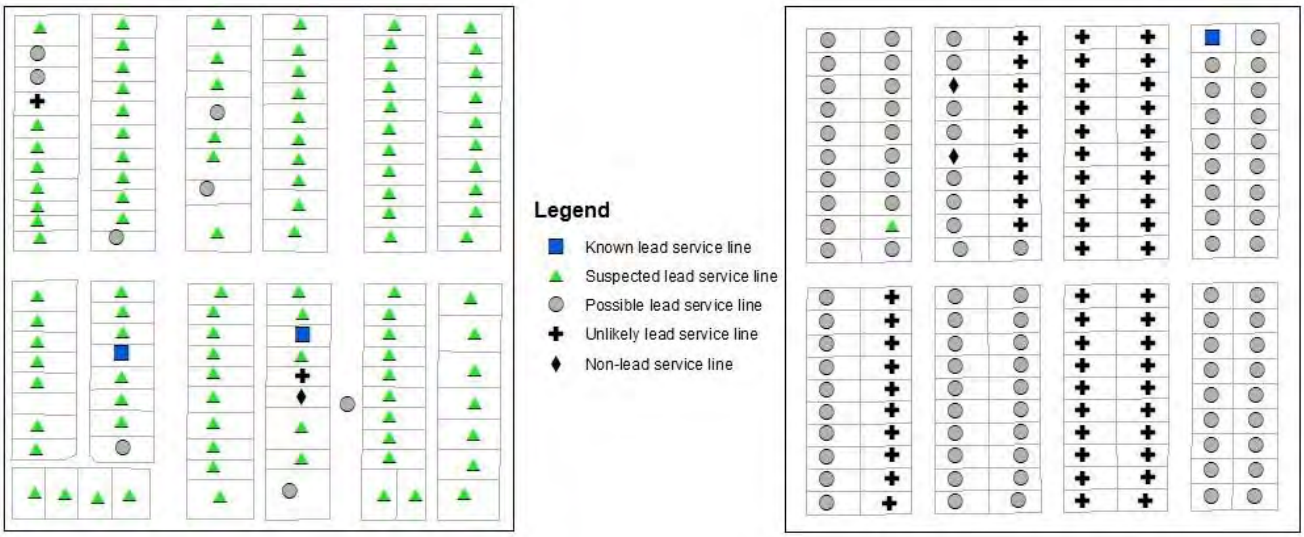
Properties types targeted for Individual lead service line replacement include:

- Multi-family units
- Daycare centers
- Private schools*
- Health facilities

These property types have a broader impact on Denver Water's customer base because their service lines provide clean drinking water to more than a single-family or customer.

* Denver Water replaced the last lead service line at a Denver Public Schools school building in spring 2019.

FIGURE 23: EXAMPLE REPRESENTATION OF LEAD SERVICE LINE REPLACEMENT BY GEOGRAPHIC AREA (LEFT) AND INDIVIDUALLY (RIGHT)



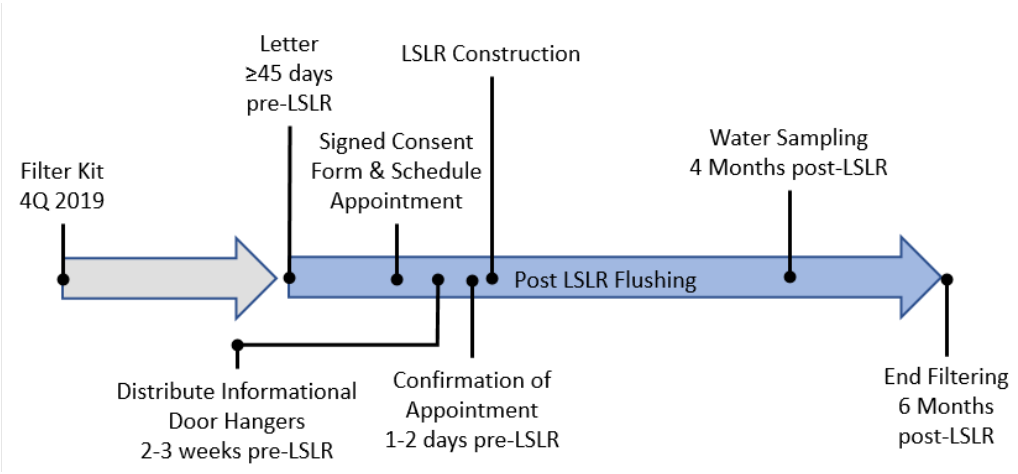
What can customers expect during a lead service line replacement?

Denver Water will contact the customer at least three times prior to the actual replacement of the lead service line. As seen in Figure 24, property owners will be (1) notified via letter at least 45 days in advance of the construction, (2) asked to set up an appointment to discuss the

[25] How these properties are prioritized and grouped is described in Appendix III.B.3

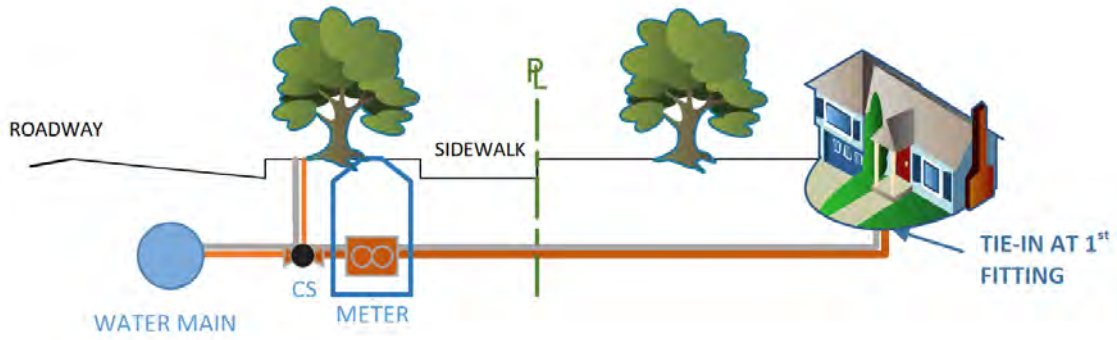
construction for their property as well as sign a consent form allowing the replacement of their lead service lines, (3) reminded via signage placed at the limits (ends of streets) within geographic work areas four to five weeks in advance of construction and (4) provided a door hanger two to three weeks in advance of construction as a reminder of the upcoming event. Also, per Denver Water policy, both owners and residents (in the case of tenanted properties) will be notified of the shutoff of service 24 hours in advance of construction.

FIGURE 24: PLANNED INTERACTION WITH PROPERTY OWNERS AND RESIDENTS DURING LEAD SERVICE LINE REPLACEMENT ACTIVITY



During construction, Denver Water will investigate the service line material and replace the service line if the material is lead. The lead service line replacement will include the service line from the water main connection to the first fitting inside the dwelling. An example of a full lead service line replacement is illustrated in Figure 25. The example shows an existing lead service line (grey) being replaced fully with a copper service line (orange). Additionally, all fittings, valves, curb stops (CS), corporation stops and water meters that are not copper will be replaced.

FIGURE 25: EXAMPLE FULL LEAD SERVICE LINE REPLACEMENT



Following construction, Denver Water will provide each property with:

- Flushing instructions (per AWWA/ANSI Standard C810-17).
- Post-replacement filter use survey.
- Educational materials on how to further reduce lead in premise plumbing.

- Additional filter replacement cartridges for use up to six months after replacement to remove any lead particles that may have been dislodged as a result of replacement.
- Water quality sampling test kit, approximately four months after replacement.

What happens if the post-replacement water quality result, at an individual property, is high?

Property owners will be educated on how to reduce lead in their premise plumbing and will be referred to community organizations and funding programs that can assist with investigating and removing lead from their home (such as the U.S. Department of Housing and Urban Development's Lead Hazard Grant Program).

How will Denver Water achieve the 7.0% replacement rate?

A number of older cities (including Pittsburgh and Detroit) have embarked on lead service line replacement plans that aim to replace several thousand service lines per program year. A review of these and other lead service line replacement programs revealed that it is reasonable to expect crews to replace upwards of two to four lead service lines per day, depending upon various factors with primary emphasis in lead service line inventory confirmation in advance of replacement.

The ALSLR Program will incorporate Denver Water's internal resources to replace up to 700 lead service lines per program year as part of water main replacement and service line leak repair work. Another 500 lead service line replacements per program year are typically performed through redevelopment. Contracting with external resources will be arranged to fulfill the remaining portion to achieve the 7.0% cumulative program year average replacement goal. Based on the practical number of replacements that can typically be completed per day (two replacements per crew per day), it is projected that Denver Water will need upwards of 13 lead service line replacement crews to meet the 7.0% goal of replacements. As the program progresses, efficiencies are expected through the annual review of lessons learned. The ALSLR Program does recognize that developers and Denver Water's LSL replacement activities will require incorporation of Denver Water and City and County of Denver processes to plan and track these replacements.

Denver Water will engage and partner with contractors through:

- Multi-year contracts to maintain flexibility and engagement of ALSLR crews to meet the 7.0% goal.
- Task orders will be issued to address investigations as part of the geographic and individual groups of the ALSLR Program.
- Contracts will incorporate a Learning by Doing approach with routine reviews of performance to identify opportunities for improvements.
- Incentive based contracts for meeting performance criteria focused on safety, quality and replacement rates.

To confirm local contracting capacity, Denver Water, in coordination with the COE Plans, conducted an Industry Day workshop to inform the contracting community of the LRP's needs. Denver Water reviewed potential contracting and procurement options and is using a

qualification-based approach to shortlist qualified contractors that will provide unit price bids. Denver Water will select the lowest and most responsive qualified contractors' unit price bid and enter into a contract for one year with the option of two one-year extensions.

What if a customer does not want their lead service line replaced?

Denver Water anticipates that, occasionally, a property owner might refuse to allow their service line to be replaced. Denver Water will use a three-step notification process along with continued outreach to try to obtain an owner's consent.

If a property owner continues to withhold consent for the LSL replacement, Denver Water may take one or more of the following actions:

- Denver Water may choose not to replace the lead service line, but instead pothole in the right-of-way to determine the service line material and proceed with other service line replacements on the same block. Restoration would be provided for the area disturbed during the investigation.
- Denver Water may perform a partial replacement of the lead service line (i.e., property cannot be accessed).
- If consent is not provided prior to the contractor entering the area, and if the property owner (or customer) is enrolled in the Filter Program, a letter will be sent to the property owner (or customer) by registered mail providing contact information and a deadline to respond with consent.
- Additional outreach and education materials will be provided to the property owner and the residents of the property to i) determine why consent was denied, ii) review the importance and features of the LRP and iii) drop off a water quality sampling kit in an effort to quantify the magnitude of lead release at the property.

Next steps if consent to replace the known lead service line is denied: If consent is still denied after implementing the above actions, the property will be added to a Service Line Refusal List maintained by Denver Water and a note will be made in the customer's account that the LSL replacement was refused. The Service Line Refusal List will be included in the annual report and made available to CDPHE.

Tracking lead service lines for replacement in the future: Upon a change in the name of the water account or property owner, Denver Water will reinitiate outreach and education efforts to determine if the new customer will consent to replacement of the lead service line. Timing for replacement will be determined on the basis of priority.

Exceptions for multi-family properties: Denver Water will make all reasonable efforts to obtain consent from a property owner of single-family and multi-family properties, including contacting out-of-state landlords where applicable. In the case of multi-family units, until the property owner provides consent to replace the lead service line, the residents (if not the property owner) will be notified by registered mail of the known or suspected presence of a lead service line, enrolled in

the Filter Program, provided with education materials to describe actions the residents can take to reduce their risk of lead exposure and provided a sampling kit. Denver Water may take action against the property owner to secure consent to replace the lead service line.

Exceptions for water main replacement: When Denver Water replaces a water main, the existing service line connection must be transferred from the old water main to the new water main. If the service line is made of lead, Denver Water will replace the lead service line as part of its water main replacement work. If consent is not given by the property owner, after three notices, Denver Water will perform a partial lead service line replacement to the water meter, the address will be added to the Service Line Refusal List and educational materials will be provided to the property owner (to encourage replacement) and the resident (if different from the property owner, to provide measures the resident can take to prevent lead exposure).

How will the predictive model be used to guide the ALSLR Program?

The goal of the ALSLR Program is to replace 7.0% of the lead service lines within Denver Water's service area annually. The predictive model will be used to generalize the results of past service line investigations to guide future investigations, fine-tune the LSL Inventory and assist in the early identification of the subsequent program year's lead service line replacement plan.

Denver Water will consider additional service line investigations, based on areas selected for replacement in a program year, to confirm information in the LSL Inventory and increase the reliability of delivering the 7.0% cumulative program year average rate of replacement.

What happens if a lead service line is found after the LRP is completed in 15 years?

Lead service lines found after the LRP is completed will be replaced within six months of discovery. Customers will immediately receive a filter and replacement cartridges (NSF-certified to remove lead) and will continue to receive shipments of replacement cartridges up to six months after the line is replaced, along with educational materials on reducing lead exposure.

How will Denver Water demonstrate a 7.0% replacement rate?

On an annual basis, Denver Water will receive credit for every lead service line replacement completed that program year, including lead service line replacements completed by third-party contributors (e.g., governmental agencies, developers, homeowners, non-profits). Denver Water will inspect all third-party lead service line replacements.

The cumulative program year average will be calculated for each program year by dividing the number of lead service lines replaced (X) during the program year by the known number of lead service lines (Y). A calculation for the cumulative program year average replacement rate can be found in Appendix III.D.1. Adjustments to X or Y can be made in agreement with EPA and CDPHE if evidence supports the adjustment and still results in a minimum 7.0% cumulative program year average replacement of all known lead service lines within 15 years. Adjustments to X and Y may include:

Potential Adjustments to X (Number of Lead Service Lines Replaced during Program Year)	Potential Adjustments to Y (Known Number of Lead Services)
No adjustment: property owner declines replacement after multiple attempts by Denver Water to encourage replacement.	**Adjust down:** known or suspected lead service line confirmed to be non-lead during investigation phase.
Adjust up: entire lead service line replaced or existing partial lead service line replaced such that entire line is non-lead after replacement.	**Adjust up:** lead service line confirmed after customer sampling reveals high lead concentrations in all three bottles.
Counts as more than one: multiple lead services replaced as part of a redevelopment project, even if replaced with on larger service line.	

The 7.0% cumulative program year average replacement rate will take effect beginning the third program year following the launch of the ALSLR Program. Although the 7.0% replacement rate will not apply during the first three years of the ALSLR Program, as a practical matter, lead service line replacement counts cannot drop below 6.0% for the first year and 6.5% for the second year, if Denver Water is going to achieve a 7.0% cumulative annual average replacing rate beginning the third program year.[26]

Can Denver Water replace lead service lines in less than 15 years?

Protection of public health and reduction of long-term program management costs will incentivize Denver Water to replace lead service lines as quickly and responsibly as possible, which may exceed the proposed 7.0% cumulative program year average replacement rate. Over the next 10 years, Denver Water is completing two large water supply resiliency projects including construction of the new Northwater Treatment Plant and the expansion of Gross Reservoir. **Denver Water must balance these projects and rate increases in a manner that supports its mission without creating affordability issues for its customers.** Note: force majeure events (e.g., severe flooding, drought or material shortage) may adversely impact Denver Water operations and by default, capital programs. As a result of these factors, Denver Water believes it is prudent to commit to the minimum 7.0% rate but will strive to do more when feasible.

III.E Corrosion Control Treatment

As part of the variance approach, Denver Water is proposing to use pH/alkalinity adjustment to reduce lead releases from copper piping with lead solder and from premise plumbing containing lead. Additionally, Denver Water will submit a modification request asking CDPHE to change the optimal corrosion control treatment designation from orthophosphate to pH/alkalinity. Denver Water must have approval of both the variance and modification request to move forward with this plan.

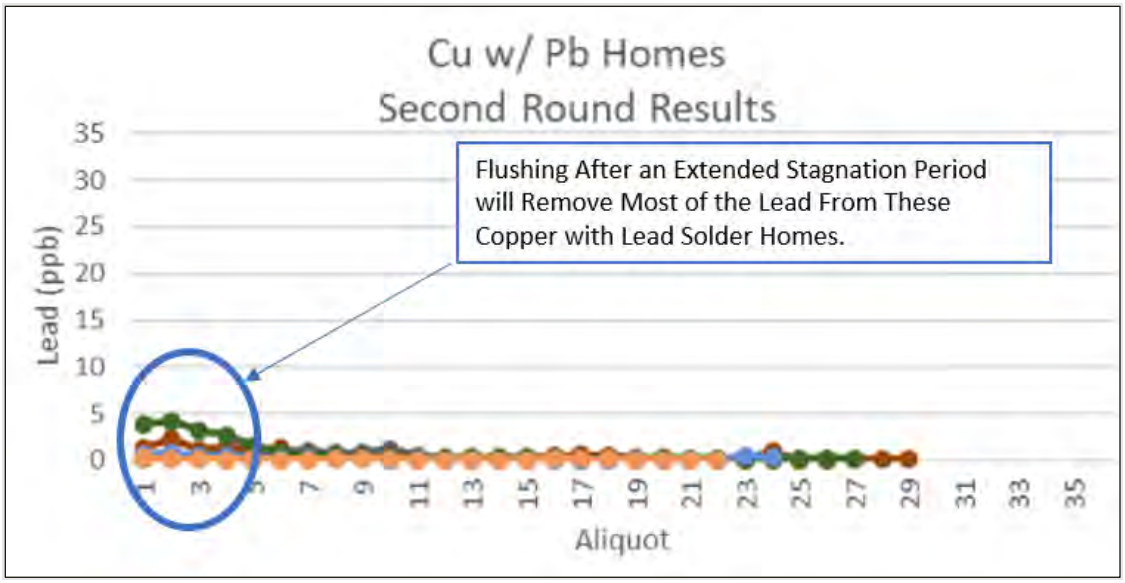
[26] See Appendix III.D.1 for example calculations for the cumulative program year replacement rate.

How will pH/alkalinity adjustment protect customers with copper piping with lead solder?

As discussed in Section II, lead concentrations in first draw samples for homes with copper pipes with lead solder are expected to decrease by 41% to 43% with pH/alkalinity adjustment.[27] Using LCR compliance data from 2011 to 2019 for homes served by copper pipes with lead solder and built from 1983 to 1987, Denver Water expects the projected lead concentrations in first draw samples under the LRP to decline from 7.2 ppb to 4.2 ppb.

As seen in Figure 26, flushing after an extended stagnation period (first thing in the morning, after work or school) will remove most of the lead. The COE Plans incorporate this messaging to help customers understand how to reduce their exposure to lead.

FIGURE 26: HOW FLUSHING CAN HELP REMOVE LEAD FROM WATER AT HOMES SERVED BY COPPER PIPING WITH LEAD SOLDER



How will Denver Water address equivalency for 1983 to 1987 homes?

The decade analysis described in Section II demonstrated that most homes served by copper pipes with lead solder will see lead concentrations drop to near non-detect limits for either pH/alkalinity adjustment or orthophosphate, except for 1983 to 1987 homes, as seen in Figure 12. To address this gap in equivalency, Denver Water has committed to the following:

- Communications, outreach and education campaigns targeted at expecting and existing families with formula-fed infants/children.
- Free water quality test kits.
- If lead concentrations exceed 3 ppb, free filters will be offered to the family.
- Replacement cartridges will be provided for the formula-fed infant/children up to their 24th month of age.

[27] Based on coupon testing, see Table 4.

Can the proposed corrosion control treatment protect customers with lead service lines who choose not to use filters?

Yes, to some extent. Customers with lead service lines who use a filter will reduce the amount of lead in their drinking water by 97%. For customers with lead service lines who do not adopt filters, the Corrosion Control Treatment alone will reduce lead concentrations approximately 50%.[28] Applying this 50% reduction to the average of all 90th percentile results from 1997 to 2019 equates to 7.0 ppb, as shown in Table 13.

TABLE 13: PAST AND PROJECTED LEAD CONCENTRATIONS IN FIRST DRAW SAMPLES FOR HOMES WITH A LEAD SERVICE LINE PROTECTED BY PH/ALKALINITY CORROSION CONTROL TREATMENT ONLY (NO FILTER)

Time Period	Average Lead Concentration (ppb)	90th Percentile Lead Concentration (ppb)
Pre-Variance: 1997 to 2019 (average)	6.7	14.0*
Projected Post-Variance: 2021 & Beyond	3.4	7.0

*Based average of all 90th percentile lead concentration reported for each monitoring period from 1997 to 2019.

How will Denver Water verify corrosion control is working?

Under the LRP, Denver Water will continue to sample at Tier 1 homes with a) lead service lines and b) copper pipes with lead solder constructed between 1983 and 1987. Samples will be collected from an unfiltered tap (by-passing the filter if used to remove lead). Samples will be collected twice a year using the sampling protocols described in the Lead and Copper Rule.

The success of the pH/alkalinity corrosion control treatment depends on Denver Water's ability to maintain a target pH within ±0.2 standard units in water leaving the treatment plants and ±0.3 standard units in water in the distribution system. Additionally, Denver Water will maintain a minimum alkalinity level to help stabilize pH in the distribution system.

Denver Water will use its real-time monitoring system to track and trend pH, alkalinity and conductivity (where on-line instrumentation is available) at the treatment plants and in the distribution system. Figures 27 and 28 display the existing monitoring screens, one for the overall distribution system and the other for one of the treatment plants, respectively.

[28] As discussed at the end of Section I.

FIGURE 27: REAL TIME DISTRIBUTION SYSTEM CORROSION CONTROL MONITORING

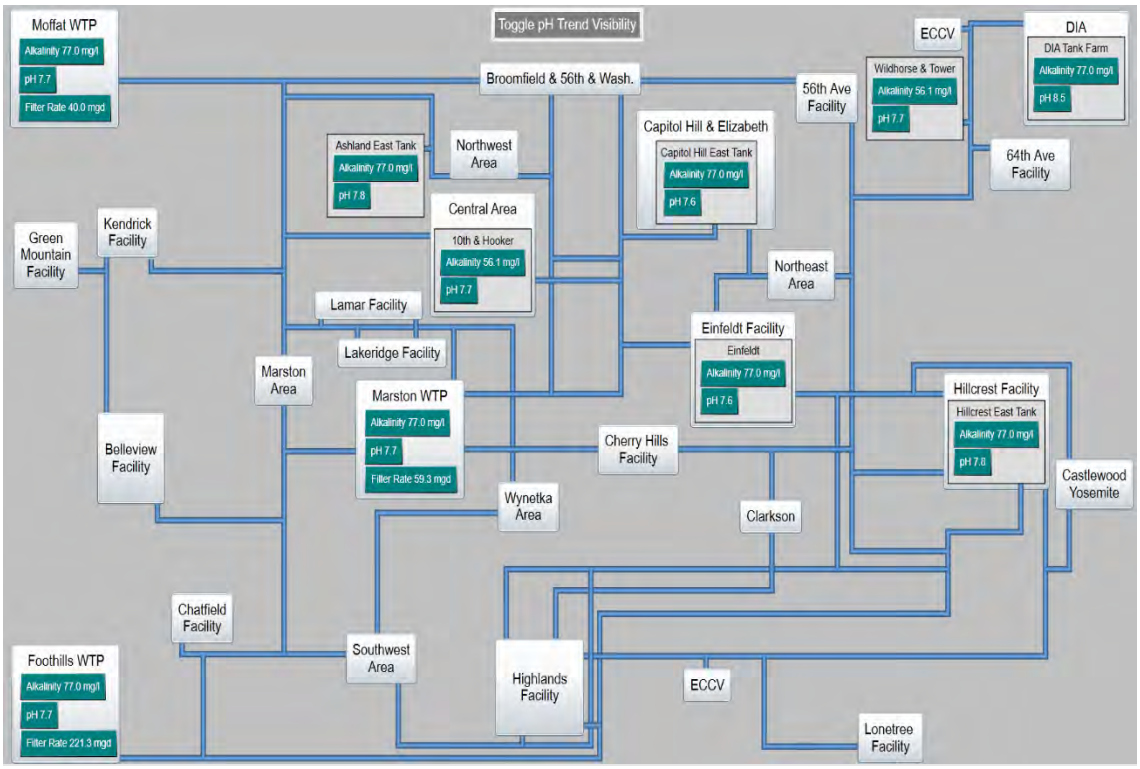
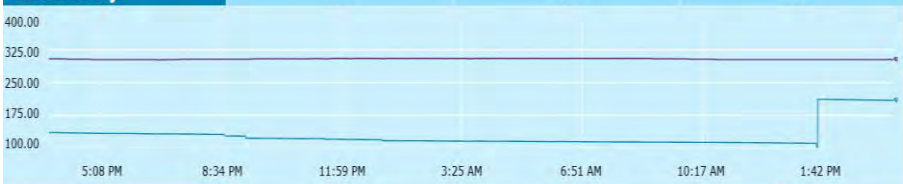


FIGURE 28: REAL TIME TREATMENT PLANT CORROSION CONTROL MONITORING

Corrosion Control Operating Conditions / Boundaries / Excursions

Parameter	Normal Range	Boundary	Excursion	Actual Value
Orthophosphate	2-3 mg/L	1.5 - 1.9 mg/L 3.1 - 3.5 mg/L	< 1.5 mg/L <> 3.5 mg/L	(Future) FWC
pH	7.70 - 7.80 +/- 0.2 Units - Treatment +/- 0.3 Units - Distribution	7.65 - 7.69; 7.81 - 7.85	< 7.65 > 7.85	FWC
Conductivity	TBD	TBD	TBD	Raw & FWC
Alkalinity	> 45 mg/L	< 40 mg/L	< 35 mg/L	e.RIS Dashboard
DIC	> 12 mg/L	10 - 12 mg/L	< 10 mg/L	e.RIS Dashboard
CSMR	< 0.4	0.4 - 0.6	> 0.6	e.RIS Dashboard

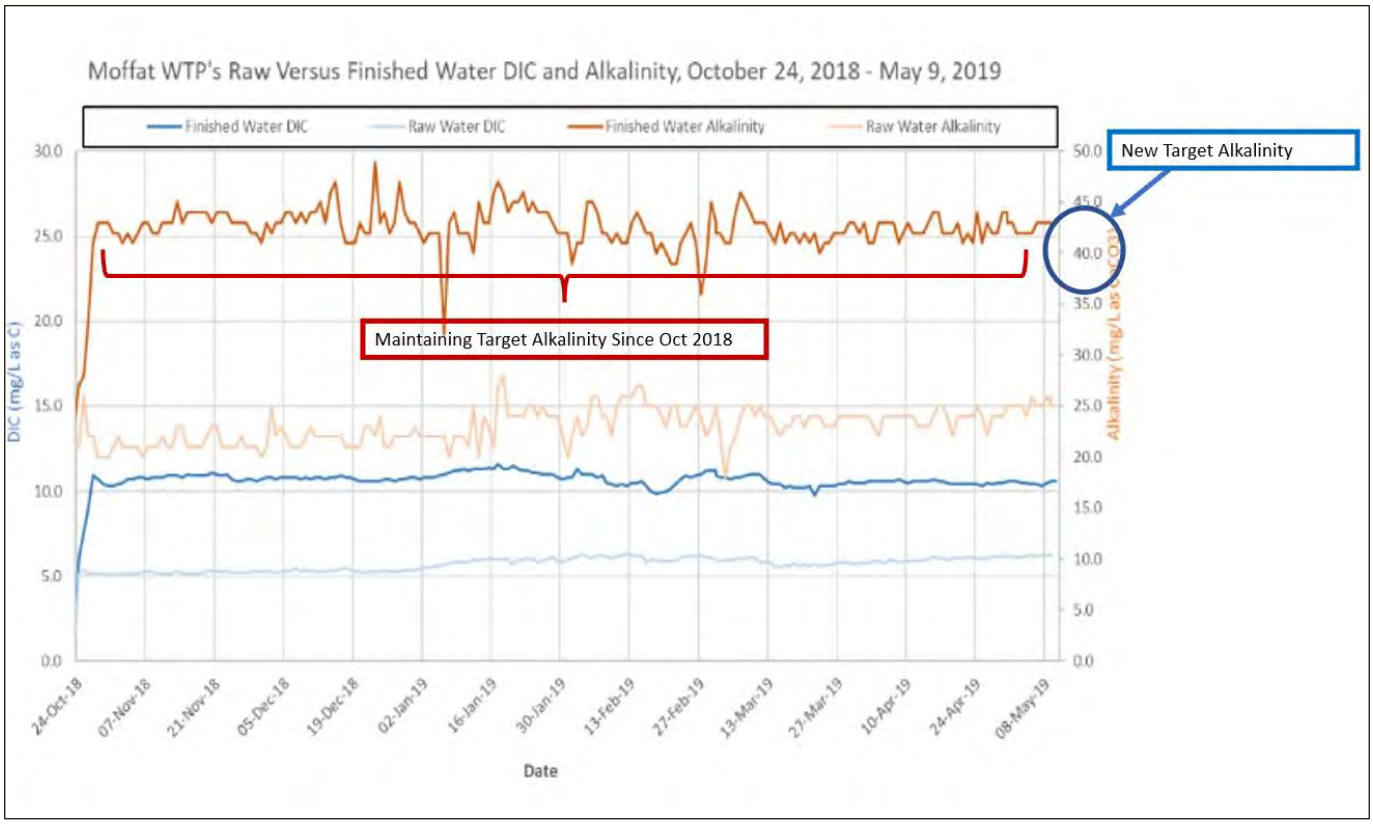


Will Denver Water have to make modifications to the treatment plants to support pH/alkalinity adjustment for corrosion control?

As a result of the 2018 CDPHE designation of orthophosphate as the optimal corrosion control treatment, Denver Water was required to install additional corrosion control treatment systems to support orthophosphate dosing, which are under construction and will be ready for use in early 2020. Portions of those systems can also be used for adjusting pH/alkalinity corrosion control, and therefore no additional modifications are necessary.

Additionally, Denver Water will have to maintain a minimum monthly average alkalinity to support consistent pH levels in the distribution system. Denver Water operates three potable water treatment plants: Moffat, Foothills and Marston. Only the Moffat Treatment Plant requires daily alkalinity control due to the low alkalinity Fraser River source water that feeds the plant. In 2018, the Moffat Treatment Plant's finished water alkalinity was raised to 40 mg/L as $CaCO_3$ which has been successfully maintained since implementation, as shown in Figure 29.

FIGURE 29: ALKALINITY IN RAW AND FINISHED WATER AT THE MOFFAT TREATMENT PLANT



The other two treatment plants receive raw water from the South Platte River and/or Marston Reservoir, which are moderately high in alkalinity, averaging between 50 mg/L and 70 mg/L as $CaCO_3$ most of the year. The alkalinity in the South Platte River can drop to levels between 20 and 35 mg/L as $CaCO_3$ for up to three weeks during runoff season (May to July). During the two to three weeks of low alkalinity that occur in the South Platte River, raw water intake can be

shifted to Marston Reservoir, as needed, to maintain a minimum monthly alkalinity in the distribution system.

Table 14 shows Denver Water's proposed water treatment objectives to support pH/alkalinity corrosion control. Denver Water will work with CDPHE during the first year of implementation to optimize pH adjustment and identify the final proposed pH and alkalinity targets.

TABLE 14 PROPOSED TREATMENT OBJECTIVES FOR PH/ALKALINITY CORROSION CONTROL TREATMENT

Proposed Water Quality Standards for Treatment Plants and Distribution System	
Treatment Plants at Point of Entry*	• pH = monthly average 8.8 standard units, with an operating range of 8.6 to 9.0 • Alkalinity = minimum monthly average of 30 mg/L as $CaCO_3$
Distribution System*	• pH = monthly average 8.8 standard units, with an operating range of 8.5 to 9.1

*Treatment objectives for pH and alkalinity adjustment to be approved by CDPHE.

Denver Water has also undertaken some changes in the types of chemicals it uses at the treatment plants to maintain a low chloride-to-sulfate mass ratio. Chemicals such as liquid ammonium sulfate and acidified alum (containing 5% sulfuric acid) help reduce the chloride-to-sulfate mass ratio, which at times can peak above 0.6 in the finished water from the two treatment plants that use the South Platte River for their source. Although much higher chloride-to-sulfate mass ratios (1+) are indicative of corrosion, Denver Water is doing what it can to keep the ratio at or below 0.6.

Will the proposed pH/alkalinity changes affect the release of lead within a service line?

During the pipe rack studies, Denver Water also evaluated the corrosion control coatings (or "protective scale") that formed on the inside walls of the service lines under each of the treatment conditions: (1) the existing pH 7.8, (2) the increased pH of 8.8 and (3) orthophosphate at 3 mg/L. The purpose of the protective scales is to prevent the migration of lead from the service line into the water.

Different protective scale layers will form based on the specific chemistry conditions established within the service line. The analysis found that the coating within Denver Water service lines, at pH 7.8, is a lead carbonate coating, or species, called hydrocerussite. Increasing the pH to 8.8 resulted in the formation of a similar type of primary hydrocerussite coating that has a lower solubility and is thus more protective than the coating formed at pH 7.8. Similar results were seen in a study of water with dissolved inorganic carbon concentrations similar to Denver Water. While there can be differences between theoretical solubility models and actual field observations, pH/alkalinity adjustment systems most frequently match the predicted phase, whereas phosphate-based systems are the least predictable.[29]

[29] Tully, J., DeSantis, M.K., Schock, M.R., 2019. Water quality–pipe deposit relationships in Midwestern lead pipes. AWWA Water Science 1, e1127.

Based on these results and the observed lead levels coming from the pipe racks when transitioning from a pH of 7.8 to 8.8[30], the proposed high pH adjustment creates favorable conditions for the formation of less soluble coatings that are more protective of public health, even during the transition between pH treatment conditions.

How does Denver Water propose to maintain and optimize corrosion control using pH/alkalinity adjustment?

For optimal corrosion control, Denver Water will:

- Incorporate continuous on-line corrosion control SCADA (supervisory control and data acquisition) monitoring that tracks and trends pH, alkalinity, dissolved inorganic carbon, conductivity, chlorine residual and temperature at the treatment plants and seven key locations throughout the distribution system, with clear action levels and response measures to be taken if the parameters are out of bounds (See Figure 26).
- As part of the corrosion control upgrades at the treatment plants, automated pH dosing control loops will be installed by March 2020 to maintain constant feedback and adjustment of pH in the finished water leaving all treatment plants.
- Complete LCR sampling of Tier 1 homes.
- Monitor lead concentrations in LCR compliance and customer requested samples on a monthly basis, looking for upward trends and adjusting treatment systems or operating practices to reverse trends, where possible.
- Monitor the chloride-to-sulfate mass ratio and adjust treatment chemical dosing to target a ratio at or below 0.6.
- Continue daily communications between treatment plants to review corrosion control targets and performance.
- Collect a weekly sample from the point of entry of each treatment plant and test for pH and alkalinity.
- Complete monthly sampling (pH, alkalinity) at 25 representative sites from across the Denver Water service area; the sites are yet to be determined and will be agreed upon as part of the CDPHE modification approval.
- Continue quarterly profile sampling at volunteer homes, with both lead and copper service lines, to gauge corrosion control effectiveness during the first year of implementation of the variance.
- Strive to consistently hit water quality goals for finished water leaving the treatment plants, as proposed in Table 14.

[30] See Appendix II.B.

Are there other water quality considerations?

Nitrification is known to occur seasonally in the Denver Water distribution system. The addition of orthophosphate can increase nitrification in cases where phosphorus is the limiting nutrient. This is likely to be the case with an alum coagulated first-use mountain water source like the source Denver Water uses. Nitrification is a biological process that produces acid as a by-product, which can lower pH, particularly in poorly buffered water. The low pH can, in-turn, result in increased lead release. Waters with pH above 8.3 have been shown to inhibit nitrification.[31] If the variance is granted, nitrification should not be a concern at the proposed pH target of 8.8 standard units.[32] To verify this, Denver Water plans to:

- Complete distribution system modeling, evaluating pH, nitrification, disinfection by-products and water age by January 31, 2020.
- Subsequently develop and implement a Nitrification Control Plan by July 2020, detailing sampling, monitoring and flushing plans for nitrification control.

It is important to note that Denver Water's disinfection by-products in the distribution system (e.g., total trihalomethanes and haloacetic acids) are and have historically been less than 50% of the existing regulations of 80 ppb and 60 ppb, respectively. These low levels are accomplished as a result of using chloramine as a secondary disinfectant rather than free chlorine. If the variance is not granted, then Denver Water will increase the amount of chlorine and ammonia added to the treated water to reduce the nitrification potential caused by orthophosphate.

III.F Learning by Doing

The Learning by Doing approach uses data in collaborative reoccurring cycles of collective inquiry and action to achieve improved LRP results. The process used in the Learning by Doing approach involves the following steps:

1. Gather evidence of current results and collaboratively evaluate with stakeholders.
2. Develop strategies and ideas to build on strengths and improve results in challenging areas.
3. Implement the strategies and ideas.
4. Analyze the impact of the changes to discover what was effective and what was not.
5. Apply new knowledge in the next cycle of continuous improvement.

Through Learning by Doing, Denver Water proposes to work collaboratively with CDPHE, EPA and other stakeholders to find new ways to efficiently implement the LRP while continuously improving upon past results with a goal of surpassing the monitoring and reporting requirements.

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[31] AWWA M56 Nitrification Prevention and Control in Drinking Water (2nd Edition), 2013.
[32] See Appendix III.E.3.

Denver Water and other stakeholders have a mutual interest in ensuring that this goal is achieved.

To implement the Learning by Doing concept, Denver Water will form an LRP Advisory Committee to inform Denver Water on more efficient and effective ways to implement the LRP to achieve the variance metrics in accordance with the terms and condition in Appendix IV.A. The LRP Advisory Committee will provide recommendations on a variety of community, public health and environmental considerations related to the implementation of the LRP.

Denver Water proposes the LRP Advisory Committee membership include representation from:

- EPA.
- CDPHE.
- Denver Water distributors.
- Organizations that advocate for health equity and environmental justice.
- Representatives from communities across Denver Water's integrated service area with specific focus on representation from underserved communities.
- Wastewater dischargers.
- Environmental organizations and/or watershed groups.
- Medical and/or public health agency professionals.

The LRP Advisory Committee will be formed no later than six months after the variance request is approved.

The LRP Advisory Committee will operate with the following goals:

- Identify, through consensus, voluntary efforts that would improve upon results achieved by the LRP.
- Provide technical input on implementation of the variance and efforts.
- Achieve consensus and seek to resolve disagreements.
- Explore methods to achieve an even greater degree of efficiency than projected in the LRP.

In implementing the Learning by Doing concept as part of the LRP, the following principles will be used to build and promote a stable, permanent, relationship that respects the interests and legal responsibilities of the parties, while achieving the goal of the program:

- All of the advisors will work in good faith to implement the Learning by Doing approach in a way that complements the LRP and its terms and conditions.

- The Advisory Committee will not seek a culprit for a failure to improve upon results but will provide a mechanism to identify issues of concern and focus available resources to address those issues.
- Because resources available to the Advisory Committee are limited, the use of those resources will be prioritized as part of the Learning by Doing effort.
- If the Advisory Committee desires additional resources beyond what Denver Water has made available, the Advisory Committee will work with other stakeholders and granting agencies to identify sources of funding to provide additional resources. If mutually defined additional resources are still desired, the Advisory Committee may agree to consider contributing more of their own resources on a case-by-case basis and within the context of these principles. Each party retains its sole discretion to provide any additional resources without further judgment or prejudice by the other parties.

The industry's understanding and utilities' experience with corrosion control and replacing lead service lines is rapidly evolving. As the industry's understanding advances over the next 15 years, Denver Water will leverage the lessons learned through the Learning by Doing element of the LRP.

As part of its existing day-to-day operations, Denver Water has a robust oversight process in place. Results from sampling from the water system and operations data from the treatment plants are used to monitor performance in conjunction with results from its LCR monitoring pool. This will allow Denver Water to identify performance issues early and have data available to take proactive steps to remain below the LCR action level.

IV. MONITORING AND REPORTING

Denver Water has developed proposed Terms and Conditions to govern the activities and outcomes of the variance as presented in the Lead Reduction Program Plan.[33] The proposed Terms and Conditions include monitoring and reporting requirements and clearly defined metrics to define whether Denver Water's LRP is being implemented as intended.

How Denver Water will evaluate performance of the LRP

For five of the six elements that together make up the LRP (COE Plan, LSL Inventory, Filter Program, ALSLR Program and Corrosion Control Treatment), the proposed program metrics will be used to determine whether the LRP is successfully being implemented (see Table 15). Because Learning by Doing is a strategy, and not an outcome in itself, performance metrics are not identified for this element of the LRP.

TABLE 15: LEAD REDUCTION PROGRAM EVALUATION FOR COMPLIANCE

Element	Compliance	Correction Active	Failure to Meet Condition
Lead Service Line Inventory	Must investigate a minimum of 1.4% of total LSLs in inventory per year.	• Achieve compliance by following year. • Provide notice of corrective action to customers with filters.	If less than 1.4% investigations occur for three program years: • Notice to all customers.
Filter COE	Outreach and education materials provided each year to at least 95% of households enrolled in the Filter Program.	• Must achieve compliance by following year. • Notice to customers with filters.	If Denver Water fails to provide outreach and education materials to at least 95% of households enrolled in the Filter Program for three years: • Notice to all customers.
Filter Program	Achieve minimum filter adoption rate of 65% per year.	• If filter adoption rate is less than 65% in a year, increase outreach and education efforts to improve filter use. • Notice of corrective action to customers with filters.	If failure to achieve 65% adoption rate for three years: • Termination of variance. • Notice to all customers.
Accelerated Lead Service Line Replacement	Must achieve 7.0% cumulative annual average replacement rate each year.	• Achieve compliance by following year. • Notice to customers with filters.	If less than 7.0% of lead service lines are replaced for three years: • Termination of variance. • Notice to all customers.
Corrosion Control Treatment	Lead and Copper Rule sampling results remain below action level for lead.	• Must adjust corrosion control and distribution management. • Customer education and notice.	If action level exceeded for two monitoring periods: • Must provide customer notice. • Termination of variance unless CDPHE requires otherwise.

[33] See Appendix IV.A.

The performance metrics presented in Table 15 are designed to communicate regulatory compliance and the overall effectiveness of the LRP, including corrective action(s) to restore compliance, termination of the variance (i.e., implement orthophosphate) and completion of the variance (i.e., all known lead service lines have been replaced).

Routine reporting

Denver Water will prepare annual compliance reports for CDPHE and EPA using the performance metrics described in the proposed Terms and Conditions.

Data will be provided such that is easily accessed via the web in a public dashboard of performance in addition to being presented to CDPHE every six months. Information that will be provided in the dashboard will include, but is not necessarily limited to, the following:

- COE program plant, contacts, and media activity.
- Lead service line inventory status and access to maps.
- Annual number of lead service lines replaced and total to date.
- Filter Program enrollment, survey responses, and filter adoption rate.
- Summary of issues and concerns from previous report reviews that Denver Water is working to correct.

The annual or end-of-year report will include:

- Key performance parameters for the LSL Inventory, filter adoption rate, and the ALSLR Program performance.
- Quantitative data to describe COE outreach, contacts, etc. and qualitative evidence, which includes documentation of stakeholder feedback, common themes, stories, etc.
- Number of partial lead service line replacements completed each program year.
- Names and addresses of property owners who have refused consent to allow replacement of their lead service lines in a given year (referred to as the Service Line Refusal List).
- Filter adoption rate and number of lead service line replacements in vulnerable communities.

V. HEALTH EQUITY AND ENVIRONMENTAL JUSTICE

The purpose of this section is to describe how Denver Water intends to address health equity and environmental justice in the Lead Reduction Program and within the specific program elements.[34]

The following HE&EJ principles inform the foundational basis for the LRP:

- All people should have the opportunity to attain their full health potential regardless of income, education, age, disability, sexual orientation, gender identity, race or ethnic background or geographic location.
- Conditions in the environments in which people are born, live, learn, work, play and age affect a wide range of health and quality-of-life outcomes and risks. These factors are known as social determinants of health.
- To achieve equity and justice, societal structural inequities (attitudes, policies and practices that create or reinforce patterns of inequity in communities) must be addressed.
- No group of people should bear a disproportionate share of the adverse environmental consequences of industrial, governmental and commercial operations or policies.
- People should have access to information and an adequate opportunity to participate in decisions about activities that may affect their environment and/or health. Meaningful decisions are made with the participation of affected citizens.
- While equal treatment of all people is often viewed as the goal, to address health equity and environmental justice, all people must be treated equitably. Equitable treatment means the conscious and deliberate investment of additional resources to populations experiencing inequity.

Denver Water consulted with EPA, CDPHE, the City and County of Denver and other jurisdictions to prioritize the integration of HE&EJ principles into the LRP. As a result of this consultation process, Denver Water received valuable input, including the following recommendations:

- Coordinate with the Offices of Health Equity for CDPHE and the City and County of Denver to identify new sources of data to implement HE&EJ principles in the COE Plans, Filter Program and ALSLR Program.
- Obtain language breakdown by neighborhood to meet translation and interpretation needs to provide effective COE materials and increase the rate of filter use.
- Tailor outreach efforts to take into account the linguistic and cultural needs of each neighborhood.

[34] This list is informed by CDPHE's June 2016 policy incorporating HE&EJ principles.

- Design the predictive model to prioritize vulnerable populations in the planning and implementation of the LRP.
- Collaborate with community organizations and other representatives to identify implementation strategies that are the least disruptive to the neighborhood.

Denver Water will continue to consult and collaborate with the organizations listed above and other HE&EJ experts, stakeholders, community members and customers to continually improve upon integration of the HE&EJ principles with the LRP.

Incorporation of HE&EJ principles in LRP planning

Experience from other jurisdictions suggests that median income level alone does not fully incorporate the HE&EJ principles and other weighting factors need to be considered. The predictive model is combined with weighted criticality factors in a risk model to address equity in LSL replacement throughout the integrated system. The criticality factors and weights were established in consultation with EPA and CDPHE.[35] For example, individual properties with a high risk of lead exposure as well as geographic groupings of households that collectively represent a high risk of lead exposure are identified in the predictive model as factors to support annual planning efforts for the COE Plans, Filter Program and the ALSLR Program. One benefit of using the risk model is that a sensitivity analysis can be performed on the results to test the assumptions for the criticality factors, their application and weightings on the prioritization results.

Denver Water will take the following steps in applying the above principles into the LRP:

- Start with collating available data to understand community demographics, language and culture, health risk factors and potential challenges to project acceptance.
- Use these data to develop targeted communications plans and LSL replacement schedules aimed at reaching vulnerable populations at greatest risk from lead exposure.
- Follow with linguistically and culturally appropriate outreach and actions to reach the communities most at risk from lead exposure.
- Use the Learning by Doing approach to address challenges and improve effectiveness of outreach in hard to reach communities.

Denver Water will create equitable access for all communities within the integrated system so that all residents will benefit from the reduction in lead exposure.

[35] See Section III.B and Appendix III.B.3.

Annual updates

Each year, Denver Water will update the ALSLR Program prioritization based upon work performed the previous year and new information learned from outreach efforts, including the filter survey responses. As part of this update, Denver Water will adjust the prioritization process and logic (i.e., criteria and weighting factors) used to plan and implement the LRP with the aim of creating a robust process coordinated in a manner that considers existing community projects and needs. Denver Water will use a similar strategy for the initial filter distribution as part of the Filter Program as well as in executing and updating the COE Plans.

The following strategies and best practices for vulnerable populations allows all Denver Water households to access the benefits of the Lead Reduction Program[36]

- **Soliciting feedback from impacted communities on lead reduction strategies**
  - Incorporate comments on the Draft Lead Reduction Program Plan.
  - Seek feedback at ongoing community presentations and events throughout impacted area.
  - Consider the comments received from the EPA 30-day public input period.
  - Include community representation in the LRP Advisory Committee.
- **Prioritizing implementation in the communities most impacted**
  - Reach households and geographic areas at most risk to lead exposure first, including schools, child care providers and expecting and existing families with formula-fed infants/ children up to age 2.
- **Removing economic barriers**
  - Allocate the necessary financial resources for the 15-year LRP.
  - Replace of the full lead service line at no cost to the property owner.
  - Provide water filters and replacement cartridges distributed for free to households.
- **Removing communication barriers**
  - Make available communications, education and outreach materials in the languages used by the communities impacted the most by lead exposure.
  - Use different methods to make information accessible (e.g., offline and available at facilities such as the library or recreation center).
  - Partner with community groups to distribute filters and encourage proper use.
- **Targeting rental properties in the LRP**
  - Provide water filters, replacement cartridges and education materials to tenants in rental properties.
- **Creating opportunities for community workforce development**
  - Partner with local workforce development organizations in the implementation of the LRP to provide training and employment for community members.
- **Addressing all sources of lead exposure**
  - Collaborate with other agencies and groups to holistically manage lead from paint, manufactured goods and other sources in addition to lead in drinking water infrastructure.

[36] Adapted from the Human Impact Partner's "Achieving Equity in Lead Poisoning Prevention Policy Making: Proceedings from a Consensus Conference," May 2019. See HumanImpact.org/LeadPolicyEquity

Addressing HE&EJ and all sources of lead exposure

Data from Denver Department of Public Health and Environment indicate that in addition to drinking water, other sources of lead exposure adversely affect Denver communities, including but not limited to lead paint, dust, soil, spices and household products imported from abroad and exposure to lead in countries where regulations for lead use are less stringent than those in the United States. Denver Water views the LRP as an opportunity to raise awareness about the risks of lead exposure and to collaborate with public health experts, medical providers, schools and community groups to reduce lead exposure from all sources, particularly in vulnerable households.

VI. PROGRAM IMPLEMENTATION SCHEDULE

The schedule for the LRP as shown in Table 16 is based on a late 2019 or early 2020 variance approval. Final schedule dates will be secured upon approval of the variance.

TABLE 16: PROGRAM IMPLEMENTATION SCHEDULE

Phase I – Submission	
September 2019	Denver Water submits Final Variance Request, Lead Reduction Program Plan and Treatment Modification Request to EPA and CDPHE and awaits decision.
Phase II — Implementation	
Late 2019/Early 2020	**Upon approval of the variance:** • Begin region wide Communications, Outreach and Education including: - Tier II Notification to all customers with known, suspected and possible lead service lines. - Publications of service line inventory map. - Community meetings. • Begin distribution of filters. • Notify customers that are identified for LSL replacement in first the year of the LRP and ALSLR Program. • Begin corrosion control treatment per CDPHE's approved schedule. **First Program Year Begins** • 91 days after approval of the variance, Lead Reduction Program begins accelerated lead service line replacement and the 15-year program begins.
Phase III — Maintenance	
Annually	**Annual compliance meetings with EPA and CDPHE:** Review progress report and develop corrective actions for non-compliant element(s). Reports will be available 35 days following the end of the program year.
15 Years After First Program Year	All lead service lines within service area have been replaced. Replacement cartridges provided for up to six months after the line is replaced.

VII. COST IMPACTS

In addition to assessing public health and environmental impacts, Denver Water estimated the life cycle costs associated with both alternatives, the variance and orthophosphate.[37] The MOU stakeholders, which include Denver Water, CDPHE and regional stakeholders, also contributed capital and operating cost data associated with downstream impacts to regional stormwater entities, wastewater utilities, water utilities, watershed basin and recreational entities.

Stormwater, watershed basin and recreational cost impacts were included because 40% of Denver Water's treated water supply is used for irrigation between the months of May and October. Under the orthophosphate alternative, a portion of the orthophosphate added to drinking water for corrosion control will accumulate in soil, runoff into stormwater collection systems, reach streams and eventually load downstream reservoirs.

The Denver metro area is situated in a high-elevation, arid environment that requires regional water entities to capture snow melt and stormwater runoff in nearby reservoirs, typically between the months of May and August, which is then used during the remainder of the year for drinking water supplies or water rights exchanges. Warm temperatures and year-round sunny conditions make these reservoirs susceptible to algal blooms, a condition expected to be exacerbated with additional phosphorus loading in the watershed.

Capital and operating costs were developed for (but are not limited to):

- Adding treatment processes and/or increasing chemical dosing at wastewater treatment plants to remove the additional phosphorus loading.
- Adding corrosion control treatment processes at connected water utilities receiving a portion of their supply from Denver Water.
- Adding treatment processes or infrastructure at downstream drinking water treatment plants to combat taste and odor compounds and potential cyanotoxins resulting from algal blooms.
- Accounting for the loss of revenue at regional reservoirs due to closures or restrictions during algal blooms.
- Adding stormwater infrastructure or street sweepers to remove phosphorus from stormwater pathways.
- Treating regional reservoirs with alum to bind up phosphorus to make it unavailable to algae as a food source.
- Increasing education and outreach to reduce other sources of phosphorus loading in the watersheds.

[37] Details are provided in Appendix VII.A.

Both low and high cost estimate ranges were calculated to reflect different assumptions for the timing and need of various capital projects.[38] For example, an underlying assumption that CDPHE and the Water Quality Control Division would allow wastewater and stormwater providers until the early to mid-2030s to remove the phosphorus loading from orthophosphate addition would result in delayed and reduced life-cycle costs for those entities but added interim costs for downstream reservoir and recreational entities to account for impacts up through 2030 or 2035.

Other major assumptions driving costs included the duration to replace lead service lines under either scenario—the variance approach (15 years) or orthophosphate for corrosion control (50 years or more).

Per Figures 30 and 31, life-cycle costs have been calculated using two slightly different approaches. Figure 30 reflects CDPHE's request to include only the incremental costs, above existing practices or already planned projects, necessary to implement either the variance or orthophosphate alternatives. Figure 31 reflects Denver Water's approach to includes costs for replacement of lead service lines, whether this occurs over 15 years under the variance alternative or over 50 years under the orthophosphate alternative. Denver Water believes customers should understand the full cost impact under either alternative. Both figures represent total costs (solid bars) plus net present value costs (striped bars) to reflect the time value of money.

As seen in Figure 30, the estimated net present value for the variance request ranges between $265 million and $362 million (depending on assumptions made for other capital projects), while the net present value for orthophosphate was estimated to range between $322 million and $505 million.

Denver Water replaces lead service lines at a rate of 700 per year based on existing operations, with an additional 500 per year replaced through redevelopment. To replace all lead services within 50, Denver Water would have to increase the rate of replacement from 700 per year to 780 per year. These costs are included in the amounts shown in Figure 31.

Using the upper estimate of the net present values (blue striped bars), Figure 32 demonstrates the cost splits among regional stakeholders depending on the alternative under consideration. Orthophosphate costs would be spread among many different entities whereas the variance costs would be largely supported by Denver Water. There is significant overlap in customers between Denver Water, Metro Wastewater and City and County of Denver Stormwater. Costs under either alternative will be supported by many of the same people.

[38] See Appendix VII.A for detailed cost information.

FIGURE 30: COST COMPARISON BETWEEN VARIANCE AND ORTHOPHOSPHATE ALTERNATIVES, EXCLUDING CURRENT LEAD SERVICE LINE REPLACEMENT COSTS

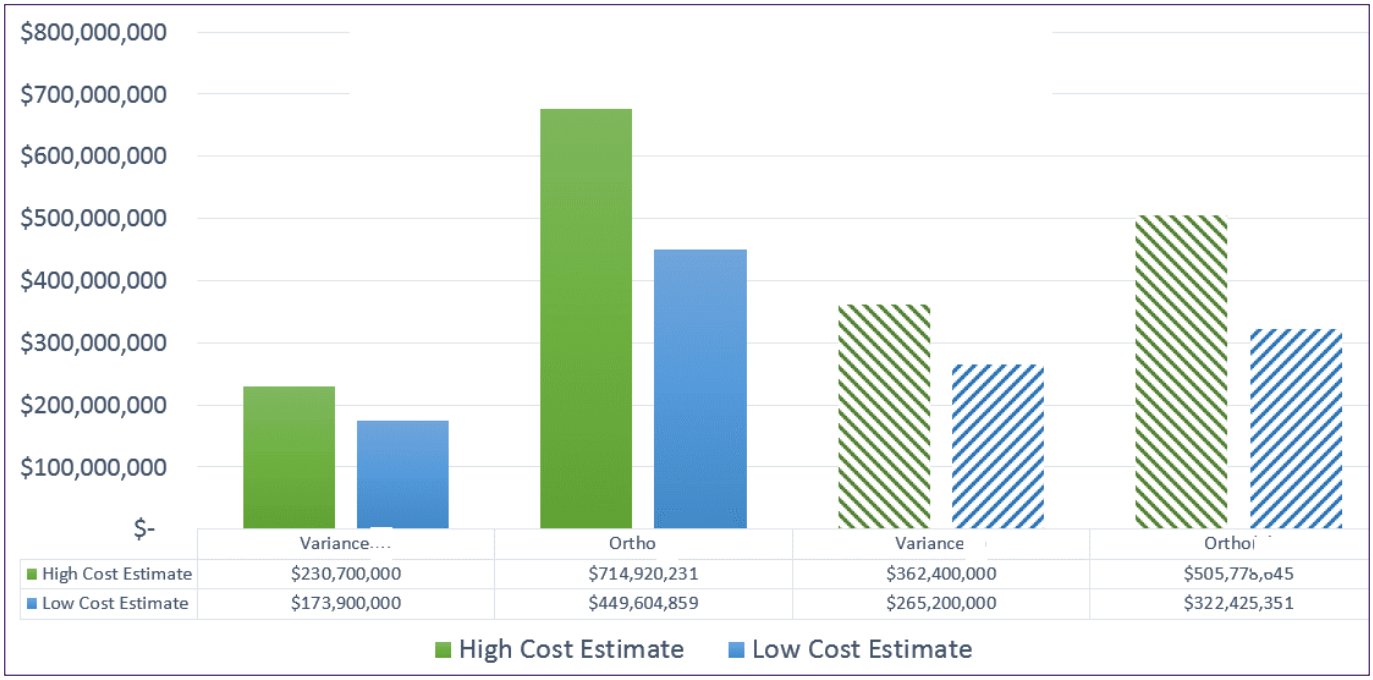


FIGURE 31: COST COMPARISON OF VARIANCE AND ORTHOPHOSPHATE ALTERNATIVES (INCLUDING EXISTING LSL REPLACEMENT COSTS)

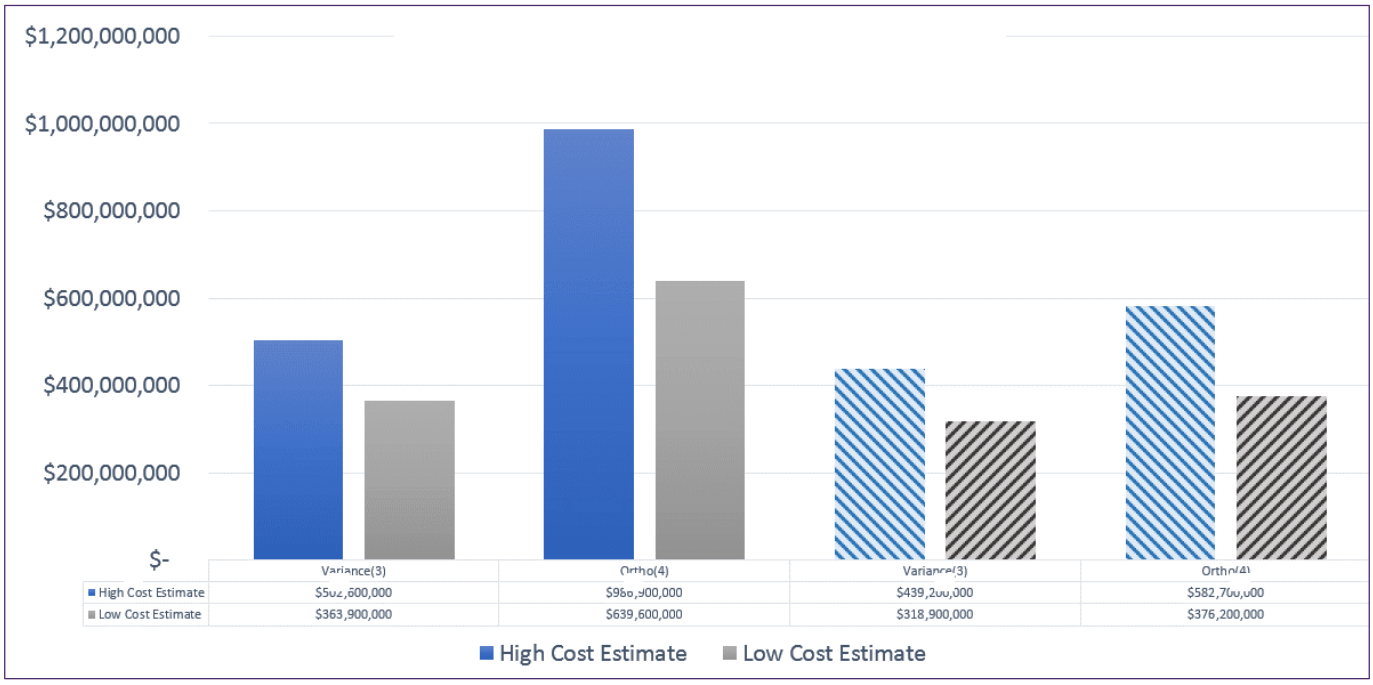
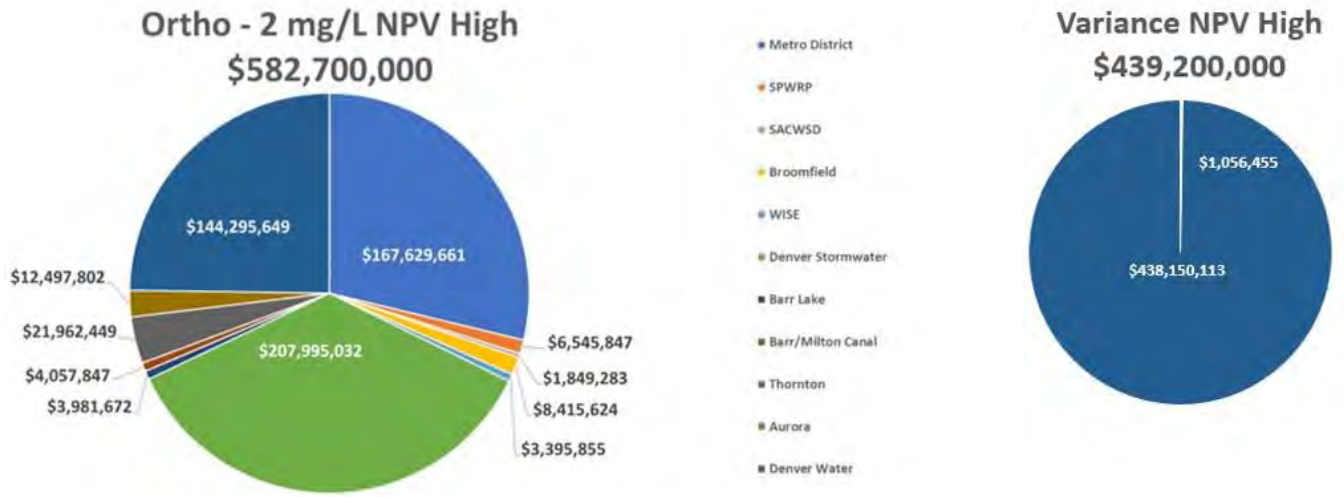


FIGURE 32: HIGH COST, NET PRESENT VALUE ESTIMATE COMPARISON OF ORTHOPHOSPHATE AND THE VARIANCE (INCLUDING EXISTING LSL REPLACEMENT COSTS)



Based on the cost estimates presented herein and in detail in Appendix VII.1, the variance cost is estimated to be less than the orthophosphate alternative while providing a holistic solution that replaces all known lead service lines 35 years sooner than the orthophosphate alternative. Other benefits include:

- The variance allows Denver Water greater flexibility with new water sources within 15 years because the lead service lines, the major source of lead contamination in the water, will be replaced. With ever increasing stresses on the Colorado River, Denver Water will have to rely more frequently on maximum utilization of its existing supplies east of the continental divide, including reuse. Reducing limitations on the type of supply alternatives as a result of corrosion control concerns allows Denver Water to be more adept at responding to ever increasing water supply constraints.
- Downstream reservoirs, including those owned by Denver Water, will see lower phosphorus loading between 2020 and 2035.
- According to the 2017 Health Impact Partners report,[39] every $1.00 spent on replacing lead service lines eventually results in a $1.30 net gain to the community attributable to future income gains and reduced public health costs. Based on the total variance costs (solid bars) presented in Figure 31, this equates to a return on investment of $471M to $652M for the Denver metro area.

[39] Human Impact Partner's "Achieving Equity in Lead Poisoning Prevention Policy Making: Proceedings from a Consensus Conference," May 2019. See HumanImpact.org/LeadPolicyEquity

VIII. GLOSSARY OF DEFINITIONS

Abbreviations, Acronyms or Terms	Abbreviations, Acronyms or Terms Descriptions
90th Percentile	The 90th percentile refers to the concentration below which 90% of samples are measured for a given monitoring period. Alternatively, 10% of samples are measured with lead concentrations above the concentration associated with the 90th percentile.
Action Level	As used in the Lead and Cooper Rule, if the lead concentration exceeds the action level, addition actions are required to control corrosion. Also referred to as the AL.
Adoption	For the purpose of the filter survey means that the customer enrolled in the Filter Program is using a filter for drinking water and cooking.
ALSLR Program	Refers to the Accelerated Lead Service Line Replacement Program.
Blood Lead Level (BLL)	A blood test can be given to measure the level of lead in an individual's blood. Measured in unit of micrograms of lead per deciliter of blood (ug/dL).
COE Plans	Refers to the Communications, Outreach and Education Plans associated with the Lead Reduction Program.
Contact	Refers to direct mailing, water bill inserts, door hangers, in person contact, email, phone call, educational materials accompanying filters and cartridges, or any other direct communication channels identified in Denver Water's communications, outreach, and education plans.
Corrosion Control Treatment (CCT)	Refers to corrosion control treatment, such as by orthophosphate addition or pH/alkalinity adjustment.
Coupon Testing	Refers to bench-scale laboratory testing with metal coupons and is used to estimate the effectiveness of corrosion control treatment. It is also referred to as immersion testing.
Filter Program	Refers to the distribution of filters and replacement cartridges to Denver Water customers with a known, suspected or possible lead service and the related survey for filter adoption.
Households	Refers to any single family or multi-family unit in Denver Water's service area enrolled in the Filter Program.
Integrated System	An integrated system is a system where a wholesale system and one or more consecutive systems have distribution systems that are physically connected, where the wholesaler has assumed responsibility for compliance with one or more of the regulatory requirements applicable to the supplier responsible for the consecutive system.

Abbreviations, Acronyms or Terms	Abbreviations, Acronyms or Terms Descriptions
Known LSL	100% direct evidence documenting that the material of the service line is lead.
LCR	Lead and Copper Rule.
LSL	Lead Service Line.
Lead Service Line	Means a water service line made of lead that connects the water main to the building inlet and any lead pigtail, gooseneck or other fitting that is connected to such lead line.
LSL Inventory	An inventory of the material used for each non-irrigation service line that is a known, suspected, and possible LSL associated with a customer premise within Denver Water's system. The inventory includes private service lines and all LSLs in the service areas of all distributors who are a part of the system.
LSL Replacement	Lead Service Line Replacement.
LRP	Lead Reduction Program.
Non-detect	Means that the concentration of a given compound is too low to be measured. The method detection limit refers to the lower limit of an analytical method below which a compound cannot be measured by that method.
Non-Lead LSL	The material of the service line is 100% confirmed to be non-lead based on direct evidence or statistically defensible factors supporting categorization as a non-lead service line.
OCCT	Optimal Corrosion Control Treatment.
Orthophosphate Treatment	Phosphate-based treatment as described in the Colorado Department of Public Health and Environment's March 20, 2018 letter to Denver Water designating orthophosphate as optimal corrosion control treatment.
Possible LSL	50% likelihood of the service line material being lead, as some data may be conflicting or missing but there is not enough information to confirm a non-lead service line.
Program Year	Has the same meaning as calendar year.
Public Notice	For the purpose of this variance, means a Tier II public notice as described in Rule 11.26 of the Colorado Primary Drinking Water Regulations, 5 CCR 1002-11, with messaging approving by CDPHE.
Suspected LSL	80% to 90% likelihood of the service line material being lead, based upon available data (i.e., homes built prior to 1951).

Abbreviations, Acronyms or Terms	Abbreviations, Acronyms or Terms Descriptions
Threshold for Filter Adoption Rate	Refers to the minimum percentage of households that use filters (i.e., filter adoption rate) such that the LRP is considered equivalent to orthophosphate.
Tier 1 Site	Tier 1 homes as defined in the Lead and Copper Rule. A Tier 1 home is a sample site that is a single-family structure built between 1983 and 1987 that (1) contains copper pipes with lead solder, (2) contains lead pipes and/or (3) is supplied by a lead service line.
Tier II Public Notice	Tier II public notice as described in section 11.33 of the Colorado Primary Drinking Water Regulations, 5 CCR 1002-11.
Unlikely LSL	Based on available data, there a very low likelihood (less than 10%) that the service line is made of lead.

Enclosure 2

Denver Water's Proposed Terms and Conditions

Denver Water Request for Variance From Optimal Corrosion Control Treatment Requirements Under the Safe Drinking Water Act's Lead and Copper Rule

Note: This document sets forth Denver Water's proposed terms and conditions that will control if the variance to the treatment technique and the modification to the designated OCCT is granted. This document is preliminary and subject to modification.

Denver Water's Proposed Terms and Conditions for its Variance Request for Optimal Corrosion Control Treatment under SDWA 42 U.S.C. § 300g-4(a)(3)

In furtherance of Denver Water's variance request from 40 C.F.R. § 141.82(e) of the Optimal Corrosion Control Treatment Requirements under the Safe Drinking Water Act's Lead and Copper Rule, Denver Water is submitting its proposed terms and conditions which control during the term of the variance approval. The following proposed terms and conditions will become binding on Denver Water only upon the date that a variance becomes effective and so long as the variance remains in place. Except as otherwise provide herein, Denver Water must continue to follow the compliance requirements under the provisions of the Lead and Copper Rule as promulgated under state and federal law, 5 CCR 1002-11, 40 C.F.R. § 141.80-141.91, and as may be modified in the future.

1. Definitions:

A. *"Action level"* has the same meaning as action level in the Lead and Copper Rule, 40 C.F.R. § 141.80(c) and §§ 11.26(1)(c) and (2)(b) of the Colorado Primary Drinking Water Regulations (5 CCR 1002-11).

B. "*Adoption*" or *"Adopted"* for the purposes of the filter survey means that the customer enrolled in the filter program is using a filter NSF/ANSI (53) certified for lead removal for drinking, cooking, and infant fed formula (ingestion). Respondents who indicate that they use bottled water or an alternative NSF/ANSI (53) certified filter for ingestion will count as having adopted the use of a filter under paragraph 5.G.i. below.

C. "*Contact*" means direct mailing, water bill inserts, door hangers, in person contact, email, phone calls, educational materials accompanying filters and cartridges, or any other direct communication channels identified in Denver Water's communications, outreach, and education plan. Communications via information posted on the Denver Water website, social media websites, water bills, distribution of filters and replacement cartridges alone, or public notices required as a corrective action or a failure to meet a condition are excluded from this definition.

D. *"Customer Premise"*, for the purpose of these terms and conditions only, means a property or a residential unit within a multi-family property that receives water service pursuant to a Denver Water or distributor tap license.

E. "*Customer(s) Enrolled in the Filter Program*" means a customer premise, as defined herein where there is a known, suspected or possible lead service line (LSL), that will automatically be distributed a filter under section 5 below, unless otherwise refused by the customer.

F. "*Day*" means calendar day.

G. "*Effective Date*" means ninety-one (91) calendar days following approval of the variance or issuance of the State's modification decision, whichever occurs later.

H. *"Integrated System(s)"* means the defined term used in section 11.42(4) of 5 CCR 1002-11, as may be modified in the future. Currently, "integrated system" is defined as a "wholesale system and one or more consecutive systems with distribution systems that are physically connected [that] . . . choose to operate in a manner where the wholesaler assumes responsibility for compliance with one or more regulatory requirements applicable to the supplier responsible for the consecutive system, if the requirements of … section 11.42(4) are met."

I. *"Ingestion"* means the use of tap water for drinking, cooking, and infant fed formula.

J. *"Investigated"* refers to any activity used to identify the service line materials including a lead water quality test, potholing, visual inspection, or other methods that allows for a determination of the service line material.

K. *"Known LSLs"* are based upon direct evidence that gives a 100% estimated probability that a service line is an LSL.

L. "*Known, suspected and possible LSLs*" collectively refers to known LSLs, suspected LSLs, and possible LSLs.

M. "*Lead and Copper Rule (LCR) Regulatory Sampling*" means the collection of lead and copper tap samples for homes that have lead solder without a lead service lines and homes with lead service lines sampled in accordance with § 11.26 of 5 CCR 1002-11 and 40 C.F.R. § 141.86.

N. Lead Reduction Program Plan (LRPP) means Denver Water's Lead Reduction Program Plan dated September 2019.

O. *"Lead Service Line" or "LSL"* means a service line made of lead which connects the water main to the building inlet and any lead pigtail, gooseneck or other fitting which is connected to such lead line. This definition is intended to be inclusive of the term "Lead Service Line" as defined under section 11.26(1)(g) of 5 CCR 1002-11 and 40 C.F.R. § 141.2.

P. *"LSL Replacement"* is defined in paragraph 4.B, below.

Q. "*Orthophosphate Treatment*" means phosphate-based treatment as described in the Colorado Department of Public Health and Environment's (CDPHE) March 20, 2018 letter to Denver Water designating orthophosphate as optimal corrosion control treatment.

R. *"Possible LSLs"* are based on conflicting or missing data that provides an estimated probability value between 50% to 79% that a service line is an LSL.

S. "*Program Year*" has the same meaning as calendar year.

T. "*Public Notice*" for the purpose of this variance means either:

i. a Tier 2 public notice as described in § 11.33 of 5 CCR 1002-11 and 40 C.F.R. § 141.203, initiated within thirty (30) days following a CDPHE notice of a violation of the variance with messaging approved by CDPHE provided to all customers served by Denver Water;

ii. a public notice that contains the same elements of Tier 2 Public Notice described above initiated within sixty (60) days after learning of the need for corrective action provided to customers enrolled in the filter program to be delivered by making at least two (2) forms of direct contact with the customer subset, with messaging approved by CDPHE;

iii. a public notice by Denver Water that meets the requirements as described in § 11.26(7) of 5 CCR 1002-11 and 40 C.F.R. § 141.85, including public education associated with the Lead and Copper Rule initiated within sixty (60) days to all recipients specified in § 11.26(7)(c) of 5 CCR 1002-11 and 40 C.F.R. § 141.85(b);[1]

iv. a notice included in Denver Water's annual summary report; or

v. a Tier 3 public notice as described in § 11.33(4) of 5 CCR 1002-11 and 40 C.F.R. § 141.204, initiated as soon as possible but no later than 365 days following a violation or situation notification from CDPHE.

U. *"Suspected LSLs"* are based upon available data that provides an estimated probability value between 80% to 99% estimated probability (i.e. homes built before 1951) that a service line is an LSL.

V. *"System*" means the community water system that Denver Water owns and operates (PWS ID# CO0116001) and the integrated systems covered under Master Meter, Read and Bill, and Total Service agreements with Denver Water as detailed in Appendix III.B.1 of the Lead Reduction Program Plan submitted by Denver Water in support of its variance request.

W. *"Variance End Date"* means fifteen (15) years after the effective date, unless extended by EPA.

2. Corrosion Control Treatment:

A. *pH/Alkalinity Adjustment Corrosion Control Treatment*. By the effective date, Denver Water must begin to make adjustment to pH and alkalinity as corrosion control

[1] The public notice requirements under Subpart Q of the LCR (40 C.F.R, § 141.201 *et seq.*) will continue to apply if there is a violation of the schedule, and/or any terms and conditions of the variance –tier 1 and tier 2 notices, respectively.

treatment (CCT) according to an implementation schedule and treatment targets approved by CDPHE. Denver Water must maintain the corrosion control parameters and targets within the ranges designated by CDPHE under § 11.26(3)(d)(iii) of 5 CCR 1002-11 and 40 C.F.R. § 141.82(h).

B. *Monitoring and Sampling:*

i. *LCR Regulatory Sampling for Action Level 90th Percentile Calculation.* During the variance, Denver Water must maintain Lead and Copper Rule (LCR) sampling sites pursuant to § 11.26(2) of 5 CCR 1002-11 and 40 C.F.R. § 141.86 for lead service lines and lead solder sites.

ii. *Use of Sampling Results.* Lead water quality tests collected to identify LSLs for the inventory under this variance and to verify lead concentrations post-replacement shall not be used in the calculation of the 90th percentile. Any customer-requested samples that meet the Tier 1 sampling requirements will still be included in Denver Water's compliance calculations.

iii. *Monitoring for Water Quality Parameters*. Denver Water must follow §§ 11.26(4)(j)-(l) of 5 CCR 1002-11 and 40 C.F.R. §§ 141.82(g)-(i) for treatment technique compliance determinations for continued operation and maintenance of the CCT.

C. *CCT Compliance Metrics, Corrective Actions, and Failures.*

i. *CCT Compliance.* For each six-month sampling period, Denver water must achieve LCR Regulatory Sampling at or below the LCR Action Level based upon the 90th percentile calculation.

ii. *Corrective Action.* If compliance has not been achieved under 2.C.i., Denver Water must follow the requirements of the LCR in the case of a lead or copper Action Level exceedance under § 11.26 of 5 CCR 1002-11 and 40 C.F.R. § 141.82. If Denver Water's LCR regulatory sampling exceeds the LCR's Action Level as measured at the 90th percentile for two (2) LCR monitoring periods within the duration of the variance, Denver Water has failed to meet the condition in 2.C.i., and either:

a. this variance shall terminate; or

b. CDPHE will require Denver Water to follow the corrosion control treatment steps under § 11.26(3)(c) of 5 CCR 1002-11, in which case the variance will be continued pending the results from corrosion control treatment studies until CDPHE makes a determination under § 11.26(3)(c)(ii). EPA may nevertheless terminate this variance in the interests of public health under paragraph 7.D below.

c. In either case above, CDPHE will issue Denver Water a treatment technique violation and Denver Water must conduct a Tier 2 public notice to all customers under 1.T.i above.

3. Lead Service Line Inventory:

A. *LSL Inventory*. Denver Water must create and maintain on an ongoing basis an inventory of the material used for each service line used for drinking water that is a known, suspected, and possible LSL associated with a customer premise within Denver Water's system, and update the inventory each program year in agreement with CDPHE as LSLs are replaced and the material used for service lines are investigated. The inventory must include private service lines, and must include all LSLs within the system, including in the service areas of all distributors who are a part of the system. Denver Water must complete the initial LSL inventory no later than thirty-five (35) days after the effective date. The total estimated number of known, suspected, and possible LSLs equals (Y) as further described in paragraph 4.A below. Any updates to (Y) will be submitted in Denver Water's annual summary report described in paragraph 6 below.

B. *Investigation of Service Line Materials*. On an ongoing basis Denver Water must investigate known, suspected, and possible LSLs using lead water quality tests, potholing, visual inspections, or other means that supports a determination of the service line material. The number of known, suspected and possible LSLs for the purpose of investigating properties for the first year following the variance approval will be based on the (Y) factor, as adjusted under paragraph 4.A below. Denver Water must incorporate its findings under this subsection into its required LSL inventory annual updates.

C. *Publication of LSL Inventory.* No later than seventy (70) days following the effective date, Denver Water must provide public access to its LSL inventory on its external customer website, which will allow the public to view whether service line materials used for any customer premise in the system is (i.e. lead, copper, or unknown). During the term of this variance, Denver Water must continue to provide public access to its LSL inventory, including access to any updates to its inventory required under this section 3. For owners or residents of a customer premise who call Denver Water by phone, Denver Water must disclose whether its inventory shows that the owner's or resident's service line is a known, suspected and possible LSL, is unlikely to be an LSL or is a non-lead service line.

D. *LSL Inventory Compliance Metrics, Corrective Actions, and Failures.*

i. *Compliance Metric.* Denver Water must investigate a minimum of 1.4% of the total estimated number of suspected and possible LSLs in the LSL inventory each program year until 20% of the total estimated number of suspected and possible LSLs are investigated based upon the inventory at the beginning of the first program year (based on a subset of Y as described in paragraph 4.A below) as adjusted. These investigations are performed independently of the LSL replacements under paragraph 4 below.

ii. *Corrective Action.* If Denver Water does not conduct the minimum 1.4% of investigations by the end of the program year, the denominator (Y) in paragraph 4.A below will revert to the value established at the beginning of the previous program year, less LSL replacements for the previous program year, until Denver Water achieves compliance with this paragraph. Denver Water must also provide public notice that the metric was not met in its annual summary report under paragraph 1.T.iv above.

iii. *Completion of Inventory.* When Denver Water has completed the confirmation of the material for all suspected and possible LSLs under paragraph 3.D.i., Denver Water must provide written notice to CDPHE and this variance metric will terminate.

4. Accelerated Lead Service Line Replacement Program:

A. *LSL Replacement*. By the effective date, Denver Water must begin to implement accelerated LSL replacement in its system and replace all known LSLs within 15 years of the effective date. By the end of program year 1, Denver Water must achieve a 6.0% replacement rate,[2] and by the end of program year 2, Denver Water must achieve a 6.5% replacement rate based upon the known, suspected and possible LSLs (Y) at the beginning of the program year. By the end of the third program year and every program year thereafter, Denver Water must maintain a minimum cumulative annual average replacement rate of 7.0% per year. At the end of each program year, the cumulative program year average must be calculated using the total number of LSLs replaced during the term of the variance (X) divided by the total estimated number of known, suspected, and possible LSLs (Y), consistent with the most recent update of the LSL inventory. Program year adjustments to (X) and (Y) will be made at the end of each program year with the approval of EPA and CDPHE based upon any changes to the total estimated number of known, suspected and possible LSLs in Denver Water's updated LSL inventory except as otherwise provided in paragraph 3.D.ii above; provided, however, all LSLs must be replaced within 15 years of the effective date. For program year 1, X = 3,838 and Y= 63,955.

B. *LSL Replacement Defined*. For the purpose of calculating the cumulative program year average replacement rate, the following types of LSL replacements will count as credit for an entire LSL replacement:

i. full LSL replacement of a single service line;

ii. replacement of an existing partial LSL that results in a non-lead service line from the main to the first fitting inside the structure;

iii. replacement of a galvanized service line downstream of an existing or previously existing LSL, including any lead that is part of the upstream segment of the service line; and

[2] If the effective date is after January 1, 2020, the 6.0% replacement rate for the first program year will be prorated through December 31, 2020 by dividing the number of remaining full months from the effective date to the end of the Calendar Year by 12 and multiplying this factor by the 6.0% replacement rate.

iv. LSL replacement completed by other governmental agencies, developers, homeowners, non-profits, etc. and inspected by Denver Water.

C. *Replacement to Fitting.* All LSLs must be replaced from the main up to the first fitting inside the structure excluding any portion of the service line that is copper. If there is no fitting within five feet of the location where the service line enters the structure, Denver Water must install a fitting to allow for connection of the service line at a location convenient for Denver Water.

D. *Partial LSL Replacements.* Denver Water may not make a partial replacement of an LSL during the term of the variance except when i. emergency repairs must be made to a service line or water main to protect the distribution system; or ii. property owner consent cannot be obtained or the property cannot be accessed. A partial replacement that does not result in complete replacement of all portions of the LSL shall not be counted as an LSL replacement for the purposes of the accelerated LSL replacement program until the partial LSL is fully replaced.

E. *Post Replacement Samples*. Denver Water must offer to collect and analyze lead samples at homes where LSLs have been replaced six (6) months post LSL replacement.

F. *Test Out.* The "test out" provision in 40 C.F.R. § 141.84(c) and § 11.26(6)(b)(i)(B) of 5 CCR 1002-11 does not apply while Denver is subject to this variance. Any lines that "test out" do not count toward LSLs that were replaced under the terms of this variance.

G. *Property Owner Consent.* Denver Water must contact property owners at the customer premise before replacement to secure the property owner's documented consent. Work at the customer premise may commence once consent is documented. If Denver Water has not made contact with a property owner, Denver Water must use reasonable efforts to secure consent. Reasonable efforts must include at least three attempts to contact the property owner including an attempt to send at least two (2) written requests by U.S. mail to the property owner at the most recent mailing address identified through Denver Water records for consent to replace the LSL at the property, and an attempt to obtain permission by making in-person contact with the property owner if necessary. If documented consent to replace the LSL is not granted after reasonable efforts are made to achieve consent, the property will be added to Denver Water's Service Line Refusal List as described in paragraph 4.H. below.

H. *Customer Refusals and Changes in Customer Accounts.* Denver Water must maintain records of the addresses of all structures at which the property owner does not consent to LSL replacement (Service Line Refusal List). When Denver Water customer account records indicate a change in ownership at the customer premise, Denver Water must determine whether the address is on the Service Line Refusal List, and within ninety-one (91) days of a change in Denver Water account records, undertake reasonable efforts to obtain permission from the new property owner of the customer premise to replace the LSL. Reasonable efforts include the efforts described in paragraph 4.G. above. If permission is granted and conditions allow for

the LSL to be accessed and safely replaced, Denver Water must replace the LSL. By the variance end date, Denver Water must replace all LSLs at properties on the Service Line Refusal List.

I. *LSLs Discovered After Variance Term.* Denver Water must continue to replace any LSL discovered after the variance end date and report any LSL replacements to CDPHE on an annual basis. This condition shall survive the term of the variance.

J. *Accelerated LSL Replacement Compliance Metrics, Corrective Actions, and Failures.*

i. *Compliance Metric*. Denver Water must achieve at least a 6.0% LSL replacement rate by the end of program year 1, 6.5% in program year 2, and beginning the end of program year 3 and thereafter a 7.0% cumulative annual average LSL replacement rate each program year.

ii. *Corrective Action.* If the compliance metric in paragraph 4.J.i. is not achieved after program year 3, Denver Water must increase LSL replacements to achieve a 7.0% cumulative annual average replacement rate by the end of the next program year. In addition, Denver Water shall provide public notice to all customers who have known, suspected, or possible LSLs that correction under this variance metric under 1.T.ii

5. Filter Program:

A. *Filters.* Denver Water must distribute to the occupant of all customer premises with known, suspected and possible LSLs one (1) filter and enough replacement cartridges for the first six months of use. Denver Water shall begin to distribute filters and cartridges within ninety-one (91) days of the effective date and complete distribution one hundred and eighty-two (182) days following the effective date. If Denver Water does not distribute all of the filters and cartridges by the above deadline, then Denver Water must conduct public notice to all customers enrolled in the filter program under paragraph 1.T.ii. All filters and cartridges distributed must be certified NSF/ANSI (53) for lead removal and not remove fluoride. Denver Water need not distribute a filter and replacement cartridge to a customer premises if the occupant confirms that their household uses bottled water, an existing under the sink filter certified NSF/ANSI (53) for lead removal, refrigerator filter certified NSF/ANSI (53) for lead removal, or other lead removal device that is certified NSF/ANSI (53) for lead removal for ingestion purposes.

B. *Filter Replacement Cartridges.* Denver Water must distribute replacement cartridges to customers enrolled in the filter program per the filter manufacturers' recommended replacement rate unless the customer refuses the filter or replacement cartridges. Replacement filters must be provided to each customer premise enrolled in the filter program until six months after replacement of a customer premise's LSL or until the time the service line of the property is confirmed to be non-lead. If Denver Water does not distribute all of the replacement cartridges per the manufacturers' recommended replacement rate, then Denver Water must conduct public notice to all customers enrolled in the filter program under paragraph 1.T.ii.

C. *Changes in Customer Accounts.* If a change in the customer name of the water account associated with a customer enrolled in the filter program occurs at any time, then Denver Water must distribute a new filter within thirty-five (35) days of the change in customer account and replacement cartridges per manufacturers recommended replacement rate to the new customer so long as the customer premise or a residential unit at the customer premise is enrolled in the filter program.

D. *Filters for Infants in '83 to '87 Customer Premises*. If a customer has a formula-fed infant/child up to 24 months of age and resides in a customer premise that is built between 1983-1987 and served by a copper service line with lead solder, upon customer request Denver Water must provide a free lead water quality test kit. If the water quality results in the first draw show lead concentrations above 3 ppb, Denver Water must offer a filter and enough replacement cartridges to last the customer until a child at the customer-premise exceeds the age of 24 months.

E. *Filter Adoption Assessment.*

i. *Surveys.* Denver Water must conduct a survey each program year of randomly selected customers enrolled in the filter program to receive at minimum 1,059 responses. The minimum number of required responses may be reduced upon written approval of CDPHE and EPA as the number of customers enrolled in the filter program decline during the term of this variance. The survey must inquire whether the customer has adopted the filter for water used for infant formula if applicable, cooking and drinking or is using bottled water or a filter device that is certified NSF/ANSI (53) for lead removal not provided by Denver Water for infant formula, cooking and drinking. The filter survey will be provided to and approved by CDPHE before distribution to customers enrolled in the filter program. If Denver Water:

a. Does not conduct the annual survey during any program year, then Denver Water will be issued a treatment technique violation and must conduct public notice to all customers under paragraph 1.T.i.

b. If Denver Water does not collect the minimum number of received survey responses during any program year, then Denver Water must conduct public notice to all customers enrolled in the filter program under paragraph 1.T.v, unless CDPHE determines that Denver Water must conduct public notice under paragraph 1.T.ii.

ii. *Survey of Filter Adoption Rate.* All of the received survey responses will be used to calculate the filter adoption rate based on the number of responses that confirm adoption of the filter, or use of bottled water or alternative filer device not provided by Denver Water that is certified NSF/ANSI (53) for ingestion. All respondents who indicate that they do not use the filter, bottled water, or alternative filter device that is certified NSF/ANSI (53) for cooking but have adopted for drinking water and infant fed formula, if the latter is applicable to the respondent, will be summed and multiplied by 50% and the result may be counted as having adopted a filter for the purposes of determining the average filter adoption rate in paragraph 5.G.i. below.

iii. *Bottled Water and Alternative Filter Devices*. Customers who indicate that they use bottled water or alternative filter device certified NSF/ANSI (53) will continue to be customers enrolled in the filter program unless they refuse a filter or contact Denver Water to opt-out of the filter program. Denver Water will maintain a list of customers who have refused filters or opted-out of the filter program and provide the list to CDPHE upon request.

F. *Filter Performance*.

i. *Confirmation of Filter Performance Before Distribution*. Before distributing filters to customers enrolled in the filter program in program year one, Denver Water will test the lead removal effectiveness of 12 units of each type of filter to be distributed to customers using water from Denver Water's pipe racks as described in the LRPP from at least one Denver Water treatment plant in accordance with a testing protocol approved by CDPHE to confirm that the filters meet their NSF/ANSI (53) certification. All filter testing results will be reported to CDPHE. Denver Water will not distribute a filter model that fails to meet the NSF/ANSI (53) certification based upon the lead samples collected under this paragraph.

ii. *Confirmation of Filter Performance in Field*. To confirm performance of filters in use at customer premise, Denver Water will collect fifty (50) samples from filters in use by customers enrolled in the filter program who are also enrolled in Denver Water's LCR regulatory sampling program in accordance with a testing protocol approved by CDPHE. Samples will be collected from filters used by customers enrolled in the filter program at the same frequency as LCR regulatory sampling and reported to CDPHE and EPA.

iii. If Denver Water does not complete testing of filters under this section 5.F. in accordance with the CDPHE approved protocols, Denver Water must provide public notice in accordance with paragraph 1.T.ii. above.

G. *Filter Adoption Compliance Metrics, Corrective Actions, and Failures.*

i. *Compliance.* Denver Water must achieve a filter adoption rate of 65% at the end of each program year.

ii. *Corrective Action*. If this metric is not achieved at the end of a program year, then Denver Water must achieve a 65% filter adoption rate by the end of the following program year. Denver Water will also provide public notice to customers enrolled in the filter program under paragraph 1.T.ii.

H. *Filter Communication Compliance Metrics, Corrective Actions, and Failures.*

i. *Compliance*. Denver Water must make direct contact with lead outreach and education materials to 95% of all customers enrolled in the filter program in every program year. Compliance shall be documented by mailing lists and mail receipts,

lists of customer email addresses for customers who elect to receive email communication, or other forms of documentation approved by CDPHE.

ii. *Corrective Action*. If Denver water does not achieve compliance with paragraph 5.H.i., then Denver Water must increase outreach efforts to reach 95% of Denver Water customers enrolled in the filter program, and Denver Water must also provide public notice to all customers enrolled in the filter program of its failure to achieve the metric under paragraph 1.T.ii.

6. Recordkeeping and Reporting Requirements:

A. *Reporting.* In the event that Denver Water determines that it will not meet any of the terms and conditions as defined in this document, Denver Water must notify CDPHE and EPA no later than two business days after the determination occurs. CDPHE will provide any resulting requirements (e.g., notification of violation, public notice requirements, etc.) to Denver Water (and copy EPA) in writing.

B. *Recordkeeping.* On an ongoing basis for the term of the variance, Denver Water shall record, maintain records of, and report each year the following information. Denver Water will provide any of the "raw" data to CDPHE or EPA, when requested. Unless otherwise stated, the reporting and recordkeeping requirements under the LCR remain in effect:

i. *CCT.*

a. all lead and copper regulatory sampling results, as required in § 11.26 of 5 CCR 1002-11;
b. CCT parameters for pH and alkalinity; and
c. all water quality sampling results collected as part of Denver Water's investigation of LSLs and post LSL replacement.

ii. *LSL Inventory.*

a. total number of service lines;
b. the total number of replaced LSLs during the variance;
c. the total number of known, suspected, and possible LSLs;
d. the total number of unlikely LSLs;
e. the total number of non-LSLs;
f. the number of investigations conducted each year to improve the LSL inventory;
g. an updated distribution system map; and
h. the rationale for requesting a change in the status of a service line in the inventory (e.g. investigation, replacement, water quality data, etc.).

iii. *LSL Replacements.*

a. the address and date of all LSL replacements occurring during the variance, including by year;
b. the type of LSL replacement (full, partial including galvanized, by third party);
c. the service line refusal list, including addresses of customer premises on the refusal list and documented attempts to contact the property owner; and
d. those customer premises where Denver Water performed a partial LSL replacement due to an emergency repair and property owner consent could not be obtained.

iv. *Filters.*

a. addresses of customer premises where filters and replacement cartridges have been provided;
b. the total number of filters and replacement cartridges distributed per program year;
c. a summary of filter survey responses per program year (i.e., descriptive statistics), the response rate, the percent filter adoption for each year of the variance, and the specific survey questions and responses;
d. a list of customer accounts reporting the use of bottled water or a filter certified NSF/ANSI (53) for removal of lead, and any changes in the list;
e. a list of customers enrolled in the filter program who have refused a filter or replacement cartridges or have opted out of enrollment in the filter program; and
f. filter lead sampling results collected under paragraph 5.F above.

v. *Compliance Metrics*. Results achieved under the compliance metrics in sections 2.C, 3.D, 4.J, 5.G, and 5.H above.

vi. *Communications, Outreach and Education*. A summary of activities conducted under the Communications, Outreach and Education program, including the updated communications, outreach and education plan for the new program year. The summary will include, at a minimum:

a. a description of outreach activities conducted;
b. a list of any partner organizations who conducted, or were involved in the implementation of the communications, outreach and education plan; and
c. if in-person or telephone surveys are conducted, the answers to filter usage survey questions that were asked, date and time of call.

vii. *Health Equity and Environmental Justice.* A summary of activities conducted and designed to address health equity and environmental justice (HE&EJ) principles set forth in the Lead Reduction Program Plan (LRPP), including:

a. a description of how the HE&EJ principles are being incorporated into the accelerated LSL replacement program, lead filter program, and communications, outreach and education plan;
b. socioeconomic or demographic data collected through the survey that may inform the filter adoption rate by neighborhood or demographic group to the extent practical; and
c. socioeconomic or demographic data collected from or other sources (e.g. census data, local public health agencies) to target communications, outreach and education programs to specific neighborhoods, demographic cohorts, or non-English speaking groups.

C. *Annual Program Year Reports.* No later than thirty-five (35) days following the end of a program year, Denver Water must submit a program year report to CDPHE and EPA, containing a summary of the information and data required under this section 6 for the previous program year, including an assessment of which metrics were achieved and the status of any corrective actions. This requirement remains in effect for the term of the variance. The annual report will also document any modification requests made by Denver Water to the Lead Reduction Program Plan or deviations from the LRPP during the most recent program year, along with a rationale for the request. If CDPHE or EPA provides any comments or requests related to the annual report, Denver Water must provide a written response within thirty-five (35) calendar days that addresses any identified comments/requests.

7. General Miscellaneous Provisions:

A. *Enforcement*. CDPHE has primary implementation and enforcement authority over the variance, subject to EPA oversight. CDPHE will implement, oversee, and enforce these terms and conditions, and may make recommendations to EPA to terminate or continue this variance, provided that EPA has the authority to ultimately decide whether to continue this variance.

B. *Revisions to the Lead and Copper Rule.* If EPA revises the federal LCR in a manner that affects the provisions and conditions of this variance, then EPA may modify or revoke this variance in a manner that is consistent with federal law.

C. *Lead Reduction Program Plan*. Denver Water will work in good faith to fully implement Section III of the LRPP. If Denver Water deviates from Section III the LRPP during the term of the variance or fails to implement Section III of the LRPP, Denver Water will provide notice to CDPHE within thirty-five (35) days with a description of the deviation from section III of the LRPP and the reason for the deviation. In no case shall a deviation from Section III of the LRPP modify these terms and conditions, except as provided in paragraph 7.J below. In the event of a

conflict between these terms and conditions and Section III of the LRPP, these terms and conditions take precedence.

D. *Enforcement.* Notwithstanding any metric and/or corrective action identified herein, EPA and CDPHE may take enforcement if EPA or CDPHE find, in their sole discretion, that Denver Water has not complied with any requirement of the variance in accordance with 42 U.S.C. §§ 300g-3(a)(1) and 300g-4(b) of the SDWA, including when:

i. Denver Water does not comply with its terms and conditions;

ii. A material aspect of Section III of the LRPP has not been implemented in good faith;

iii. Denver Water requests that EPA terminate the variance; or

iv. EPA or CDPHE believes that there is a risk to public health.

An enforcement action does not automatically terminate the variance.

E. A*utomatic Termination of Variance.* This variance terminates if one or more of the following conditions occur:

i. Denver Water fails to replace LSLs at the required minimum cumulative program year average rate of 7.0% for a total of three program years; or

ii. Denver Water fails to achieve a minimum of 65% filter adoption rate in a program year for a total of three program years.

If the variance is terminated Denver Water will provide public notice under 1.T.i

F. *Optimal Corrosion Control Treatment*. If EPA revokes the variance under paragraph 7.D. or the variance automatically terminates under paragraph 7.E, within 182 Days Denver Water shall install and operate orthophosphate as its designated optimal corrosion control treatment, in accordance with CDPHE's March 20, 2018, OCCT determination, and provide public notice to its customers in accordance with paragraph 1.T.i above. The initial dose of orthophosphate must be 2 mg/L. The specific orthophosphate dose may be further modified by CDPHE according to the provisions under 40 C.F.R. § 141.82(h).

G. *Effective Date of Termination or Revocation of the Variance*. Termination or revocation of the variance will be effective within 182 days of automatic termination under paragraph 7.E. above, or EPA's revocation under section 7.D. above, whichever occurs first. Failure to complete installation and operation of orthophosphate by this deadline will be considered a treatment technique violation under § 11.26 of 5 CCR 1002-11.

H. *Notice of Lead Reduction Program Plan.* No later than 14 days following effective date, Denver Water must begin a multi-media public information campaign and customer notification by written letter and pamphlet to notify customers enrolled in the filter program of Denver Water's variance, including the accelerated LSL replacement program and the distribution of the NSF/ANSI (53) certified filters for lead removal.

I. *Term of Variance.* Unless EPA revokes or modifies, the terms, this variance shall extend from the effective date through the variance end date, or until EPA accepts the notice of completion pursuant to section 7.L. below. Additionally, as described in, paragraph 4.I, Denver Water shall replace within six (6) months of discovery, any LSLs discovered after the variance end date. Denver Water must provide an annual summary of these efforts to CDPHE by January 10th of each calendar year for the previous program year.

J. *Modification of Conditions.* EPA may modify the conditions of this variance in consultation with CDPHE. EPA will notify Denver Water thirty-five (35) days prior to the effective date of any modification.

K. *Notices.* All notices, reports, disclosures, or other communications required or related to this variance must be sent via certified U.S. Mail, overnight express delivery service, or electronic means to the recipients and addresses below.

EPA:
Safe Drinking Water Branch Chief
Water Division U.S. Environmental Protection Agency, Region 8
1595 Wynkoop St.
Denver, CO 80202-1129
Current E-mail: **[To be added upon finalization.]**

Denver Water:
James S. Lochhead
CEO/Manager
Denver Water
1600 West 12th Avenue
Denver, Colorado 80204
E-mail: **[To be added upon finalization.]**

Office of General Counsel:
ATTN: Jessica Brody
Denver Water
1600 West 12th Avenue
Denver, Colorado 80204
E-mail: **[To be added upon finalization.]**

CDPHE:
Jill Hunsaker Ryan
Executive Director
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, CO 80246
E-mail: **[To be added upon finalization.]**

All reports will be sent to Drinking Water Compliance Assurance through its on-line portal at https://wqcdcompliance.com/login or through such other means as designated in writing by CDPHE.

Attorney General's Office
ATTN: **[To be added upon finalization.]**

L. *Notice of Completion.* Denver Water may submit a notice of completion of the terms and conditions of this variance to CDPHE, with a copy to EPA, by the variance end date or earlier in accordance with this variance. EPA may either accept or reject Denver Water's notice of completion in writing within thirty-five (35) days of receipt.

Enclosure 3

August 14th Board Resolution

Denver Water Request for Variance From Optimal Corrosion Control Treatment Requirements Under the Safe Drinking Water Act's Lead and Copper Rule

DENVER WATER

Board Resolution

TITLE: Variance from the Lead and Copper Rule to Implement Denver Water's Proposed Lead Reduction Program Plan

ADOPTED AND APPROVED ON AUGUST 14, 2019 BY THE CITY AND COUNTY OF DENVER ACTING BY AND THROUGH ITS BOARD OF WATER COMMISSIONERS

Paula Herzmark, Board President

James S. Lochhead, CEO/Manager

WHEREAS, Denver Water delivers lead-free water to its customers; and

WHEREAS, customer-owned lead service lines and lead-containing internal plumbing fixtures can release lead into the water; and

WHEREAS, the Safe Drinking Water Act's Lead and Copper Rule requires public water systems to monitor lead levels in customers' homes with known lead service lines or lead solder and implement corrosion control treatment methods to minimize the corrosivity of water as it passes through customers' service lines and lead-containing plumbing fixtures; and

WHEREAS, in 2012, the 90th percentile value for sample results of lead levels in tap water for Denver Water's sampling pool was 17 µg/L, exceeding the Lead and Copper Rule action level of 15 µg/L; and

WHEREAS, in response to the 2012 lead action level exceedance, which was Denver Water's first and only exceedance of the lead action level, Denver Water conducted a detailed study to improve its corrosion control treatment; and

WHEREAS, based on the results of the study, the Colorado Department of Public Health and Environment (CDPHE) designated orthophosphate treatment as the optimal form of corrosion control for Denver Water's integrated system and directed Denver Water to begin treatment with orthophosphate by March 20, 2020; and

WHEREAS, orthophosphate can result in increased levels of nutrients in wastewater and storm water, which may adversely affect wastewater treatment plants, storm water control programs, streams and reservoirs, and Denver Water's downstream gravel pits and other Denver Water facilities; and

WHEREAS, the estimated regional capital, operational and maintenance costs

for nutrient removal associated with orthophosphate is projected to range between a low of approximately $369,000,000 and a high of $691,000,000; and

WHEREAS, once orthophosphate treatment begins, it cannot be discontinued without risk of pipe corrosion, and is therefore a permanent form of water treatment; and

WHEREAS, based upon the input of a diverse stakeholder group, CDPHE, and the Environmental Protection Agency (EPA), Denver Water conducted additional studies of orthophosphate and alternative forms of corrosion control to determine if there are alternative approaches that are equally protective of public health; and

WHEREAS, based on this analysis, Denver Water has developed a Lead Reduction Program Plan consisting of the following elements:

- creation of a lead service line inventory to identify and facilitate the removal of lead service lines in Denver Water's integrated system;
- implementation of an accelerated lead service line replacement program to remove all lead service lines in Denver Water's integrated system within 15 years;
- distribution of filters to customers with known, likely or possible lead service lines to provide additional public health protection until all lead service lines can be removed;
- adjustment of pH/alkalinity to a level of 8.8 standard units upon approval of CDPHE;
- utilization of a communications, outreach, and education plan to provide increased public outreach to Denver Water customers regarding best practices to reduce lead levels; and

WHEREAS, the Lead Reduction Program provides equivalent or better protection of public health as compared to orthophosphate in part, by removing lead service lines, which are the primary source of lead, and providing lead filters to customers with known, possible, and likely lead service lines to provide additional protection; and

WHEREAS, the Lead Reduction Program also achieves equivalent or better protection of customers at a reduced cost with a range between a low of approximately $256,000,000 and a high of $518,000,000, without the adverse impacts to wastewater treatment plants, storm water control programs, streams and rivers, and certain Denver Water facilities; and

WHEREAS, although Denver Water does not own its customers' service lines or plumbing, the Board finds that the permanent removal of lead service lines is necessary to:

- protect public health;
- achieve economies of scale through a uniform approach to replacement of lead service lines;
- realize health equity and environmental justice for all customers, including those who are tenants, located in high traffic areas where replacement of their lead service line is difficult, and those who cannot afford to replace

their lead service lines;

- maintain Denver Water flexibility in its treatment of drinking water and ability to draw on new sources of water that might otherwise contribute to lead releases from lead service lines; and

WHEREAS, Denver Water must obtain concurrence from CDPHE and a variance from EPA to implement the Lead Reduction Program instead of orthophosphate treatment.

NOW, THEREFORE, BE IT RESOLVED:

1. Submission of Variance Request. The Board directs its CEO/Manager to apply to EPA for a variance from the corrosion control treatment requirements under the Safe Drinking Water Act's Lead and Copper Rule to implement the Lead Reduction Program in place of orthophosphate treatment with the program components described above.

2. Coordination with Distributors. In addition, the Board directs its CEO/Manager and staff to work with distributors to implement the Lead Reduction Program within their respective service areas in a cooperative manner. In doing so, Denver Water staff should explore how to integrate the Lead Reduction Program within its distributors' existing programs with minimal disruption, and coordinate with distributors to determine how best to use their methods and means of communications with their customers.

3. Operating Rule Modifications. The Board further directs its CEO/Manager and staff to review the Board's Operating Rules and make recommendations for new or modified Operating Rules to facilitate implementation of the Lead Reduction Program, as necessary.

4. Lead Reduction Program Implementation. Finally, the Board directs its CEO/Manager and staff to issue requests for proposals, implement procurement processes, negotiate contracts, and take other such actions as necessary to timely implement the Lead Reduction Program should it be approved by EPA and CDPHE.

LEAD REDUCTION PROGRAM PLAN

APPENDICES

VOLUME 1 OF 2

DENVER WATER

APPENDIX I.A – PUBLIC COMMENT FORM RESPONSES

September 2019

DENVER WATER

Appendix 1.A. Public Comment Form Responses

Denver Water conducted a public comment period from July 12 to Aug. 7 to gather feedback on the program benefits, filter preferences, communication preferences and overall support. The information was distributed through a variety of different engagement channels such as newsletters, targeted emails to stakeholders and customers who have expressed an interest in Denver Water's lead reduction efforts, TAP news site distribution, social media, distributors, neighborhood groups, etc. During this four-week period, Denver Water received 406 comments from unique IP addresses that have indicated that more than 98% of respondents support the Lead Reduction Program, emphasizing benefits for future generations, environmental health and protecting infants and children. Full results are below.

Breakdown of Most Common Respondent Zip Codes and Corresponding Results

Zip Code	Neighborhoods	Number of Respondents	Percentage of Total Respondents	Top way to make the use of filters more convenient and accessible	Percentage of Program Support (Strongly support and more likely to support)
80220	Crestmoor, East Colfax, Hale, Hilltop, Montclair, Northeast (NE), Park Hill, South Park Hill, Southeast (SE)	50	12%	Offer at-home consultations with a Denver Water representative on filter use and maintenance, as well as installation if needed.	98%
80210	Cory Merrill, Platte Park, Rosedale, Southeast (SE), University, University Park, Washington Park, Washington Park West, Wellshire	42	10%	Offer at-home consultations with a Denver Water representative on filter use and maintenance, as well as installation if needed.	100%
80205	Ballpark, City Park, City Park West, Clayton, Cole, Curtis Park, Five Points, North Capitol Hill, Northeast (NE), Skyland, Uptown, Whittier	38	9%	Provide option for filter pick-up or at-home delivery. Provide option for replacement cartridge pick-up or delivery through a cartridge voucher system.	100%
80207	North Park Hill, Northeast (NE), Northeast Park Hill, Park Hill, South Park Hill, Stapleton	38	9%	Provide customers with the option to select a preferred filter type (i.e. pitcher filter, refrigerator, etc.).	100%

80209	Belcaro, Bonnie Brae, Cherry Creek, Country Club, Polo Grounds, Southeast (SE), Speer, Washington Park, Washington Park West	32	8%	Provide customers with the option to select a preferred filter type (i.e. pitcher filter, refrigerator, etc.).	100%
80211	Berkeley, Highland, Jefferson Park, Northwest, Sloan Lake, Sunnyside, West Highland	27	7%	Provide customers with the option to select a preferred filter type (i.e. pitcher filter, refrigerator, etc.).	100%
80212	Barkeley Village, Berkeley, Berkeley Gardens, Berkeley Industrial Park, Berkeley Village, Lowell, Mastin Industrial Park, Northwest, Regis, Regis Place, Saint Claire, Sloan Lake, Sunnyside Manor, Tennyson Industrial Park, West Highland	26	6%	Provide customers with the option to select a preferred filter type (i.e. pitcher filter, refrigerator, etc.).	100%
80206	Cheesman Park, Cherry Creek, City Park, City Park West, Congress Park, Country Club, Southeast (SE), Uptown	25	6%	Provide customers with the option to select a preferred filter type (i.e. pitcher filter, refrigerator, etc.).	96%
80204	Auraria, Baker, Barnum, Barnum West, CBD (Central Business District), Civic Center, Colfax, Downtown (Central Business District), Golden Triangle, Lincoln Park (La Alma), Lower Downtown (LoDo), Sheridan Boulevard, Sloan Lake, Southwest (SW), Sun Valley, Union Station, Valverde, Villa Park	16	4%	Offer at-home consultations with a Denver Water representative on filter use and maintenance, as well as installation if needed.	93%

80223	Athmar Park, Baker, College View, Overland, Ruby Hill, South Platte, Southwest (SW), Valverde	14	3%	Provide customers with the option to select a preferred filter type (i.e. pitcher filter, refrigerator, etc.).	100%
80218	Alamo Placita, Capitol Hill, Cheesman Park, City Park West, Country Club, Five Points, North Capitol Hill, Speer, Uptown	12	3%	Offer at-home consultations with a Denver Water representative on filter use and maintenance, as well as installation if needed.	100%

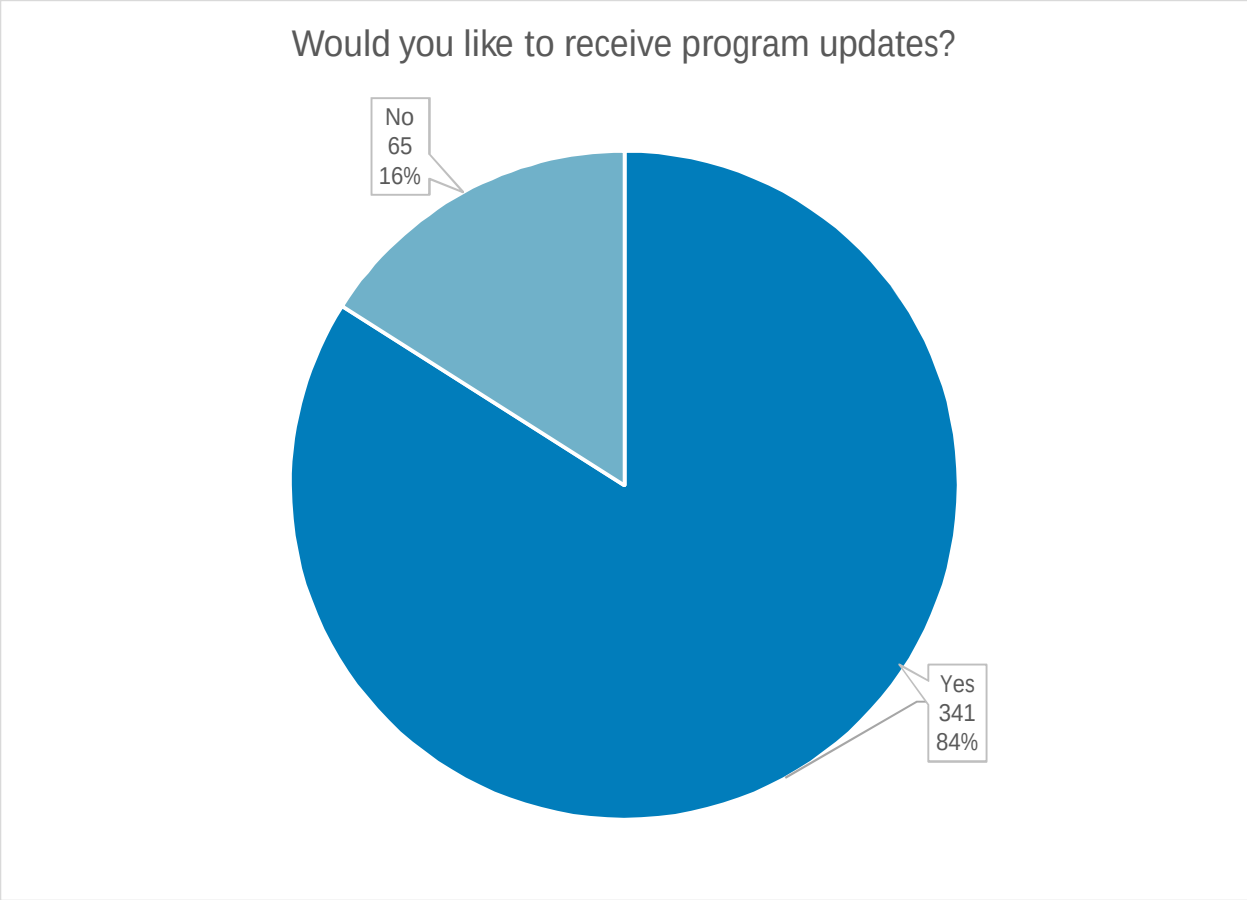
Additional respondent zip codes included:

Zip Code	Number of Respondents	Percentage of Total Respondents
80231	8	2%
80221	7	2%
80203	6	1.5%
80120	4	1%
80216	4	1%
80246	4	1%
80123	3	<1%
80219	3	<1%
80333	3	<1%
80111	2	<1%
80121	2	<1%
80222	2	<1%
80229	2	<1%
80236	2	<1%
80237	2	<1%
80238	2	<1%
01027	1	<1%
20009	1	<1%
22937	1	<1%
80004	1	<1%
80014	1	<1%
80016	1	<1%
80022	1	<1%
80035	1	<1%
80110	1	<1%
80214	1	<1%
80215	1	<1%
80224	1	<1%
80228	1	<1%
80232	1	<1%
80235	1	<1%
80241	1	<1%

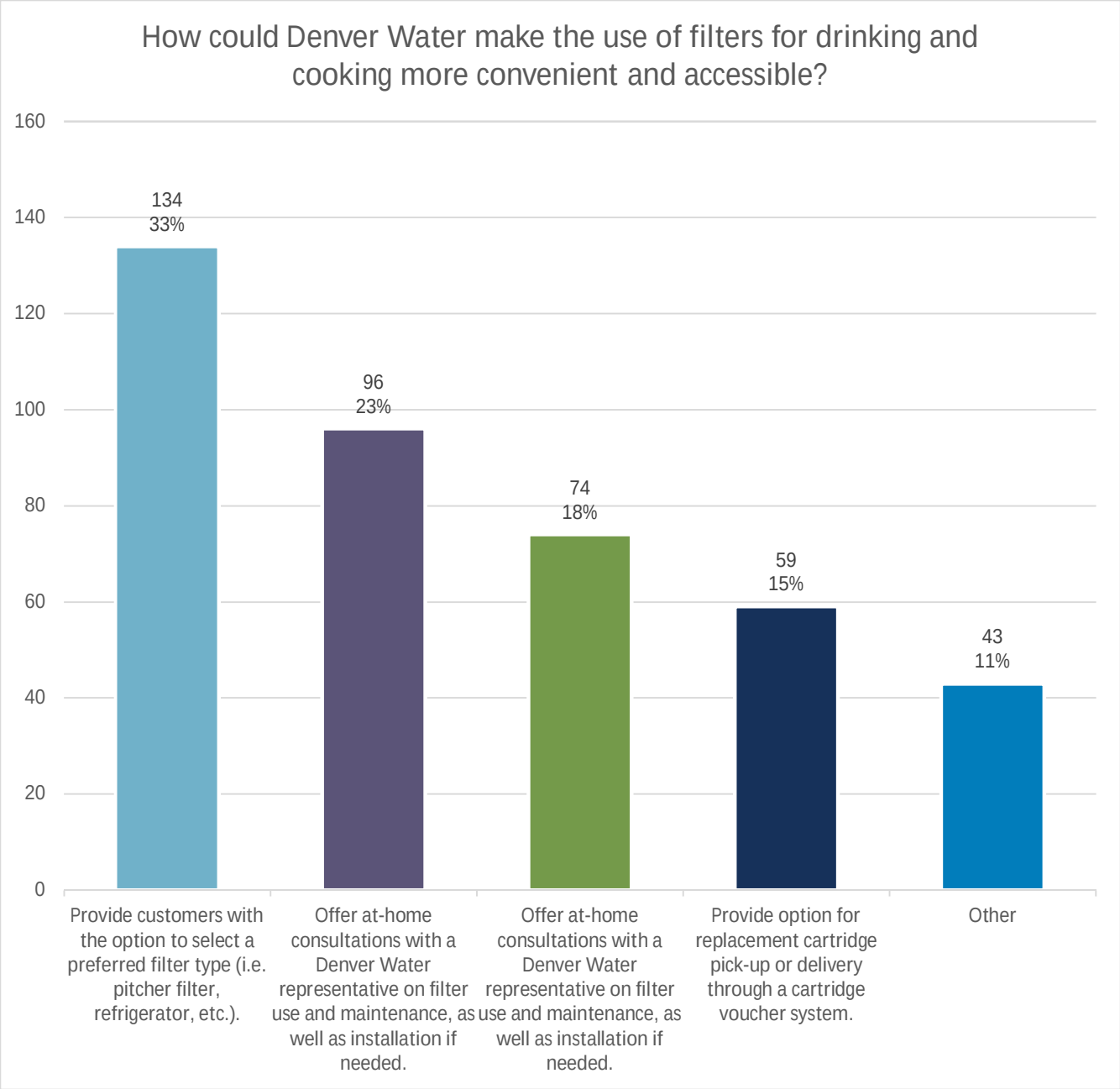
80247	1	<1%
80250	1	<1%
80401	1	<1%
80504	1	<1%
81623	1	<1%
89231	1	<1%
803204*	1	<1%

**Zip codes are presented as entered by respondents.*

Question Answer Results

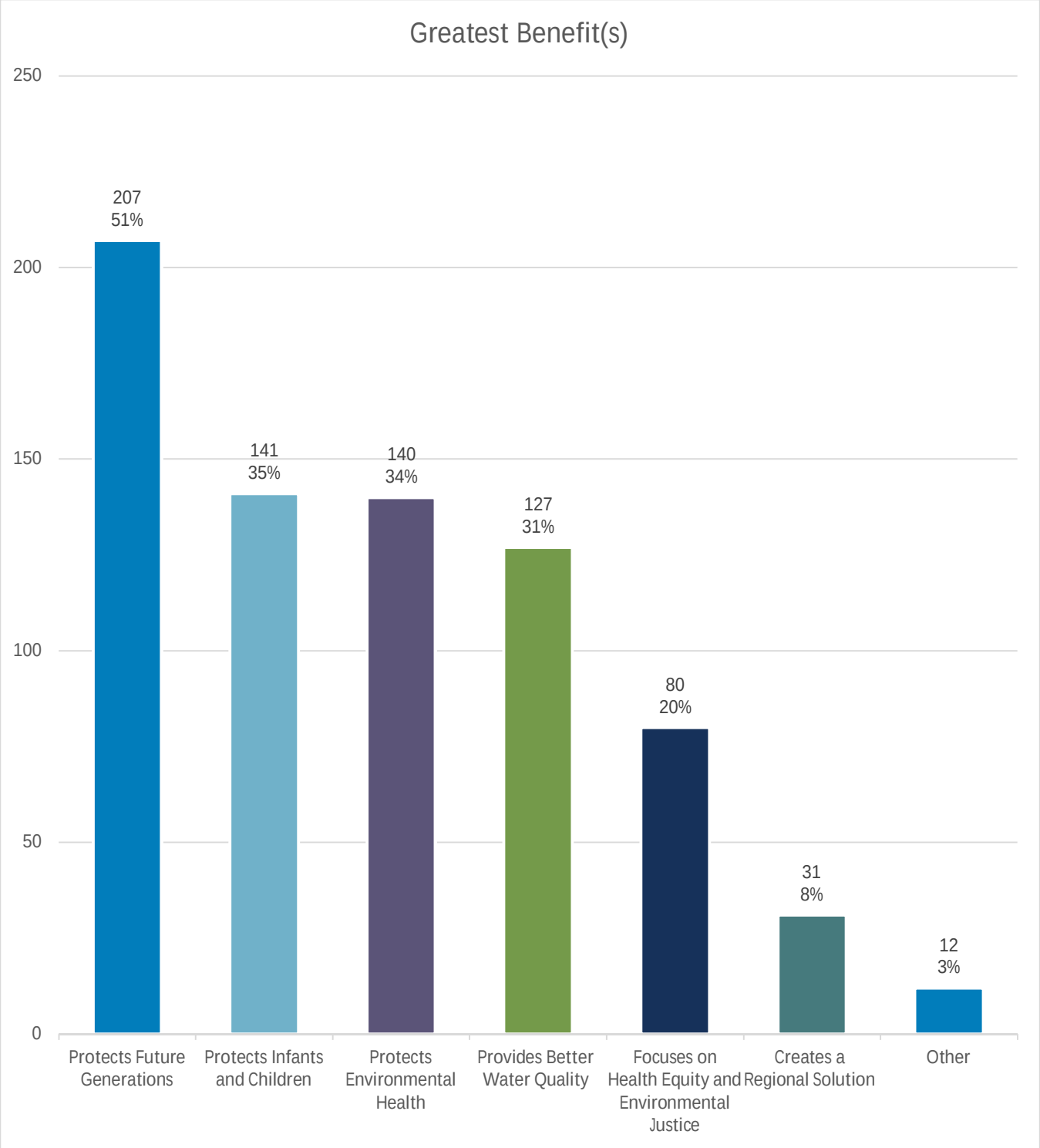


1. As part of the proposed Lead Reduction Program, Denver Water would provide at-home filters to customers with a suspected lead service line, free of charge. How could Denver Water make the use of filters for drinking and cooking more convenient and accessible? (Select one)



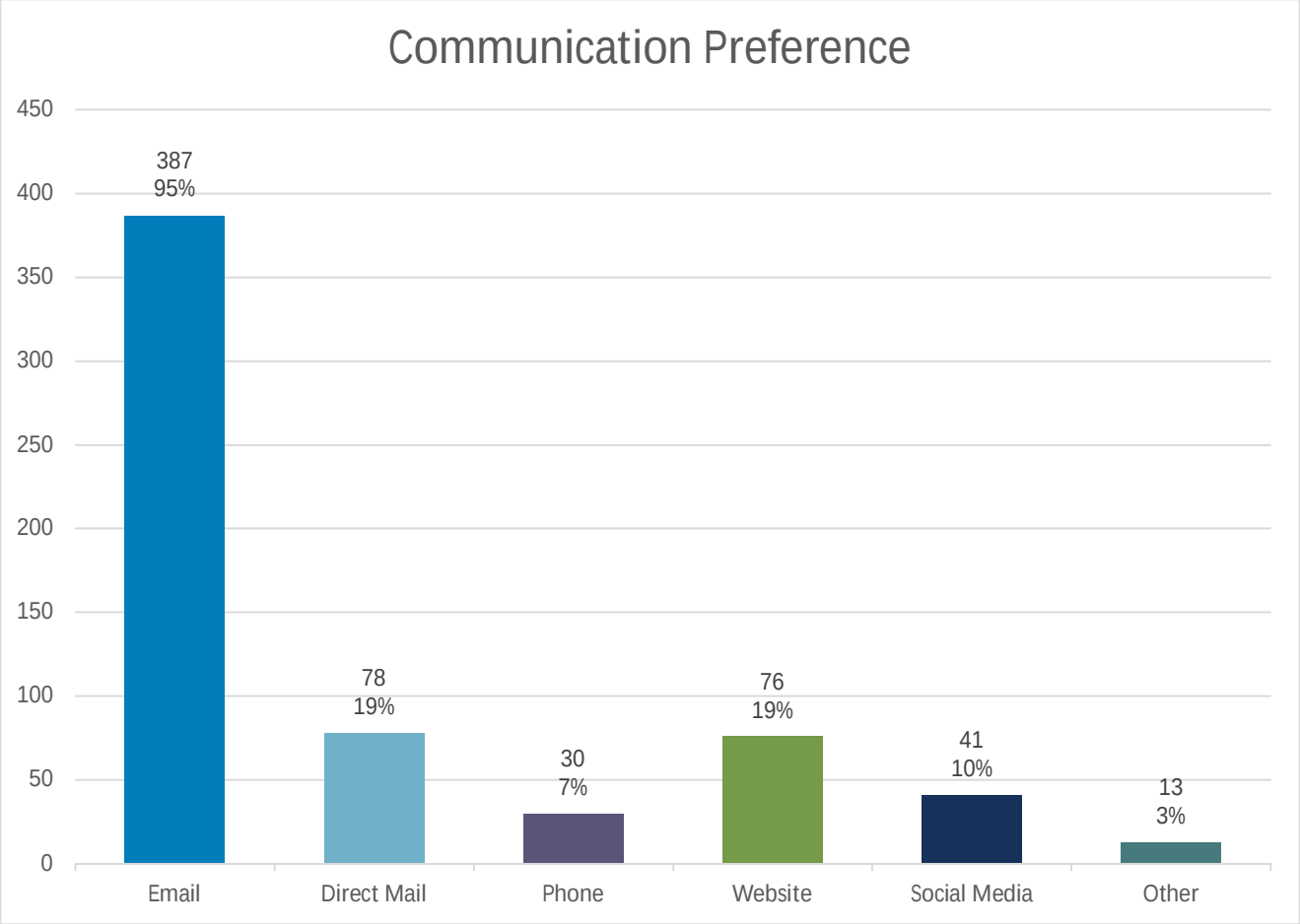
**"Other" responses available following response result graphs.*

2. What do you see as the greatest benefit of the proposed Lead Reduction Program? (Select up to two)



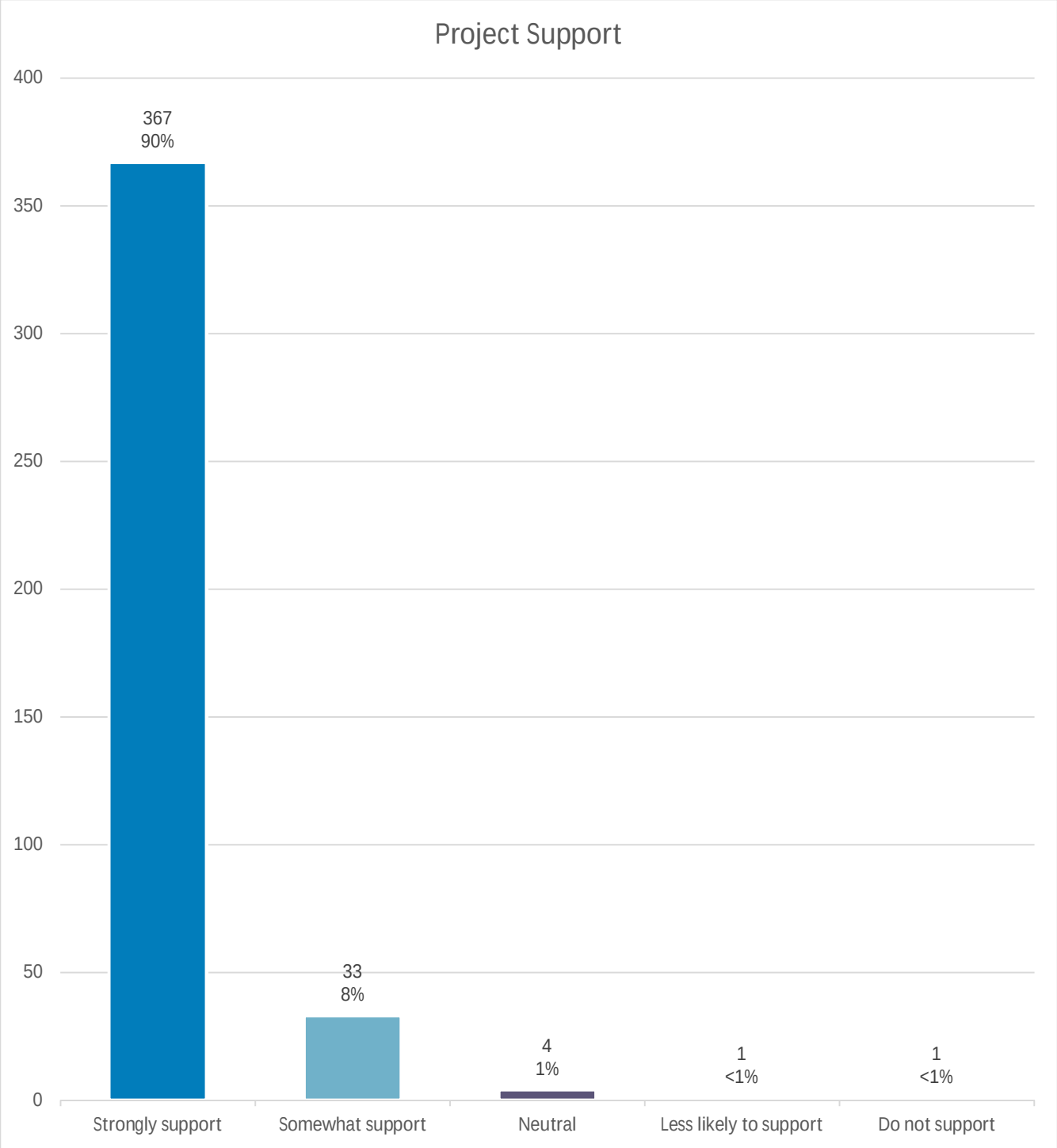
**"Other" responses available following response result graphs.*

3. What is your preference for how we communicate information and updates on the proposed Lead Reduction Program Plan? (Select all that apply)

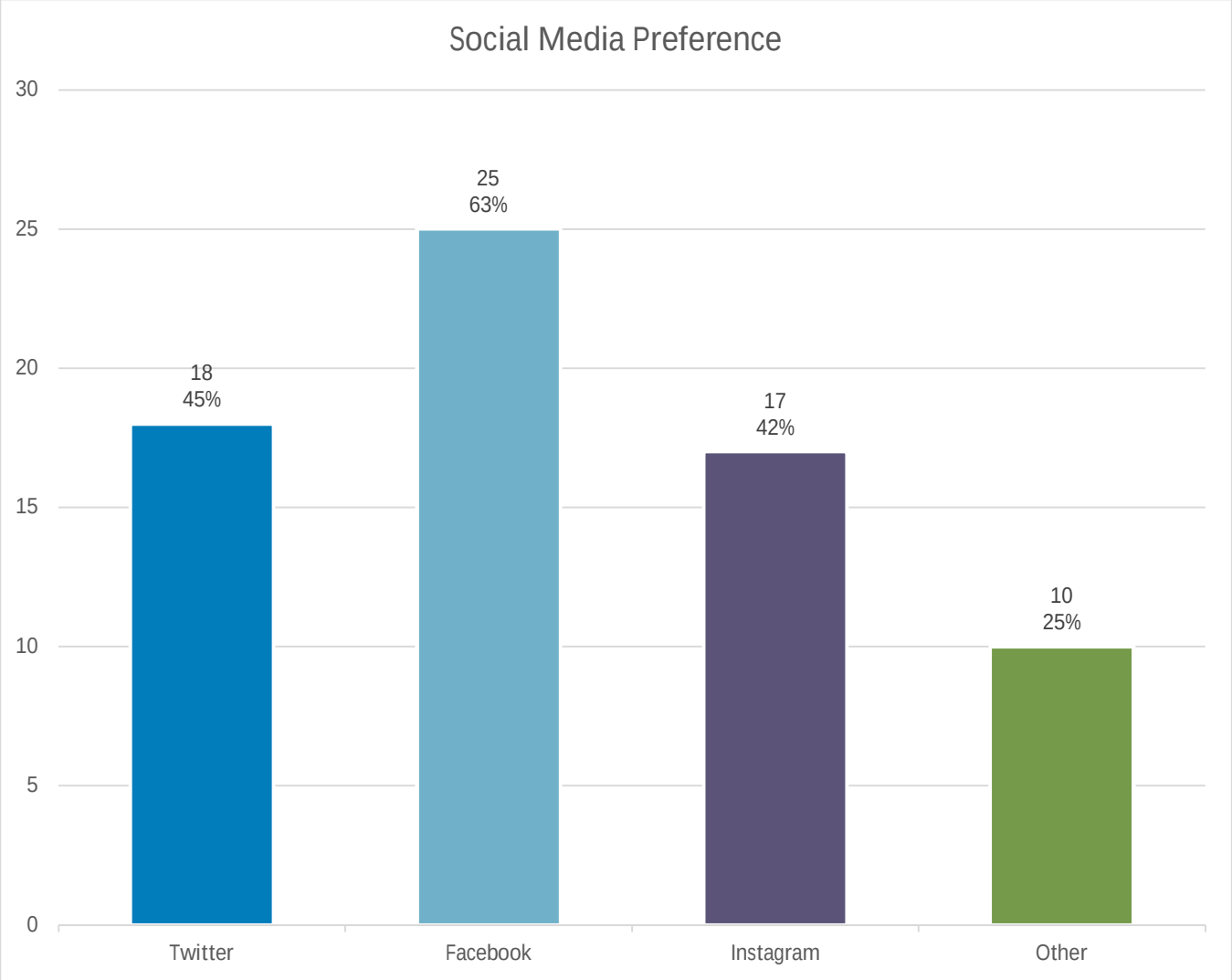


**"Other" responses available following response result graphs.*

4. How would you characterize your overall support for the proposed Lead Reduction Program?



5. Which social media option is your preference for how we communicate information and updates on the proposed Lead Reduction Program Plan? (Select all that apply)



Raw Comments

The following comments are included as they were received. No edits have been made to spelling, grammar or punctuation.

"Other" responses to How could Denver Water make the use of filters for drinking and cooking more convenient and accessible?"
all of the above
All of these options are important for helping residents use filters correctly and consistently
The basic thrust of this aspect of the lead remediation program is good. We don't have any preferences as to the four proposed methods for distributing filters.
...
Deliver filters to every home and offer consultation at the time of the delivery or scheduled at a later date, if requested.
Provide a list of allowable filters and then provide a statement credit when homeowner submits a receipt - similar to efficient toilet program. Add in a cartridge pick-up delivery program for ongoing maintenance..
I can't answer this one as I don't know the different types of filter types, or the difference between filters vs cartridges. Don't know where I'd have to go to pick up filter or voucher. If installation on the faucet is an option, I'd prefer that over a pitcher. But I need more information to be able to answer this, Maybe i need to re-read the
I think all of the above are important - customer needs to know what will work best for them and then have the opportunity to get that filter or cartridge in the easiest way possible (home delivery seems better)
All of the above
Would like to see filter attached to the main facet (in Kitchen)
I have been using an EverPure filter for 20 years - if denver will provide filter replacements - that would be terrific. My lines are lead - 1910 - I have submitted this response a cople weeks ago -it took a lot of read - read everything - resonded - call the water dept to expressmy interest in the possiblityi of a line replacement program in 2020 - I was told I would be contacted by that department (handling the lead issue once the decisions have been made - - have heard nothing.
Free, free filter replacements, delivered to homes,
Faucet filter
Faucet filter with delivery cartridge replacement
All of the above.
My choice is whatever would most increase access and participation for households most affected, especially in high-poverty areas. Otherwise I'd say being able to choose type of filter is would be helpful to make sure it's relevant to usage.
Provide water filters for ice makers
Provide the option of a whole house filter. This would make any water in the house safe to drink and use for cooking.
Provide water service and delivery like deep rock 5 gallon bottles and dispensers
Free filtration system
I have had a filter (Everpure)on my kitchen sink and ice maker since I moved into my house in 1996
Provide preferred filter type AND offer consultation. Be clear about why the filters are necessary and how and when they should be used
I want lead lines removed!
Test water at home, recommend type of filter and provide filter of choice

X
It would be great if Denver water could supply an easy at home test kit to help determine if your pipes introduce lead into your drinking water
Install whole home filtration system
Replace lines quickly. Already filling water filters to keep up with family drinking water use is cumbersome. In time, I can see folks getting lazy with dealing with it.
all of the above.
Offer undersink units
A combination of these needs to be offered rather than just one. For example combining the option of a preferred filter type, at home consultation and filter pick-up and delivery.
I understand you are requesting I select only one option, but I believe all of these options would equally make the use of filters more convenient and accessible, and I hope you decide to employ all of these options
Provide whole house water filters to be installed on the actual water line, or replace the lead pipes entirely.
Provide maintenance support for existing filters that customers have already installed
Filters need to also be installed in the showers and bathroom sinks where we brush our teeth. It will only really help if it's a whole-house filter, and my vote is for having all of the above available. Especially with the high prices we pay for water and wastewater.
I'm worried that the pitcher filter will be too slow for families to use for their needs. But the alternatives are not cost effective. Kitchen sink filter for those without fridge filter option?
Offer filtration for whole house/water main
Familiarize customers with kitchen water faucets that connect to filters under-the-counter.
Tell me where I can pick up my free (ideally) filter.
Replace service lines ASAP and/or provide subsidies to contract third party vendors to do so.
Provide under sink or whole house option as well rather then single source such as Refrigerator or single Pitcher.
Different customers may have different needs. We already have an in-refrigerator filter, and I'd appreciate replacement filters, but that probably isn't the most helpful for other households.

“Other” responses to “What do you see as the greatest benefit of the proposed Lead Reduction Program? (Select up to two)”
The DWD's proposed mixture of remedies is markedly better than simply adding a potential pollutant to wastewater and/or landscaping run-off.
...
This program benefits and protects consumers who have the means to replace their inside lead water pipes. When the city replaces water lines into people's homes and businesses, those of us with interior lead lines will continue to be exposed to lead.
silly question. Is it better to drink lead free water? of course. For all reasons above and more
I responded as described above - I will have a lot of expense to relocate my" in house" plumbing lines to a new location to hook up to new lines pulled from the street
All of the above.
I believe the root cause of the issue must be addressed, instead of a bandaid, for current residents and future generations.
repairing outdated infrastructure
Offers a more complete solution to the lead problem than any alternative
This program addresses a minority of all Denver Water customers.
all of the above.
Protects not just infants and children but also young adults, and animals in the home as well.

"Other" responses to "What is your preference for how we communicate information and updates on the proposed Lead Reduction Program Plan? (Select all that apply)"
…
Denver Water should use as many different means of communication that are feasible in order to reach the most people.
I would like to get on the list if the replacement program is the final solution that the Water deepartment decides to take!! I've tried to do what I can to make my interst known. I tested my water in April (your program - followed instruction explicitly!!)- it's not good
text/SMS with a short update and link to details
Text
Bill inserts
text message
Denver Water TAP Headlines
text message. a number of residents in our community do not have email but do use text. It is critical that everyone has access to the information that could affect their, and their children's, health.
outreach tables at community events and flyers through schools, community centers, etc.
Nextdoor
Nextdoor.com
Some neighbors might only be reachable via direct mail

"Other" responses to "Which social media option is your preference for how we communicate information and updates on the proposed Lead Reduction Program Plan? (Select all that apply)"
Via email: jeff.shoemaker@greenwayfoundation.org
There are options for automatic cross-posting on multiple social media platforms. No need to restrict sharing.
None used
email, us mail
Use all available social media tools.
I don't follow Denver Water currently on any social media
x
Neighborhood Email Exchanges
Hold a press conference(s). Get the Mayor to talk about it in his regular Friday broadcasts
Nextdoor

What would make you more likely to support the Lead Reduction Program? ***(For those who selected "neutral", "less likely to support" or "do not support" in response to "How would you characterize your overall support for the proposed Lead Reduction Program?")***
…
The report states on page 7 that the biggest issue is "customer owned service lines". I'd like to know why the 2012 exceedance of the lead action level took 5 years to result in the Optimal Corrosion Report. If Denver Water did not complete the lead service line pipe rack study during that time, then what new data was used to cause the Colorado Department of Public Health and Environment to designate the use of orthophosphate? I assume that this department knew that orthophosphates "could negatively affect rivers, streams and lakes in our region". Why, then, did they suggest that solution? What are the figures regarding the cost of treating orthophosphate corrosion at waste water treatment plants? Would the addition

of orthophosphates provide lead protection for the pipes in people's homes? My concern is that people without the means to replace their inside pipes and fixtures will be less protected from lead poisoning than Denver residents who have the means to incur these costs. Are we choosing between privately run water treatment facilities' budgets and Denver residents' budgets? I don't know enough about the Denver Water Dept and it's stakeholders but if this about saving corporate dollars at consumers' expense then this is a Health Equity and Environmental Justice issue.
For DENVER to REALLY do something about this problem!!
.
I would support it if the cost was not passed on to unaffected customers. Those with lead pipes should bear the cost of mitigation.
If it didn’t involve adding chemicals to my water. If you haven’t already, please watch documentary “The Devil You Know” about DuPont and 3M dumping toxic chemicals from Teflon. This also involves a water company, the EPA and a chemical in the water. I hope this is nothing like this. Water is a precious resource we all use and it would be unwise to add harmful additives without knowing the long term effects

APPENDIX I.B – LETTERS OF SUPPORT

September 2019

DENVER WATER

Bear Creek Water and Sanitation District
2517 South Flower Street, Lakewood, CO 80227-2912

August 1, 2019

RECEIVED
AUG 05 2019
Manager's Office
Board of Water Commissioners

Jim Lochhead
CEO/Manager
Denver Water
1600 West 12th Avenue
Denver, Colorado 80204
jim.lochhead@denverwater.org

RE: Comments on Denver Water's Lead Reduction Program Plan

Dear Mr. Lochhead,

On behalf of the Board of Directors of the Bear Creek Water and Sanitation District, I submit the following comments on Denver Water's draft Lead Reduction Program Plan (dated July 11, 2019).

The District recognizes that public health experts encourage the removal of lead service lines to provide public health protection from lead exposure in drinking water. We understand that Denver Water will prove to the USEPA that the proposed Lead Reduction Program provides a higher level of public health protection than the currently planned approach involving the addition of orthophosphate. If this is confirmed by the USEPA and CDPHE, the District will support Denver Water's Variance Request if the following changes are made to the final LRP Plan that is expected to be submitted to the USEPA in August of this year:

Increased collaboration with distributors regarding the development and execution of the communications and outreach plans associated with the Lead Reduction Program Plan (LRP) – The distributors were excluded from most of the pre-variance phase communication efforts mentioned on page 42 of the document. Details released to the public were typically provided to us on the same day press releases were issued with little advance warning. Moving forward, this needs to change and can be accomplished by specifically incorporating distributors into the communications for each of the action sections of the plan.

Collaboration with distributors is specifically mentioned several places with respect to the Lead Service Line (LSL) inventory actions, which is necessary given the distributors typically have most knowledge, whether field or historical records, regarding the existence of LSLs in their distribution networks. Upon a detailed review of the LRP Plan and associated appendices, the District noted that there is no mention of distributor collaboration in Section III.C (Filter Program) or III.D (Accelerated Lead Service Line Replacement Plan). This is a significant oversight on behalf of Denver Water given that customer communication is a shared responsibility for Read & Bill distributors and the sole responsibility of Master Meter distributors.

Bear Creek Water and Sanitation District does not have any homes with lead service lines within the District boundaries. However, Bear Creek Water and Sanitation District must be prepared to answer questions from our customers regarding Denver Water's Lead Reduction Program Plan including any impact to the District and our shared customers.

The District has worked hard to build a trusted relationship with our customers, similar to what Denver Water has done so well with its own inside City customers. To ensure that trusted relationship continues through the LRP, the District should be involved in any communications directed to them as part of the execution of the LRP Plan and Communications, Outreach & Education Plan (COE Plan).

We do acknowledge Denver Water is ultimately responsible for execution of the LRP Plan as they are the regulated entity. However, for this effort to be successful, Denver Water needs to revise the LRP Plan and the COE Plan to specifically commit to involving the distributors in communications efforts on the Filter Program and the Accelerated LSL Replacement Plan. The District requests Denver Water revise the LRP Plan and the COE Plan to include specific actions:

- Each distributor will be given the option to determine how they want to participate in the customer communications process. Some may prefer to be involved as a co-lead, others may only want advance notice, and a few may defer fully to Denver Water. All should be acceptable options offered by Denver Water and each district's preference should be respected.

- With respect to the Filter Program, include the following actions:
    - Develop communication materials that can be co-branded by distributors,
    - Include distributors in any planning efforts for door-to-door campaigns and neighborhood meetings (noted on page 54),
    - Provide training and/or talking points for distributor staff to use when engaging with customers on this topic. While the District understands that Denver Water prefers to be the primary POC for detailed information on the LRP, sufficient information needs to be provided to District staff to allow for informal conversations when we encounter questions from our customers, either in the field or during our own community events.

- With respect to the Accelerated LSL Replacement Plan, Denver Water should update the summary section located on page 57 to include a reference to coordinate construction activities with distributors. There is a specific reference to "coordinating with the City and County of Denver Public Works and other area municipal, utility, and public sector agencies"; however, coordination with distributors should be called out explicitly, especially for Read & Bill and Master Meter distributors.

In addition to the requested actions above regarding communication, we request two actions detailed below regarding the process of how the distributors should be included in COE Plan, which we understand will be more fully developed if the variance request is approved. Before submitting the LRP Plan and COE Plan to the USEPA, we would request the documents be revised to both increase the number of and provide more details for meaningful opportunities for engagement on customer communication for Read & Bill and Master Meter distributors.

Commit to the addition of a distributor representative on the LRP Leadership Committee – In the LRP Plan, Section III.F (Learning by Doing) outlines the approach to the formation and operation of an LRP Leadership Committee. The district supports the formation of this committee as an oversight entity that will guide the LRP through execution. However, we are significantly concerned that the distributors are not represented on that committee, especially given that 50% of the 1.4 million people who rely on Denver Water do so through a distributor. Although current indications are that only 5% of those people have a lead service line, many more may be impacted by the LSL inventory process, the Filter Program, or even ongoing communications about the LRP. Therefore, the District requests that, as the LRP Leadership Committee "invites other stakeholders to be members, such as representatives from watershed groups, wastewater dischargers, and public health agencies" (as stated on page 72), the Distributor Forum is allocated one representative to that Committee. In addition to participating in the Committee and working collaboratively towards the LRP Plan goals, this representative would also liaise between Denver Water and the distributors, ensuring continued support from that group and working to resolve any issues that may arise during the execution of the LRP. It may be that the Forum representative serves for the first few years of the LRP Plan execution process, working through the initial communication efforts, inventory tasks, filter distribution, and coordination efforts. Participation of the Forum representative can be evaluated every few years to ensure meaningful engagement opportunities still exist. If there are none, that representative could be sunset from the Committee.

Commit to an equitable distribution of the costs associated with the LRP Plan – The District understands there will be an extensive public input process over the next year to determine the appropriate allocation of costs associated with execution of the LRP Plan. However, the District requests an immediate commitment by Denver Water to an equitable distribution of those costs. We define equitable distribution to be an allocation of costs based upon the confirmed percentage of LSLs in the entire distributor network without the traditional multiplier applied to those costs. The distributor customers should not be required to subsidize the cost of replacing LSLs located within the City and County of Denver, which is where the vast majority of the LSLs are located (according to the current LSL inventory). We believe our customers would raise significant concerns to Denver Water if the cost of LSL replacement was distributed in any other way but as stated above. As Denver Water does not share in the cost of maintaining our customer's private systems, neither should the distributor customers be required to do that for inside City customers.

In conclusion, the District reiterates the need for Denver Water to revise the LRP Plan, including the appendix containing the COE Plan, to incorporate the requests outlined in this letter. The District will support the variance request and work collaboratively with Denver Water if those requests are incorporated into the final version of the LRP Plan. Successful execution of the LRP Plan depends on support from the distributor community as well as many other stakeholders located in the Denver metro area. Together we can achieve the goal of removing LSLs in our communities and significantly impacting public health protection through reduced exposure to lead in drinking water.

Should you have any questions or concerns about this letter, I can be reached by telephone at 303-986-3442 or e-mail at janwalker@bearcreekwater.org

Sincerely,

Jan C. Walker

Jan C. Walker
District Manager
Bear Creek Water and Sanitation District

cc: Dale L. Miller, Chairman, Bear Creek Water and Sanitation District
Denver Water Lead Reduction Program (lead@denverwater.org)
Julie Seagren, Denver Water Distributor Relations Manager
(julie.seagren@denverwater.org)

Citizens Advisory Committee

August 7, 2019

To: Lead Reduction Program, lead@denverwater.org

RE: Comments on Denver Water's Lead Reduction Program Plan

Dear Lead Reduction Program Staff,

On behalf of the Denver Water Citizen's Advisory Committee (CAC), I submit the following comments on Denver Water's draft Lead Reduction Program Plan (dated July 11, 2019).

The CAC recognizes that drinking water and public health experts encourage the removal of lead service lines to provide public health protection from lead exposure in drinking water. We are aware that Denver Water has substantial evidence and rationale to support a Variance Request from the USEPA to employ the proposed Lead Reduction Program (LRP), as it provides a higher level of public health protection than the currently planned approach involving the addition of orthophosphate. The CAC supports Denver Water's Variance Request.

On this matter, the CAC further advises that Denver Water:

- Commit to an equitable distribution of LRP costs and an early adoption of guiding principles to be applied in determining how costs will be distributed. Such guiding principles could include having property owners primarily responsible, not applying the cost adder for LRP costs for outside of City rate setting, seeking other sources of funding/financing, etc.
- Expand the LRP Leadership Committee to include representation from Water Distributors and outside of City Total Service Customers.
- Continue to coordinate an extensive communication plan with all customer classes.

Successful execution of the LRP Plan depends on support from many stakeholders located in the Denver metro area. Together we can achieve the goal of public health protection through reduced exposure to lead in drinking water.

Respectfully submitted on behalf of CAC,

Loretta Pineda
Chair, Denver Water CAC

August 7, 2019

Jim Lochhead, Chief Executive Officer
Denver Water
1600 W. 12th Ave
Denver, CO 80204

RE: LEAD REDUCTION PROGRAM PLAN — July 11, 2019 Draft for Public Comment

Dear Mr. Lochhead:

Clean Water Action appreciates the opportunity to comment on Denver Water's Lead Reduction Program Plan. For over forty years, Clean Water Action's national water programs have focused on addressing threats to drinking water and water quality by winning strong water pollution controls, including through Safe Drinking Water Act (SDWA) and Clean Water Act implementation. We also pioneer innovative collaborations to support fundamental changes in how water pollution and drinking water challenges are approached.

Clean Water Action strongly supports Denver Water's commitment to seek an alternative to orthophosphate that will achieve the same or greater reduction in lead exposure risk for its customers. Denver Water's proposal is an innovative approach to address unintended consequences of orthophosphate treatment, and if approved as proposed and carried out successfully, will provide a greater benefit to public health and the environment.

Our comments below highlight what we consider the greatest strengths of Denver Water's plan and we also offer some recommendations for the utility to consider as it continues to revise and refine its plan.

Plan Strengths

Goes after the source of lead instead of just treating the symptoms: Fully replacing all known lead service lines in Denver Water's service area within 15 years will permanently eliminate the largest source of lead in drinking water from its service area. The most effective and sustainable way to limit exposure to lead in drinking water is to remove lead at the source, which, for lead in drinking water, means fully replacing all lead service lines.

Provides health protection while customers wait to have service lines replaced: To address concerns that some residents may have to wait up to 15 years to have their lead service lines replaced, Denver Water will provide filters that reduce lead by 97 percent for all customers with lead service lines until six months after their lead service line is replaced.

Focuses on health equity and environmental justice: By replacing lead service lines at no-cost to the property owner, all Denver Water customers with lead service lines will have equal access to the health benefits of full lead service line replacement, regardless of their ability—or their landlord's ability— to pay.

Prioritizes protecting the most vulnerable: Infants and children are among the most vulnerable to lead exposure and Denver Water will work to identify daycare centers, schools, and areas with young families in order to prioritize these vulnerable populations for filter distribution and lead service line replacement.

Protects water quality and the environment: An unintended consequence of orthophosphate treatment is that its use can threaten water quality in nearby surface waters by increasing phosphorus levels that can harm fish, wildlife, recreational users, and downstream water systems. The Lead Reduction Program avoids this unintended consequence by preventing the introduction of an additional source of phosphorus into rivers, streams, and reservoirs.

Recommendations

Ensure an effective filter program for all participants: Denver Water's Filter Lead out of Water (FLOW) pilot outreach project was limited to owner-occupied single family homes. As Denver Water refines its FLOW program based on the results of that pilot, it will be important to consider how renters, especially renters in large, multi-family dwelling units, could have lower filter adoption rates due to occupancy turnover and other factors. Denver Water should also consider how to ensure daycare centers, schools, and other places serving populations most vulnerable to lead exposure are using filters properly.

Enhance school outreach programs: A robust education and outreach program to reach all customers impacted by lead in drinking water is critical to the success of the proposed Lead Reduction Program. Denver Water should expand on its existing lead reduction education outreach program in schools, including both public and private schools.

Address concerns over potential rate increase: Though as currently proposed there will be no cost to individual property owners whose lead service lines are replaced, there is the potential for a customer rate increase. As Denver Water completes its cost analysis for this program, it should consider how any potential rate increase could impact low-income customers and consider options for those who may be unable to absorb even a modest rate increase. Denver Water should communicate to its customers about any potential rate increases early on in the Lead Reduction Program.

Include messaging on regional water quality benefits in enhanced communications, outreach, and education plan: High rates of customer participation, especially in the FLOW program, are critical to the success of the Lead Reduction Program. Educating customers on the environmental benefits of keeping new sources of phosphorus out of regional streams, rivers, and reservoirs could increase willingness of some customers to participate in the program.

Include impacted community member(s) on Leadership Committee: It is critical that those most impacted by lead service lines have a voice at the table along with Denver Water, CDPHE, EPA, and other stakeholders. Community buy-in is vital to the success of this program, and we are concerned the

program may not be successful without meaningful inclusion of community members in decision making.

Clean Water Action is committed to working with Denver Water and other stakeholders to ensure the success of a Lead Reduction Program that protects public health and the environment. Protecting all of our communities from lead must be a top priority, and it is also critical to continue making progress toward reducing nutrient pollution in our rivers, streams, and reservoirs.

Sincerely,

Jennifer Peters
National Water Programs Director
Clean Water Action/Clean Water Fund
jpeters@cleanwater.org

August 7, 2019

Sent by email only

Jim Lochhead, Chief Executive Officer
Denver Water
1600 W. 12th Ave.
Denver, CO 80204

Re: Lead Reduction Program

Dear Mr. Lochhead:

Environmental Defense Fund (EDF) supports Denver Water's proposed "Lead Reduction Program Plan" as an innovative solution to a challenging problem. If approved as proposed, Denver Water's plan would fund full replacement of the estimated 75,000 lead service lines (LSLs) in their system within 15 years – thus removing the primary source of lead within Denver Water's system, while avoiding the use of orthophosphate that can further exacerbate nutrient pollution problems in the South Platte River and other downstream reservoirs, rivers, and streams. And Denver Water will go the extra step by providing filters certified to remove lead to residents with LSLs until the lines are replaced.

EDF's mission is to preserve the natural systems on which all life depends. We have more than two million members and a staff of 700 scientists, economists, policy experts, and other professionals around the world. Guided by science and economics, we find practical and lasting solutions to the most serious environmental problems. This has drawn us to areas that span the biosphere: climate, oceans, ecosystems and health. Our Health Program seeks to safeguard human health by reducing exposure to toxic chemicals and pollution, including accelerating lead service line replacement to reduce lead in drinking water. Our Ecosystems Program works to increase the resilience of natural systems, including reducing harmful nutrient pollution.

Moving forward, EDF recommends that Denver Water broaden the proposed Leadership Committee to include representatives of the communities with LSLs. Their engagement and guidance is crucial to the success of the Program. Their absence may undermine the Committee's credibility and effectiveness.

Ultimately, EDF hopes that this type of resilient solution can be adopted and replicated elsewhere both to protect public health and prevent degradation of our natural systems.

Sincerely,

Tom Neltner

Tom Neltner, JD
Chemicals Policy Director

Brian Jackson, MA
Senior Manager, Western Water

Glendale, Colorado

"The Urban Village"

Michael Dunafon
Mayor

Doris Rigoni
Mayor Pro-Tem

Jerry Peters
City Manager

Council Members:

Storm Gloor
Dario Katardzic
Lindsey Mintz

July 25, 2019

Jim Lochhead
CEO/Manager
Denver Water
1600 West 12th Avenue
Denver, Colorado 80204
jim.lochhead@denverwater.org

RE: Comments on Denver Water's Lead Reduction Program Plan

Dear Mr. Lochhead,

On behalf of the City of Glendale, I submit the following comments on Denver Water's draft Lead Reduction Program Plan (dated July 11, 2019).

The City of Glendale recognizes that drinking water and public health experts encourage the removal of lead service lines to provide public health protection from lead exposure in drinking water. We understand that Denver Water maintains that the proposed Lead Reduction Program provides a higher level of public health protection than the currently planned approach involving the addition of orthophosphate. If this is confirmed by the USEPA and CDPHE, the City of Glendale will support Denver Water's Variance Request if the following changes are made to the final LRP Plan that is expected to be submitted to the USEPA in August of this year:

First and Foremost, commit to an equitable distribution of the costs associated with the LRP Plan – The City of Glendale understands there will be an extensive public input process over the next year to determine the appropriate allocation of costs associated with execution of the LRP Plan. However, the City of Glendale requests an immediate commitment by Denver Water to an equitable distribution of those costs. We define equitable distribution to be an allocation of costs based upon the confirmed percentage of LSLs in the entire distributor network without the traditional multiplier applied to those costs. The City of Glendale customers should not be required to subsidize the cost of replacing LSLs located within the City and County of Denver, which is where the vast majority of the LSLs are located (according to the current LSL inventory). We believe our customers would raise significant concerns to Denver Water if the cost of LSL replacement was distributed in any other way but as stated above. As Denver Water does not share in the cost of maintaining our customer's private systems, neither should the distributor customers be required to do that for City and County of Denver customers.

Next, increased collaboration with distributors regarding the development and execution of the communications and outreach plans associated with the LRP – The distributors were excluded from most of the pre-variance phase communication efforts mentioned on page 42 of the document. Details released to the public were typically provided to us on the same day press releases were issued with little advance warning. Moving forward, this needs to change and may be accomplished by specifically incorporating distributors into the communications for each of the action sections of the plan.

950 South Birch Street Glendale, Colorado 80246-2599 Phone (303) 759-1513 Fax(303) 639-4707
http//www.glendale.co.us

Collaboration with distributors is specifically mentioned several places with respect to the LSL inventory actions, which is necessary given the distributors typically have most knowledge, whether field or historical records, regarding the existence of LSLs in their distribution network. Upon a detailed review of the LRP Plan and associated appendices, the City of Glendale noted that there is no mention of distributor collaboration in Section III.C (Filter Program) or III.D (Accelerated Lead Service Line Replacement Plan). This is a significant oversight on behalf of Denver Water given that customer communication is a shared responsibility for Read & Bill distributors and the sole responsibility of Master Meter distributors.

The City of Glendale has worked hard to build a trusted relationship with our customers, similar to what Denver Water has done so well with its own inside City customers. To ensure that trusted relationship continues through the LRP, the City of Glendale should be involved in any communications directed to them as part of the execution of the LRP Plan and Communications, Outreach & Education Plan (COE Plan). We do acknowledge Denver Water is ultimately responsible for execution of the LRP Plan as they are the regulated entity. However, for this effort to be successful, Denver Water needs to revise the LRP Plan and the COE Plan to specifically commit to involving the distributors in communications efforts on the Filter Program and the Accelerated LSL Replacement Plan.

The City of Glendale requests Denver Water revise the LRP Plan and the COE Plan to include specific action: Each distributor will be given the option to determine how they want to participate in the customer communications process. Some may prefer to be involved as a co-lead, others may only want advance notice, and a few may defer fully to Denver Water. All should be acceptable options offered by Denver Water and each City of Glendale's preference should be respected. This one specific example of how the distributors should be included in COE Plan, which we understand will be more fully developed if the variance request is approved. Before submitting the LRP Plan and COE Plan to the USEPA, we would request the documents be revised to both increase the number of and provide more details for meaningful opportunities for engagement on customer communication for Read & Bill and Master Meter distributors.

Also, commit to the addition of a distributor representative on the LRP Leadership Committee – In the LRP Plan, Section III.F (Learning by Doing) outlines the approach to the formation and operation of an LRP Leadership Committee. The City of Glendale supports the formation of this committee as an oversight entity that will guide the LRP through execution. However, we are significantly concerned that the distributors are not represented on that committee, especially given that 50% of the 1.4 million people who rely on Denver Water do so through a distributor. Although current indications are that only 5% of those people have a lead service line, many more may be impacted by the LSL inventory process, the Filter Program, or even ongoing communications about the LRP. Therefore, the City of Glendale requests that, as the LRP Leadership Committee "invites other stakeholders to be members, such as representatives from watershed groups, wastewater dischargers, and public health agencies" (as stated on page 72), the Distributor Forum is allocated one representative to that Committee. In addition to participating in the Committee and working collaboratively towards the LRP Plan goals, this representative would also liaise between Denver Water and the distributors, ensuring continued support from that group and working to resolve any issues that may arise during the execution of the LRP.

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Glendale, Colorado

"The Urban Village"

Michael Dunafon
Mayor

Doris Rigoni
Mayor Pro-Tem

Jerry Peters
City Manager

Council Members:

Storm Gloor
Dario Katardzic
Lindsey Mintz

It may be that the Distributor Forum representative serves for the first few years of the LRP Plan execution process, working through the initial communication efforts, inventory tasks, filter distribution, and coordination efforts. Participation of the Forum representative may be evaluated every few years to ensure meaningful engagement opportunities still exist. If there are none, that representative may sunset from the Committee.

In conclusion, the City of Glendale reiterates the need for Denver Water to revise the LRP Plan, including the appendix containing the COE Plan, to incorporate the requests outlined in this letter. The City of Glendale will support the variance request and work collaboratively with Denver Water if those requests are incorporated into the final version of the LRP Plan. Successful execution of the LRP Plan depends on support from the distributor community as well as many other stakeholders located in the Denver metro area. Together we can achieve the goal of removing LSLs in our communities and significantly impacting public health protection through reduced exposure to lead in drinking water.

Should you have any questions or concerns about this letter, I can be reached at 303-639-4501 or jbertrand@glendale.co.us.

Sincerely,

Joshua Bertrand
Director of Public Works
City of Glendale

cc: Jerry Peters, City Manager
Chuck Line, Deputy City Manager
Linda Cassaday, Deputy City Manager
Denver Water Lead Reduction Program (lead@denverwater.org)
Julie Seagren, Denver Water Distributor Relations Manager (julie.seagren@denverwater.org)

950 South Birch Street Glendale, Colorado 80246-2599 Phone (303) 759-1513 Fax(303) 639-4707
http//www.glendale.co.us

November 15, 2018

The Honorable Jared S. Polis
Governor-Elect of Colorado
136 State Capitol Building
Denver, CO 80203

Dear Governor-Elect Polis,

I am writing you today as a student from Denver North High School Engagement Center, and as a citizen who resides in Denver. I am concerned about the amount of orthophosphates being added to our water supply by the Colorado Department of Health. We, the citizens of Colorado, should really take this problem into consideration seeing as this is the water we drink, bathe, and play in. As you are now to be the governor of Colorado, you are now the voice of the people. Now is the time to talk about this because the Colorado Department of Health is deciding to add more orthophosphates to our water supply to prevent lead corrosion. What they don't know is it will cost the state of Colorado our excellent water quality.

In my Earth Science class, we have been researching how orthophosphates can damage our bodies of water, and can create toxic algae which can lead to many health problems for humans and animals. During our field work, we found that the phosphates in the South Platte River were completely maxed out at 4 ppm (parts per million). Orthophosphates, in excess, cause nutrient pollution. Orthophosphates are a type of nutrient phosphorus, which acts as a fertilizer for algae. This is very important because if we add orthophosphates to our drinking water supply, eventually our rivers would fill up with algae, creating toxins dangerous for both animals and humans alike.

There are intended and unintended consequences to adding orthophosphates in our water supply. The intended consequence is that orthophosphates create a barrier in our lead pipes and keeps the amount of lead in our water to below 15 ppb. This is important because we don't want another incident like what happened in Flint, where the lead was nearly 300 ppb.

But the unintended consequences of adding orthophosphates are far more disastrous to our ecosystem. As stated previously, orthophosphate acts as a fertilizer, which creates more algae (since algae uses phosphorus as a nutrient). Algae is dangerous for many reasons: it steals oxygen from the water, de-oxygenating it, and eventually suffocating the fish and other aquatic animals; also, some algae contains toxins that, if they come into contact with humans or animals, cause illnesses like rashes, vomiting, and liver damage.

Mr. Polis, there is a better alternative than using orthophosphates in our water supply: change the lead pipes to CPVC pipes. These pipes do not degrade with hot water exposure (as compared to lead pipes, which corrode when exposed to hot water), and they do not contain any dangerous chemicals (like lead). Compared to draining out the de-oxygenated water from our lakes and rivers (which costs $500-$1500 every time the body of water is drained) or charcoal filters (which cost $500-$1500 per house and must be replaced every 4-6

years), simply just replacing the pipes once (for a cost of **$6,000**-$22,000 per pipe depending on location) will last a lifetime. While the upfront cost of CPVC pipes seems high, we need to think about the long-term solution for our lead problem in Colorado. Replacing the pipe lines to our homes is the best option for a long-term solution.

If we do not act now, our water pipelines will continue to corrode. So we need to take action now or we may become the next Flint Michigan. Because I know you are a former teacher, I'm hoping a students' opinions will matter to you. Also, as a citizen of Colorado, that you, the Governor Elect, will make a difference and make Colorado's drinking water safer in an eco-friendly way. Remember, the CDH is, as of right now, is making the decision to add more orthophosphates to our water. We have a time limit, not only because of our pipes, but also because of our bodies of water.

Please contact me so we may discuss this in person.

Thank you for your time,

Itati Carson

METRO WASTEWATER RECLAMATION DISTRICT

William J. "Mickey" Conway, District Manager

August 7, 2019

Mr. Jim Lochhead, Chief Executive Officer/Manager
Mr. Tom Roode, Chief of Operations and Maintenance
Ms. Nicole Poncelet-Johnson, Water Treatment and Quality Manager
Denver Water
1600 West 12th Avenue
Denver, CO 80204

Submitted Via Electronic Mail:
jim.lochhead@denverwater.org; tom.roode@denverwater.org; nicole.poncelet@denverwater.org

Re: Denver Water's Lead Reduction Program

Dear Mr. Lochhead, Mr. Roode, and Ms. Poncelet-Johnson:

Thank you for the opportunity to comment on Denver Water's Lead Reduction Program. The Metro Wastewater Reclamation District (Metro District or District) strongly supports this Lead Reduction Program. As you know, the Metro District provides wastewater treatment and resource recovery services to more than two million people in the Denver metropolitan area. As a national model tailored to the unique needs of the arid west, this Program will permanently, holistically, and sustainably address lead in Denver Water's service area without adversely affecting downstream communities and the South Platte River watershed. This collaborative and innovative program provides protection to the District's 62 public and corporate connectors, and it has the full support of our Board of Directors representing 22 of the largest municipal entities in the metro area.

Central to this solution is the alignment of two important public health concerns—lead in drinking water and nutrients in watersheds. Since 2017, the Metro District, Denver Water, and several regional partners have worked collaboratively to develop and advocate for a solution that will protect Denver Water's customers at the tap from lead, while also protecting the public health of downstream communities and maintaining the health of the South Platte River watershed from the adverse effect of nutrients.

The Metro District supports the Lead Reduction Program presented by Denver Water because the Program:

- Is expected to **reduce lead at the tap within its service area to below 5 parts per billion (ppb) for all customers and for many customers to non-detect levels**[1]; and
- **Will eliminate the use of orthophosphate** as a corrosion control inhibitor, which will avoid adverse effects to downstream communities and the watershed.

[1] Figure 18 on page 39 of the Lead Reduction Program Plan demonstrates the Lead Reduction Program will reduce concentrations at the tap more effectively than the addition of orthophosphate.

The alternative to the Lead Reduction Program includes the use of a phosphorus-based chemical called orthophosphate as a corrosion control inhibitor. The alternative would adversely affect the public health of downstream communities and the health of the watershed by significantly increasing point and non-point phosphorus pollution in the South Platte River watershed. The following table shows the additional phosphorus loads that would result from the use of orthophosphate.

Orthophosphate Loadings

Total Loading		Year 2020	Year 2030	Year 2040	Year 2050
Average Daily Water Provided by Denver Water	MGD[1]	170	199	214	214
Percent Outdoor Use	Percent	40	40	40	40
Percent Indoor Use	Percent	60	60	60	60
Outdoor Average Daily Water Use	MGD	69	80	86	86
Indoor Average Daily Water Use	MGD	101	119	128	128
Total Annual Added Phosphorus Load from All Water Provided by Denver Water[2]	Pounds as Phosphorus	**505,603**	**591,555**	**637,060**	**637,060**

[1] Million gallons per day
[2] Based on Denver Water's Optimal Corrosion Control Technique (OCCT) result showing an orthophosphate dose of 3 milligrams per liter (mg/L)

This would be a significant new source of phosphorus pollution in the South Platte River watershed. Over the last 18 months, the region has been working with Denver Water to find an alternative solution that will avoid or minimize this new source of phosphorus pollution because the region recognizes that reducing nutrient pollution is also important for public health and the environment in the region. For decades, the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (CDPHE) have recognized that too much nitrogen or phosphorus in the environment produce more algae than the ecosystem can handle, resulting in environmental and human health issues.

National and State Frameworks to Reduce Nutrients

The EPA has conducted extensive research on nutrients, which is available on its website. The EPA website[2] explains the science concerning nutrient pollution and includes the following statements:

- **Nutrient pollution** is one of America's most widespread, costly and challenging environmental problems, and is caused by excess nitrogen and phosphorus in the air and water.
- **Too much nitrogen and phosphorus** in the water can have diverse and far-reaching impacts on public health, the environment, and the economy.
- **Excess nutrients can cause harmful algal blooms (HABs)** in freshwater systems, which not only disrupt wildlife but can also produce toxins harmful to humans.
- **Harmful algal blooms sometimes create toxins** that are detrimental to fish and other animals....Even if algal blooms are not toxic, they can negatively impact aquatic life by blocking out sunlight and clogging fish gills.

[2] https://www.epa.gov/nutrientpollution

- **Nutrient pollution has diverse and far-reaching effects** on the U.S. economy, impacting tourism, property values, commercial fishing, recreational businesses and many other sectors that depend on clean water.
- **Nitrates and algal blooms** in drinking water sources can drastically increase treatment costs.

To address these concerns, a 2011 EPA memorandum from Nancy K. Stoner to the Regional Administrators (*Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions)* (page 2) explains that when creating a program to manage nitrogen and phosphorus pollution, it is "of most importance" to:

- Prioritize watersheds,
- Set load reduction goals for watersheds, and
- Reduce loadings.

The State of Colorado followed the programmatic approach recommended by the EPA, which included the adoption of new regulations that prioritized watersheds, set load reductions goals, and required point sources to reduce nutrient loads.

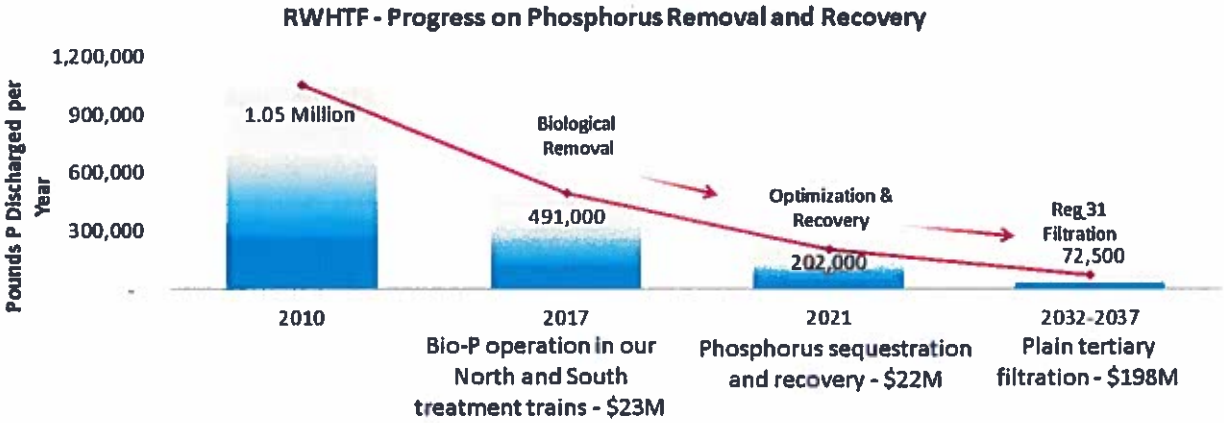
In 2012, the Colorado Water Quality Control Commission adopted parameter limitations for phosphorus and nitrogen in Regulation 85 (*Nutrients Management Control Regulation)* and numeric interim values for phosphorus, nitrogen, and chlorophyll *a* to protect domestic water supply use, recreation, and aquatic life uses in Regulation 31 (*The Basic Standards and Methodologies for Surface Water*). The CDPHE has been implementing the Regulation 85 parameter limitations in water quality discharge permits for the past several years.

In addition, in 2013 both the CDPHE and the EPA adopted Total Maximum Daily Loads (TMDL) for Barr Lake and Milton Reservoir that collectively required over 90 percent reduction in phosphorus loadings to each reservoir.

The Metro District's mission is to protect the region's health and environment by cleaning water and recovering resources. Consistent with its mission, over the last two decades, the District has partnered with the EPA and CDPHE to establish the Colorado nutrient framework and has invested in treatment technologies to reduce its phosphorus loadings.

Technological Investments and Improvements in the South Platte Watershed Water Quality

In furtherance of the national and state policy to reduce nutrients, without a current regulatory requirement to do so, the Metro District has already invested $50 million in treatment technologies to reduce phosphorus. These treatment technologies have significantly reduced the District's Robert W. Hite Treatment Facility's (RWHTF) phosphorus loads to the South Platte River watershed as demonstrated in the following graph. (Please note that the reductions presented in the graph do not include the additional load that would result from the use of orthophosphate).



The Metro District's reductions in phosphorus loads coupled with reductions achieved through the Colorado nutrient framework have resulted in measurable improvements to the water quality of the South Platte River watershed. In-stream total phosphorus (TP) concentrations downstream of the RWHTF have decreased significantly.

The nutrient reductions have also resulted in lower concentrations in the South Platte River and off-channel reservoirs, including Barr Lake and Milton Reservoir. For example:

- **Segment 15, South Platte River.** The average annual TP concentration was 0.78 mg/L in 2018, a 52 percent reduction from the 2013 average annual TP concentration of 1.5 mg/L.
- **Milton Reservoir.** The average spring TP concentration from 2014 to 2018 was 0.28 mg/L, a 60 percent reduction from the 2008–2012 average spring TP concentration of 0.72 mg/L.
- **Barr Lake:** The average spring TP concentration from 2014 to 2018 was 0.29 mg/L, a 48 percent reduction from the 2008–2012 average spring TP concentration of 0.55 mg/L and a 62 percent reduction from the 2003–2007 average spring TP concentration of 0.75 mg/L.

By avoiding the addition of a substantial amount of phosphorus into the South Platte River watershed, the Lead Reduction Program will allow the region to sustain and continue the progress already made to improve the water quality in the South Platte River watershed because of nutrient reductions.

Adding a large volume of orthophosphate to the South Platte River watershed would be a serious—and likely irreversible—setback to the progress accomplished in recent years to reduce phosphorous in the South Platte River watershed. In addition to the public health and environmental impacts, the use of orthophosphate would also result in significant financial impacts on the Metro District. To treat this significant new load of phosphorus the Metro District would install advance treatment at the RWHTF, which would increase the capital cost for advance treatment by $120 million (2017 dollars). The annual operational costs would also increase by $4.6 million due to the need for chemical addition to the treatment process. Not only would this approach conflict with the national and state frameworks to reduce nutrients, it would also put a significant financial burden on the two million ratepayers located within the service area of the District.

Maximizing Public Health through the Lead Reduction Program

The Metro District supports the Lead Reduction Program because it aligns two important public health frameworks. It achieves the greatest expected reductions of lead at the tap (short and long term) in a manner that avoids the negative impacts to the South Platte River watershed from the alternative approach, orthophosphate.

Decisions about water management in the arid west present unique challenges because of water scarcity. Throughout the arid west we are dependent upon water reuse for vibrant and healthy communities. The introduction of a large volume of chemicals, such as orthophosphate, within the water cycle will cause rippling adverse effects through the rest of the water cycle. This cannot be the right solution when there is an alternative that, on its own merits, is superior at protecting public health from exposure to lead in drinking water.

Recognizing this is a complex and interconnected issue, the Metro District and its partners have continued to advocate for the Lead Reduction Program, a one watershed and one ratepayer solution. Because of water scarcity in this region, a customized solution is more important than ever to ensure decisions today will not impair the ability of future generations to use and enjoy this valuable resource.

Sincerely,

William J. "Mickey" Conway
District Manager

July 29, 2019

Jim Lochhead
CEO/Manager
Denver Water
1600 West 12th Avenue
Denver, Colorado 80204
jim.lochhead@denverwater.org

RE: Comments on Denver Water's Lead Reduction Program Plan

Dear Mr. Lochhead,

On behalf of the Boards of Directors of the Platte Canyon Water & Sanitation District and the Southwest Metropolitan Water & Sanitation Districts (Districts), I submit the following comments on Denver Water's draft Lead Reduction Program Plan (dated July 11, 2019).

The Districts recognize that drinking water and public health experts encourage the removal of lead service lines to provide public health protection from lead exposure in drinking water. We understand that Denver Water will prove to the USEPA that the proposed Lead Reduction Program provides a higher level of public health protection than the currently planned approach involving the addition of orthophosphate. If this is confirmed by the USEPA and CDPHE, the Districts will support Denver Water's Variance Request if the following changes are made to the final LRP Plan that is expected to be submitted to the USEPA in August of this year:

Increased collaboration with distributors regarding the development and execution of the communications and outreach plans associated with the LRP – The distributors were excluded from most of the pre-variance phase communication efforts mentioned on page 42 of the document. Details released to the public were typically provided to us on the same day press releases were issued with little advance warning. Moving forward, this needs to change and can be accomplished by specifically incorporating distributors into the communications for each of the action sections of the plan.

Collaboration with distributors is specifically mentioned several places with respect to the LSL inventory actions, which is necessary given the distributors typically have most knowledge, whether field or historical records, regarding the existence of LSLs in their distribution network. Upon a detailed review of the LRP Plan and associated appendices, the District noted that there is no mention of distributor collaboration in Section III.C (Filter Program) or III.D (Accelerated Lead Service Line Replacement Plan).

This is a significant oversight on behalf of Denver Water given that customer communication is a shared responsibility for Read & Bill distributors and the sole responsibility of Master Meter distributors. The Districts have worked hard to build a trusted relationship with our customers, similar to what Denver Water has done so well with its own inside City customers. To ensure that trusted relationship continues through the LRP, the Districts should be involved in any communications directed to them as part of the execution of the LRP Plan and Communications, Outreach & Education Plan (COE Plan). We do acknowledge Denver Water is ultimately responsible for execution of the LRP Plan as they are the regulated entity. However, for this effort to be successful, Denver Water needs to revise the LRP Plan and the COE Plan to specifically commit to involving the distributors in communications efforts on the Filter Program and the Accelerated LSL Replacement Plan. The Districts requests Denver Water revise the LRP Plan and the COE Plan to include specific actions:

- Each distributor will be given the option to determine how they want to participate in the customer communications process. Some may prefer to be involved as a co-lead, others may only want advance notice, and a few may defer fully to Denver Water. All should be acceptable options offered by Denver Water and each district's preference should be respected.
- With respect to the Filter Program, include the following actions:
    - Develop communication materials that can be co-branded by distributors,
    - Include distributors in any planning efforts for door-to-door campaigns and neighborhood meetings (noted on page 54),
    - Provide training and/or talking points for distributor staff to use when engaging with customers on this topic. While the District understands Denver Water prefers to be the primary POC for detailed information on the LRP, sufficient information needs to be provided to District staff to allow for informal conversations when we encounter questions from our customers, either in the field or during our own community events.
- With respect to the Accelerated LSL Replacement Plan, Denver Water should update the summary section located on page 57 to include a reference to coordinate construction activities with distributors. There is a specific reference to "coordinating with the City and County of Denver Public Works and other area municipal, utility, and public sector agencies"; however, coordination with distributors should be called out explicitly, especially for Read & Bill and Master Meter distributors. Where there are identified LSLs to be replaced, the District would prefer a coordinated approach to identify any capital project construction synergies that could be realized during this process. Additionally, as the District already attempts to coordinate our capital projects with county paving plans, Denver Water would benefit from our existing planning efforts and relationships with those entities.

These are some specific examples of how the distributors should be included in COE Plan, which we understand will be more fully developed if the variance request is approved. Before submitting the LRP Plan and COE Plan to the USEPA, we would request the documents be revised to both increase the number of and provide more details for meaningful opportunities for engagement on customer communication for Read & Bill and Master Meter distributors.

Commit to the addition of a distributor representative on the LRP Leadership Committee – In the LRP Plan, Section III.F (Learning by Doing) outlines the approach to the formation and operation of an LRP Leadership Committee. The Districts support the formation of this committee as an oversight entity that will guide the LRP through execution. However, we are significantly concerned that the distributors are not represented on that committee, especially given that 50% of the 1.4 million people who rely on Denver Water do so through a distributor. Although current indications are that only 5% of those people have a lead service line, many more may be impacted by the LSL inventory process, the Filter Program, or even ongoing communications about the LRP. Therefore, the Districts requests that, as the LRP Leadership Committee "invites other stakeholders to be members, such as representatives from watershed groups, wastewater dischargers, and public health agencies" (as stated on page 72), the Distributor Forum is allocated one representative to that Committee. In addition to participating in the Committee and working collaboratively towards the LRP Plan goals, this representative would also liaise between Denver Water and the distributors, ensuring continued support from that group and working to resolve any issues that may arise during the execution of the LRP. It may be that the Forum representative serves for the first few years of the LRP Plan execution process, working through the initial communication efforts, inventory tasks, filter distribution, and coordination efforts. Participation of the Forum representative can be evaluated every few years to ensure meaningful engagement opportunities still exist. If there are none, that representative could be sunset from the Committee.

Commit to an equitable distribution of the costs associated with the LRP Plan – The Districts understands there will be an extensive public input process over the next year to determine the appropriate allocation of costs associated with execution of the LRP Plan. However, the Districts request an immediate commitment by Denver Water to an equitable distribution of those costs. We define equitable distribution to be an allocation of costs based upon the confirmed percentage of LSLs in the entire distributor network without the traditional multiplier applied to those costs. The distributor customers should not be required to subsidize the cost of replacing LSLs located within the City and County of Denver, which is where the vast majority of the LSLs are located (according to the current LSL inventory). We believe our customers would raise significant concerns to Denver Water if the cost of LSL replacement was distributed in any other way but as stated above. As Denver Water does not share in the cost of maintaining our customer's private systems, neither should the distributor customers be required to do that for inside City customers.

In conclusion, the Districts reiterate the need for Denver Water to revise the LRP Plan, including the appendix containing the COE Plan, to incorporate the requests outlined in this letter. The Districts will support the variance request and work collaboratively with Denver Water if those requests are incorporated into the final version of the LRP Plan. Successful execution of the LRP Plan depends on support from the distributor community as well as many other stakeholders located in the Denver metro area. Together we can achieve the goal of removing LSLs in our communities and significantly impacting public health protection through reduced exposure to lead in drinking water.

Should you have any questions or concerns about this letter, I can be reached at (303) 979-2333 or pjfitzgerald@plattecanyon.org.

Sincerely,

Pat Fitzgerald
District Manager
Platte Canyon Water & Sanitation District
Southwest Metropolitan Water & Sanitation District

cc: Richard Rock, Board of Directors, Platte Canyon Water & Sanitation District
Anthony Dursey, Board of Directors, Southwest Metropolitan Water & Sanitation District
Denver Water Lead Reduction Program (lead@denverwater.org)
Julie Seagren, Denver Water Distributor Relations Manager (julie.seagren@denverwater.org)

Comments on Denver Lead Reduction Plan

The Lead Reduction Program Plan proposed by Denver Water represents a comprehensive, proactive strategy for the nearly immediate reduction of lead exposure in drinking water at the highest risk homes by distributing filters at all lead service line homes, while beginning the longer term process of permanently removing lead service lines and optimizing corrosion control for addressing remaining sources of lead in Denver's drinking water infrastructure. The comprehensive approach also approaches the program from an equity perspective, ensuring that all high-risk customers have access to filters and lead service line replacements, regardless of ability to pay. This approach, which places public health protection and permanent removal of lead service lines as the highest priority, should be seen as a model for addressing lead in drinking water. The execution of the program as described in the program plan and the verification that all program components are executed as described will ultimately determine how successful the program is at reaching and reducing risk for all lead service line customers. The success of this program is dependent on each of these programs following through consistently. We know that any individual staff member can be the weakest link. Rigorous tracking protocols and regular program audits will be critical for verifying the program is working as intended.

The Proposed Lead Reduction Program Plan includes aggressive commitments to protect all customers in lead service line homes. However, on the whole the program evaluation criteria proposed present a low bar for identifying a system that failed to meet criteria and must proceed with a corrective action. When the program is built around the concept that all lead service lines homes have filters and the information they need to use them on a daily basis, then to meet expectations the annual filter adoption rate should be very close to 100% and the need for corrective action should be triggered when the number falls below 95%. The corrective actions should focus on providing the necessary resources to achieve the programmatic goals rather than changing course entirely as suggested in the corrective actions currently listed.

It should be noted that, contrary to the information on page 12 of the executive summary, actual "lead-free" plumbing components are not available. Plumbing components labeled "lead-free" contain up to 0.25% lead by weight. Materials that Denver Water distributes to its customers should not obscure the fact that installing new plumbing components still continues to add new lead to household plumbing systems.

Page 52 of the lead reduction program plan states that if the LSLR program is complete and a new LSL is identified, Denver Water has 6 months to replace the line. This seems far too long, given that at this point Denver will have finished the rest of the lead service line replacements and know how to replace the lead service line more efficiently than ever. After 15 years of unknown lead exposure, another 6 months if far too long for this home to race.

Page 61 of the lead reduction program plan describes a process for investigating homes with water quality above the action level. This answer implies that the inspection will identify lead in water risks in the home, but the programs described historically have not addressed drinking water sources of lead. This response should be updated to clarify the procedures of community organizations and grant programs for incorporating lead in drinking water into their lead reduction programs.

On Page 62, the service line material should be positively confirmed for any home that chooses to not participate in lead service line replacement so that it can be accurately captured in Denver Water's inventory.

On Page 71, last paragraph, please clarify the frequency with which corrosion control adjustments are made based on monthly data. Are Water Quality Parameters also adjusted from month to month to reflect this program?

Page 72, the concept of learning by doing as presented here appears to implement water treatment changes while distributing water to customers, implying that customers might be treated like guinea pigs and the water system will come back and continue to make adjustments until treatment is optimized. Updating protocols as new information becomes available is always appropriate, but it must be done in a way that does not put customers at greater risk.

Page 84, there are many limitations in using blood lead data to be able to correlate exposure to lead in drinking water to an elevated blood lead level. I recommend that this lead reduction plan does not imply that Denver is seeking evidence of elevated blood lead levels to establish causation from drinking water. The time to address lead in drinking water is when lead is detected in the water, not in children. http://graham.umich.edu/project/revised-lead-and-copper-rule/faq?faq=2

Elin Betanzo

SafeWaterEngineering.com

248-326-4339

August 6, 2019

Denver Water
Attn: Lead Reduction Program
1600 W. 12th Ave.
Denver, CO 80204

Dear Denver Water,

We are writing to commend Denver Water's Lead Reduction Program Plan. The plan's foundational statement, "When it comes to lead in drinking water, no levels are safe," its accelerated city-funded lead service line replacement plan, and its focus on protecting pregnant women, formula-fed infants and young children are exemplary science-driven actions.

The submitters of this comment are participants in Project TENDR (Targeting Environmental Neuro Developmental Risks). TENDR is a diverse group of experts in epidemiology, toxicology, exposure science, pediatrics, obstetrics and gynecology, nursing, public health, learning, intellectual and developmental disabilities, federal and state chemical policy and environmental justice, along with child and environmental advocacy organizations.

In July 2017, three Project TENDR leaders, David C. Bellinger, PhD, MSc, Aimin Chen, MD, PhD, and Bruce P. Lanphear, MD, MPH, published a Viewpoint article in *JAMA Pediatrics* titled "Establishing and Achieving National Goals for Preventing Lead Toxicity and Exposure in Children." In that article, Bellinger, Chen and Lanphear reviewed the science on the impacts of lead exposure including intellectual deficits, diminished academic abilities, attention deficits, and problem behaviors in children and affirmed the finding that there is no safe level of lead exposure.

The focus of the Denver Water Plan is on prevention, the best way to protect children and other vulnerable groups. The Plan seeks to reduce the sources of childhood lead exposures rather than solely identifying children who have already been unduly exposed or attempting to ameliorate the toxic effects after lead exposure has occurred. Thus, the Denver Water Plan is right on target to enhance public health.

We also applaud the plan's inclusion of "Focused and prioritized education and engagement to high risk community members (e.g., families with young children, including formula-fed infants, and pregnant women) with efforts to:

- Leverage existing stakeholder relationships/communication channels established by Denver Department of Public Health and Environment and Denver Water.
- Target messaging for various community organizations, doctor offices, etc.

- Partner with community health clinics, daycares/child care providers, social service programs for women and families.

Prioritizing the protection of the most vulnerable community members is sound public health policy. While the city is replacing lead service lines, the provision of effective water filters to women during their pregnanices as well as to families with formula fed infants and young children will lower the risk of neurodevelopmental harm for thousands of Denver's youngest residents. We hope the City will continue to monitor the water supply for lead levels after the new service lines are installed.

Thank you for developing a water plan grounded in science that puts children's health first; the Denver Water Plan provides a great model for others.

Sincerely,

David C. Bellinger, PhD, MSc
Research Director, Boston Children's Hospital
Professor, Harvard Medical School, Harvard T.H. Chan School of Public Health

Asa Bradman, PhD, MS
Associate Adjunct Professor, Department of Environmental Health Sciences
University of California, Berkeley

Charlotte Brody, RN
National Director
Healthy Babies Bright Futures

Carla Campbell, MD, MS
Pediatrician & Public Health Physician
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Aimin Chen, MD, PhD
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Jeanne A. Conry, MD, PhD
President, The Environmental Health Leadership Foundation
Past President, The American College of Obstetricians and Gynecologists
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Alliance of Nurses for Healthy Environments

Carol F. Kwiatkowski, PhD
Executive Director, The Endocrine Disruption Exchange (TEDX)
Assistant Professor Adjunct, North Carolina State University

Bruce P. Lanphear, MD, MPH
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Arthur Lavin, MD, FAAP
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Maureen Swanson, MPA
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The Arc

Evelyn O. Talbott, DrPH, MPH, FAHA
Professor, Department of Epidemiology
University of Pittsburgh Graduate School of Public Health

R. Thomas Zoeller, Ph.D.
Professor, Biology Department
University of Massachusetts Amherst

COLORADO
WASTEWATER
UTILITY COUNCIL

Support Statement for Denver Water Optimal Corrosion Control Treatment (OCCT) Variance Request by the Colorado Wastewater Utility Council

The Colorado Wastewater Utility Council is in support of the Denver Water OCCT variance request to the U.S. Environmental Protection Agency. Provided the variance request is deemed to be as protective to public health as the approved OCCT option, we believe it is a better overall solution. The variance request avoids addition of chemicals to the water supply that is a less sustainable alternative. The variance request proposal addresses the root cause of the problem in the form of accelerated lead service line removal rather than providing a secondary fix, which could have unintended environmental consequences.

As wastewater treatment plants, our members' first concern is the health and safety of the public and the environment. The variance would eliminate many concerns of wastewater plants impacted by the OCCT determination. These issues include addition of phosphorus to watersheds that can degrade water quality in lakes and streams. Wastewater plants are currently working on treating phosphorus and other nutrients to comply with Regulation 85 nutrient limits, and even more stringent Regulation 31 limits in the future. The variance eliminates the need for plants to remove an additional phosphorus load on the road to this end.

The Colorado Wastewater Utility Council (CWWUC) is a nonprofit organization whose members include many of the wastewater treatment plants in Colorado. The Council has always strived to find common-sense approaches to protecting the environment and meeting regulatory requirements. We feel the Denver Water OCCT variance request is in alignment with this approach and we support it.

Please let me know if you have any questions or would like to discuss this further.

Thank you,

Julie Tinetti

Julie Tinetti, CWWUC Chair

357 McCaslin Blvd., Ste. 100 * Louisville, CO 80027 * 303.317.6537 * www.cwwuc.org

Conservation Colorado is writing in support of Denver Water's proposal to accelerate the removal of customer-owned lead service lines to address the utilities 2012 exceedance of the EPA's allowable levels of lead in drinking water.

We believe this approach is the best method to permanently reduce lead in drinking water within its service area. The Utility is currently using orthophosphates to comply following the 2012 test results. While the use of orthophosphates is an effective tool for lead reduction, it comes with with negative effects to streams, rivers, reservoirs, and wastewater treatment plants by increased rates of algae blooms and phosphorus loading at wastewater treatment facilities.

We are particularly supportive of the Utility's plan because it is comprehensive and designed to meet the needs of the diverse water users who rely on Denver Water. The plan includes the provision of free of charge water filters to all customers until their lines have been replaced. Denver Water also aims to first address pipe replacement in lower socioeconomic communities which aligns with our organizational focus on equity and community health.

Conservation Colorado's support is contingent upon Denver Water's commitment of not solely being dependent upon customer rates to pay for this effort. It is our understanding that a variety of methods will be utilized to pay for this effort. This aspect is crucial to our support as we do not want to see dispropriate effects on lower socio-economic households. Additionally, we also expect the Utility to ensure the free of charge water filters distributed to all customers are functioning as anticipated.

Conservation Colorado is the state's largest environmental advocacy non-profit with 60,000 members throughout the state. For over 50 years, we've worked with communities statewide to ensure that our quality of life and our environment are protected. We recognize that not all Coloradans have access to a clean and safe environment. Communities of color, indigenous communities, and families living on lower incomes are far more likely to live, work, and play near pollution. We are fostering equity, diversity, and inclusiveness to ensure all Coloradans are fully represented and engaged in our work to protect this state we love.

We are very appreciative of Denver Water's leadership to address the issue of lead in drinking water.

Sincerely,
Josh Kuhn
Water Advocate Conservation Colorado

APPENDIX II.A - COMPARING IMPACTS OF OPTIMAL CORROSION CONTROL TREATMENT AND VARIANCE IMPLEMENTATION

September 2019

DENVER WATER

Appendix II.A

Comparing Estimated Impacts of OCCT and Lead Reduction Plan Implementation on Lead Exposure at Denver Water Customers

Date: Revised August 16, 2019
March 22, 2019

To: Denver Water

From: Corona Environmental Consulting, LLC

Executive Summary

The following analysis compares the estimated reductions of lead exposure to Denver Water customers from implementing either the designated optimal corrosion control treatment (OCCT) or the Denver Water proposed Lead Reduction Plan (LRP) conditions. The analysis demonstrates with supporting data that the requested LRP conditions of pH and alkalinity adjustment for CCT, accelerated lead service line replacement (LSLR), and distribution and validation of lead filters to customers served by lead service lines can achieve equivalent or greater lead reductions than the OCCT conditions of orthophosphate treatment and the current lead service line replacement rate. The analysis conservatively utilizes the best available data to inform the comparison through statistical analysis to compare impacts system-wide for all customers in the integrated service area.

The analysis outputs a predicted lead concentration at every tap in Denver Water's integrated system through time in one-year increments with only the number of lead service lines changing yearly due to replacements. This model analysis utilized an estimated number of lead service lines presently existing in Denver Water's integrated system of 74,138. The model was also exercised to analyze 55,000 lead service lines to test sensitivity to this parameter. The results are presented herein in multiple ways to fully represent and compare the impacts of implementing either OCCT or LRP conditions.

Implementing either OCCT or the LRP conditions achieves significant public health protection by limiting lead exposure at Denver Water customer's taps. Lead filters put customers in control to best limit lead exposure making it possible to provide the greatest protection to those at the highest risk (high lead concentrations, children, etc.). Replacing lead service lines removes the primary source of lead in drinking water. At 65% filter adoption, implementing the LRP conditions achieves greater lead reductions than OCCT implementation alone.

Objective

The objective of this analysis is to compare the estimated impacts of the designated optimal corrosion control treatment (OCCT) with the Denver Water proposed Lead Reduction Plan (LRP) conditions on lead exposure to Denver Water customers.

Approach

Corona has developed and exercised a statistical model to conservatively compare the impacts of orthophosphate addition as OCCT and LRP implementation of increased pH/alkalinity with accelerated

lead service line replacement and lead filter deployment on lead exposure to Denver Water customers. The model estimates lead concentrations for all connections in the Denver Water service area every year using defined inputs under the scenarios detailed in Table 1. Because the model predicts a lead concentration at every tap and uses pilot rack data for lead concentrations from lead service lines, it will not be representative of current or future LCR compliance data.

Table 1 Description of conditions for OCCT and LRP scenarios.

Variables	**OCCT**	**LRP**
Total Service Connections	335,457	
Estimated existing lead service lines	74,138	
Implementation Start	March 20, 2020	
Corrosion Control Treatment (CCT)	Orthophosphate starting at 3 mg/L and reduced to 2 mg/L within first year of implementation	pH/alkalinity adjustment to pH 8.8
Lead Service Line Replacement (LSLR) Rate	1,200 annually Estimated to be completed in 62 years	7% annually of initial lead service line estimate (7% * 74,138= 5,190) Estimated to be completed by July 31, 2034.
Lead Filter Implementation	No	Yes Estimates of lead filter adoption rates of 50-100% considered

Data Sources

The model uses data from the following sources.

(1) Inventory Estimate: updated by Corona on 7/31/2019 using databases provided by Denver Water on 6/17/2019 and 7/12/2019. See Appendix III.B.2 - Preliminary Identification of Lead Service Lines for more detail. The estimate provides p-values for all taps in the service area. It also includes parcel year built for most taps.

(2) Source of Supply Shape File: provided by Denver Water on June 14, 2018 The shape file was paired with the inventory to determine water supply from Marston and Foothills (S. Platte R. supplies), Moffat (Fraser R. supply), and blend areas.

(3) LCR and Customer Requested Sampling Database: provided by Denver Water on 7/22/2019 from LIMS. The data were filtered to include only first draw lead samples. The database provides project year built for customer requested samples, addresses for all samples, and lead concentrations. These data were paired with the inventory using a list of tap numbers paired with addresses provided by Denver Water on 6/7/2019. Samples taken after this date may not have been paired with tap numbers. Samples for which a tap number was not assigned were not used in the model inputs.

(4) Pipe Rack Experimental Data: updated on 7/11/2019 from Denver Water LIMS. Data from the pre-treatment period and the control racks were used for pre-treatment lead release in the model. Data meeting the target operational conditions were used for post-treatment lead release in the model. See Appendix II.B - Lead Pilot Results for additional details.

(5) Immersion Study Experimental Data: updated on 7/31/2019 from Denver Water LIMS. Only data from the copper with lead solder coupons were used in the model. See Appendix III.E.2 additional for details.

Model Assumptions

The following assumptions were informed by the listed data sources.

(1) **Total Service Connections:** The total number of service connections in the integrated Denver Water system is used to define the extent of Denver Water customers in the integrated system. For this analysis, a total of 335,457 connections are considered. Services are distributed to the approximate sources of supply: Marston/Foothills 162,540, Moffat 59,369, Blend 108,472. 5,076 services were not assigned a source in mapping and were therefore excluded from the calculated ratios.

(2) **Estimated Number of Existing Lead Service Lines (LSLs):** The estimated number of existing lead service lines is used to define the expected lead concentrations experienced at those connections under current and potential future conditions. The estimated number of lead service lines in Denver Water's integrated system used at the time of this model analysis is 74,138. Lead service lines are distributed to the approximate sources of supply: Marston/Foothills 28%, Moffat 25%, Blend 47%. The model was also exercised to analyze 55,000 lead service lines to test sensitivity to this parameter.

(3) **Estimated Number of Existing Copper with Lead Solder (CuLSs):** The estimated number of existing CuLS is used to define the expected lead concentrations for homes with CuLS under current and potential future conditions. A conservative number of CuLSs was determined by selecting the taps with a parcel build year before 1988. The number of lead service lines mathematically assigned to the same subset of taps was subtracted from this total. The total number of CuLS taps is 152,630. CuLSs are distributed to the approximate sources of supply: Marston/Foothills 38%, Moffat 49%, Blend 13%. This estimate is conservative because many of these services would have CuLS premise plumbing replaced with non-lead bearing materials.

(4) **Source of Supply:** The source of supply for each tap is assigned based on the shape file, which represents only a certain time period when the data were collected. When lead release data for blended sources is not available, samples are drawn from either Marston or Moffat data. For example, when the service is a lead service line, the fraction of samples drawn from the Marston data are equal to the number of lead service lines in the Marston zone divided by the total lead service lines in the Marston and Moffat zones. Inversely, the fraction of samples drawn from the Moffat pipe rack is equal to the number of lead service lines in the Moffat zone divided by the total lead service lines in the Marston and Moffat zones. The same procedure is used for CuLS and other.

(5) **Lead Release from Lead Service Lines (LSLs):** The lead release from lead service lines is taken from the data from the pipe rack experiments for both pre- and post-CCT. These data are used instead of the LCR data because the pipe racks directly test the effectiveness of orthophosphate and pH adjustment. The lead concentrations coming off the pipe rack have high variability and can exhibit 2 to 3 times the peak concentrations observed from sequential sampling (profiling) studies undertaken by Denver Water.

(6) **Lead Release from Copper with Lead Solder (CuLS):** The lead release from CuLS is taken from the LCR database. These data consist of LCR compliance samples and first-draw customer requested samples. Samples are identified as CuLS when the inventory parcel year built is less than 1988 and the p-value assigned in the inventory is less than 0.8 (which are likely to be lead service lines).

For samples with no parcel year built, project year built from the LCR database is used. A lognormal distribution was fit to these data and used to determine lead release at each tap.

(7) **Lead Release from Other Materials:** The lead release from other lines is taken from the LCR database. These data consist of first-draw customer requested samples (no LCR compliance samples are taken at homes without lead service line or CuLS). Samples are identified as other when the inventory parcel year built is greater than 1987. For samples with no parcel year built, project year built from the LCR database is used. These data were also fit to a lognormal distribution.

(8) **Corrosion Control Treatment (CCT):** Either orthophosphate or pH/alkalinity adjustment is considered for corrosion control treatment. The effectiveness of these approaches on minimizing lead release for lead service lines come from results of the lead service line pipe rack experiments. The reductions achieved in CuLS and other lines come from the immersion study. The data from only copper with lead solder coupons are used. Bootstrapping is used to calculate the reduction from the pH or orthophosphate treated jars in comparison with the control jars. Since lead release is not expected to increase as a result of CCT, negative reductions were changed to zero.

The remaining assumptions are a function of the OCCT and LRP conditions.

(9) **Implementation Start Date:** Either the OCCT or LRP option will be implemented on March 20, 2020.

(10) **Lead Service Line Replacement (LSLR) Rate:** Denver Water currently estimates 1,200 lead service lines are replaced annually as a result of main replacement projects and parcel redevelopment which is assumed to continue at a constant rate in the OCCT scenario. As a part of the LRP, Denver Water will implement accelerated lead service line replacement rate of 7% annually (5,190 lead service lines/yr calculated as a 3-year running annual average). After replacement of a lead service line, the service is conservatively assumed to contain CuLS as premise plumbing. The model assumes the lead service lines will be randomly selected for replacement. The LRP will prioritize high lead concentration areas and sensitive sub-populations.

(11) **Lead Filter Implementation:** As a part of the LRP, Denver Water will distribute and verify use of NSF/ANSI 53 certified lead filters at homes with known or suspected lead service line until 3 months after the lead service line is confirmed to be removed. NSF/ANSI 53 certified lead filters achieve lead reduction to the detection limit of 1 ppb (Bosscher et al., 2019). This analysis considers estimates of filter adoption rates from 50 to 100% in increments of 10%.

Model Configuration

A flowchart of the model configuration is shown in Figure 1. The model starts by estimating current lead exposure conditions across the Denver Water service area for connections characterized by having a lead service line, CuLS, or other material. The model represents lead exposure at lead service line served connections as those experienced by the lead service line pipe rack experiments. The model represents lead exposure at CuLS and other using the historic LCR samples.

The model applies a variable reduced lead release due to CCT for lead service lines by randomly drawing from the treated pilot rack data for the appropriate CCT (orthophosphate or pH). The lead reduction for CuLS and other materials is determined by calculating percent reduction from random draws of immersion study data for CuLS coupons with the appropriate CCT (orthophosphate or pH). Negative reductions were changed to zero because CCT is not expected to increase lead release. This calculation is applied to both CuLS and other material lines even though only CuLSs are represented in the immersion study because no site-specific lead reduction data for other materials are available.

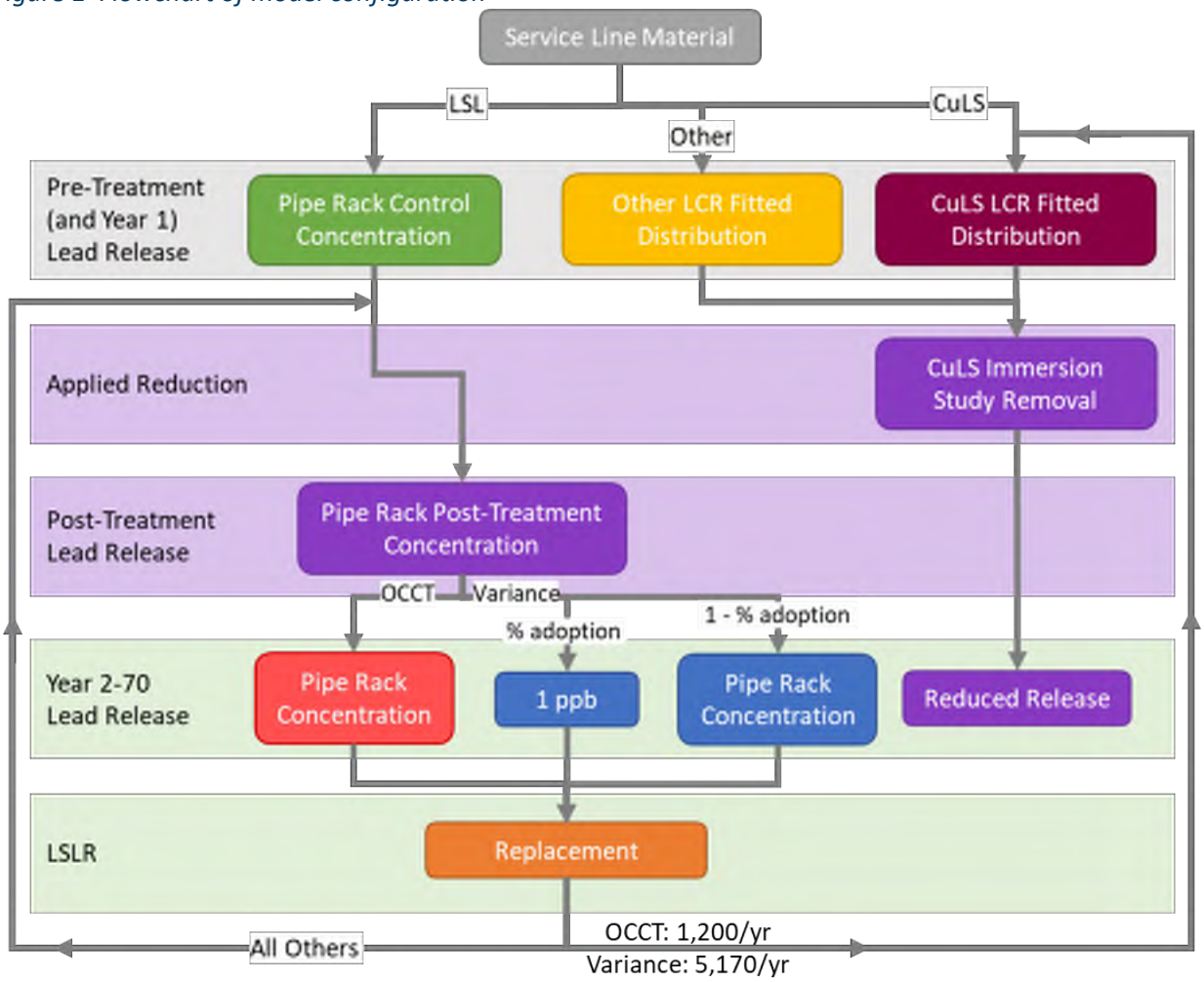
Lead filter exposure in the model is set to 1 ppb lead. Lead filters are only applied to remaining lead service lines; therefore, once a lead service line is removed, so is the filter. This service line will then be drawn from the CuLS distribution which can result in a lead concentration greater than 1 ppb.

Lead service line replacement is modeled by shifting the inventory of lead service lines in the integrated service area from lead service lines to CuLS by the number of lead service line replacements in each year.

All taps and distributions are divided by source: Marston, Moffat, or blend. The model simulates lead release from all individual taps every year for 70 years. The only parameter that changes through time is the number of lead service lines and CuLS due to replacement.

Further details describing the modeling approach, model inputs, choices, and assumptions are provided in Appendix B. Histograms of the underlying data can be found in Appendix C.

Figure 1 Flowchart of model configuration



Results

The model outputs a predicted lead concentration at every tap in Denver Water's integrated system through time in one-year increments (the only parameter to change through time is the number of lead service lines due to replacements). The results have then been summarized in multiple ways.

Lead concentration over time compares the effectiveness of the different chemical treatments and lead service line replacement rates. Figure 2 displays the 95th percentile lead concentration of the entire integrated service area over the time frame from the beginning of treatment to after the last lead service line is removed (figures showing other percentile outputs can be found in Appendix A).

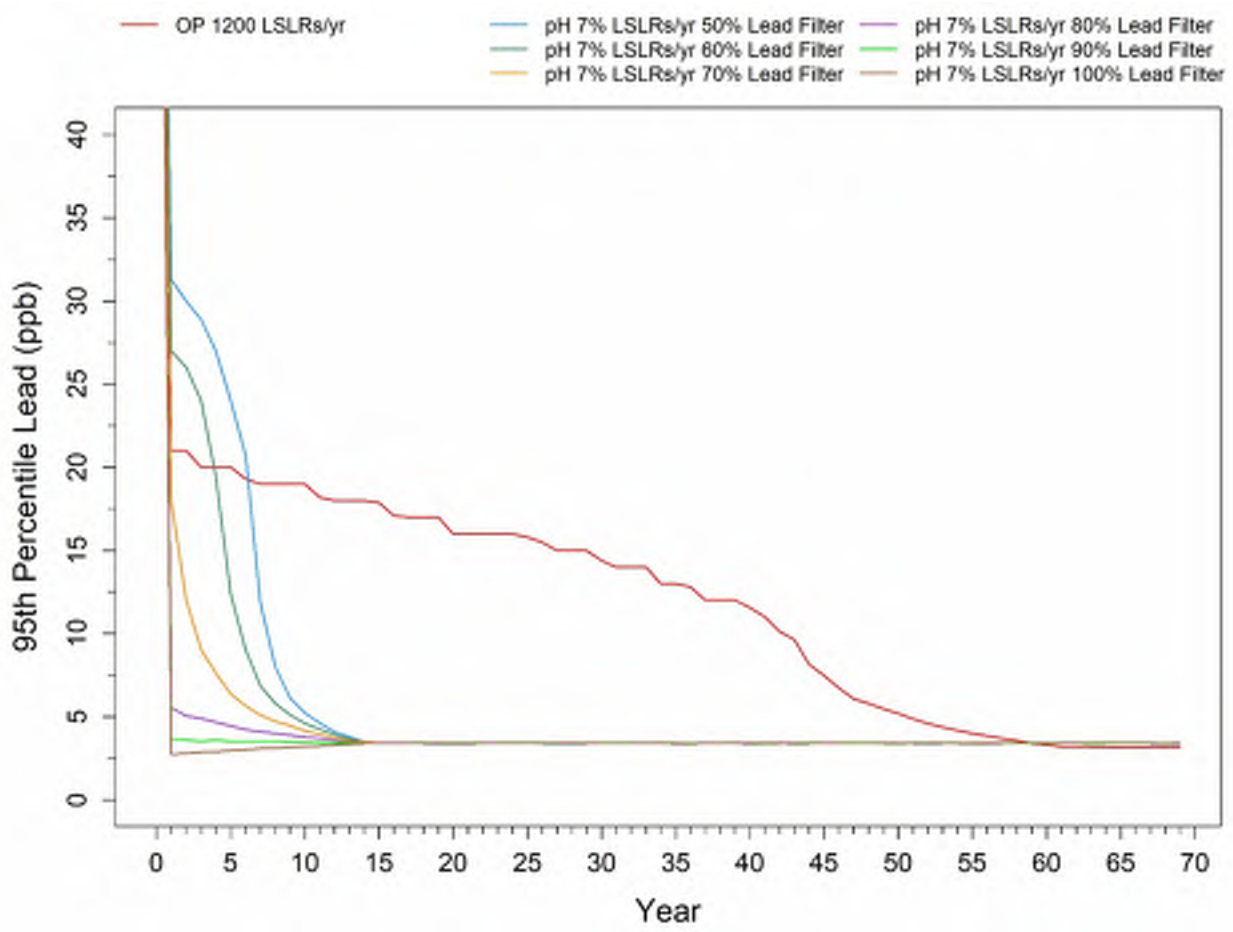
The OCCT condition of orthophosphate is shown in red, while the LRP conditions are shown in different color lines. Each LRP condition line represents a different lead filter adoption rate from 50 – 100%.

Figure 2 shows that the 70% lead filter adoption rate results in lower lead concentrations than the OCCT scenario under the conditions modeled. This is confirmed from outputs at other statistical descriptions as shown in Appendix A. The 60% lead filter adoption rate shows slightly higher concentrations than the OCCT scenario in years 1–4. Therefore, the lead filter adoption rate that demonstrates lower lead concentrations than the OCCT scenario for all tested statistical descriptions is between 60–70%. At the limits of the model, the OCCT scenario indicates lower concentrations than the LRP. This is a result of the lead reduction due to orthophosphate being higher than pH for CuLS.

Similar behavior at other statistical outputs is observed and shown in Appendix A. The 95th percentile outputs were chosen for reporting because it is the most conservative case. Model outputs indicate the LRP conditions result in lower lead concentrations at any lead filter adoption rate of at least 50% at 50th, 75th, and 90th percentiles. At the 99th percentile output, the LRP condition indicated lower lead level at all filter adoption rates 60% and above.

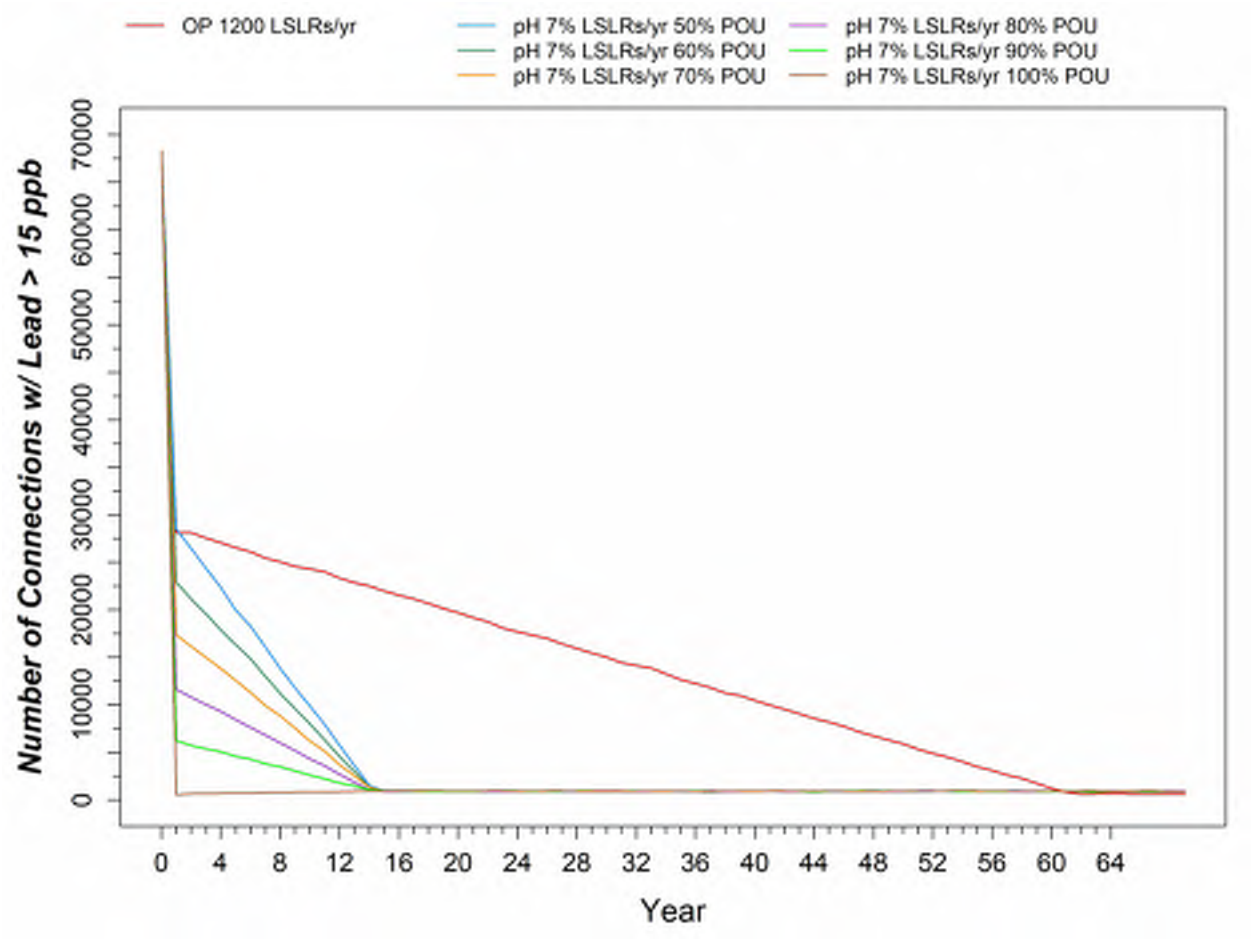
The OCCT condition shows a relatively gradual reduction in 95th percentile lead concentrations over time, while the LRP conditions show more dramatic reduction over the first 15 years. This result is due to the effective lead removal from the lead filters coupled with accelerated lead service line replacements that are included in the LRP. In the LRP condition with 100% lead filter adoption, there is a minimal increase in the 95th percentile lead concentration between years 1 and 15. The increase happens because when a lead service line is replaced, the customer will no longer get credit for use of a lead filter. The lead concentration at the tap will be drawn from the copper with lead solder distribution and therefore may have a higher concentration than with a lead filter.

Figure 2 95th percentile lead concentration over time



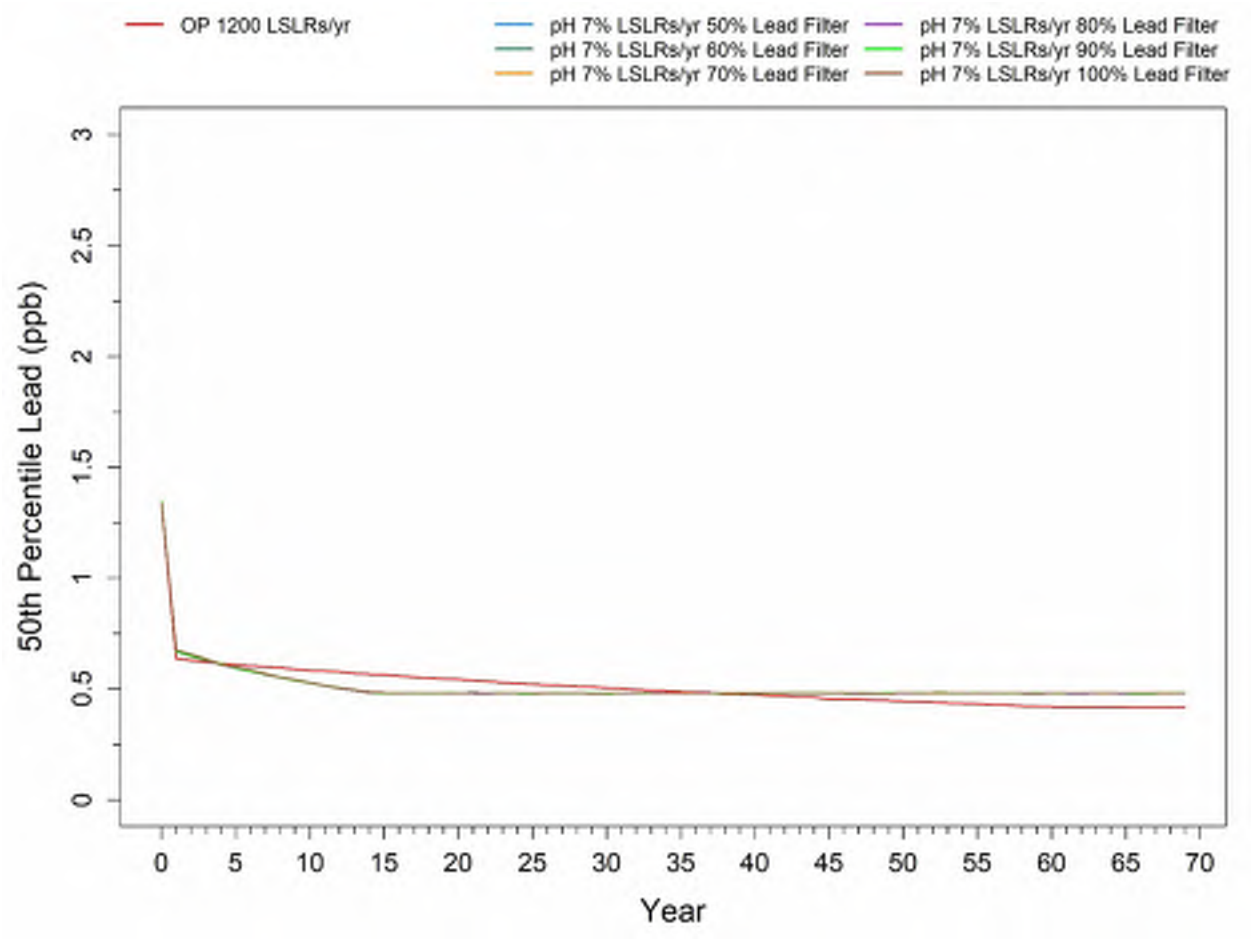
Another way to visualize the results is to compare the number of service connections above a threshold concentration. These results are presented in Figure 3 which indicates that the LRP results in a lower number of services with high lead concentrations under all filter adoption rate scenarios above 50%. Note again that this is not a prediction of the actual service connection lead concentrations but a tool to compare the conditions of the LRP to OCCT.

Figure 3 Number of connections above 15 ppb lead concentration over time



The model can also be used to look at the lead concentrations at lower statistical outputs. Figure 4 presents the median lead concentration (50th percentile), which is representative of copper with lead solder plumbing materials. In addition to the low lead concentration ranges, we see equivalent performance between the LRP and OCCT. This indicates that the LRP achieves its objectives of addressing the public health concern of the lead service lines while providing equivalent protection for the entire system.

Figure 4 Median lead concentration over time



Corona also exercised the model under two scenarios to test the senetivity of the model to major assumptions. First we tested the effect of the concentrations from lead service lines, then we tested the model for a lower inventory estimate of lead service lines.

In general, the lead concentrations from the pilot control racks range from 50 - 100 ppb. The peak lead concentrations from three rounds of profile sampling of seven in situ lead service lines generally ranges from 20 to 40 ppb. Therefore, the lead concentrations used in the model are about 2x higher than we might expect in the distribution system. The model was run with all lead service line concentrations halved; Figure 5 shows the 95th percentile results. As expected, concentrations decrease; however, the equivalence point between the OCCT and the LRP does not change substantially.

The estimated number of lead service lines is calculated based on conservative p-values and may; therefore, be high. The model was also run with 55,000 lead service lines; 95th percentile results are shown in Figure 6. The equivalence point shifts to lower filter adoption rates. In addition, the OCCT condition reaches its minimum sooner, since the rate of lead service line replacement is not dependent on the total number of lead service lines.

Figure 5 95th percentile lead concentration over time with lead concentrations from pilot racks halved to be more representative of actual lead concentrations observed in the distribution system

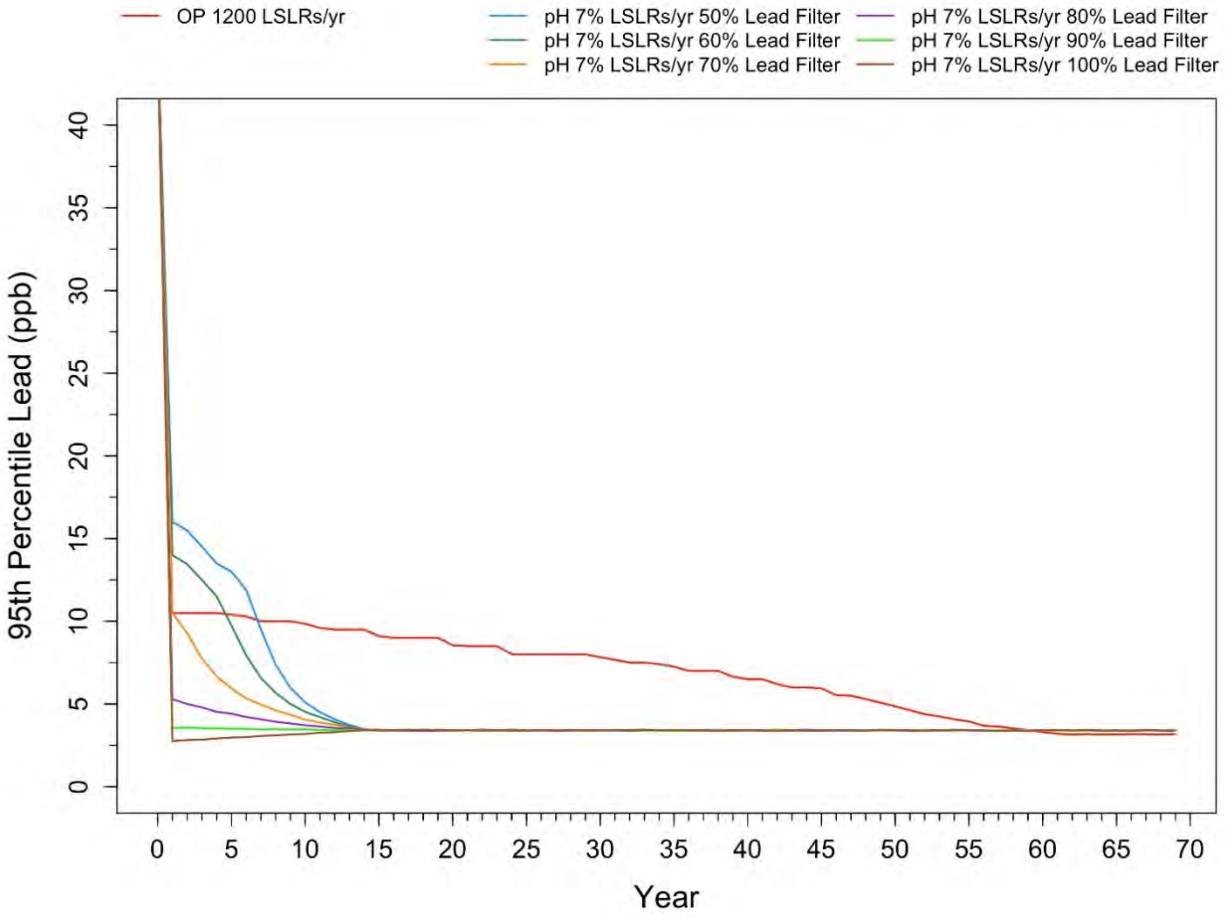
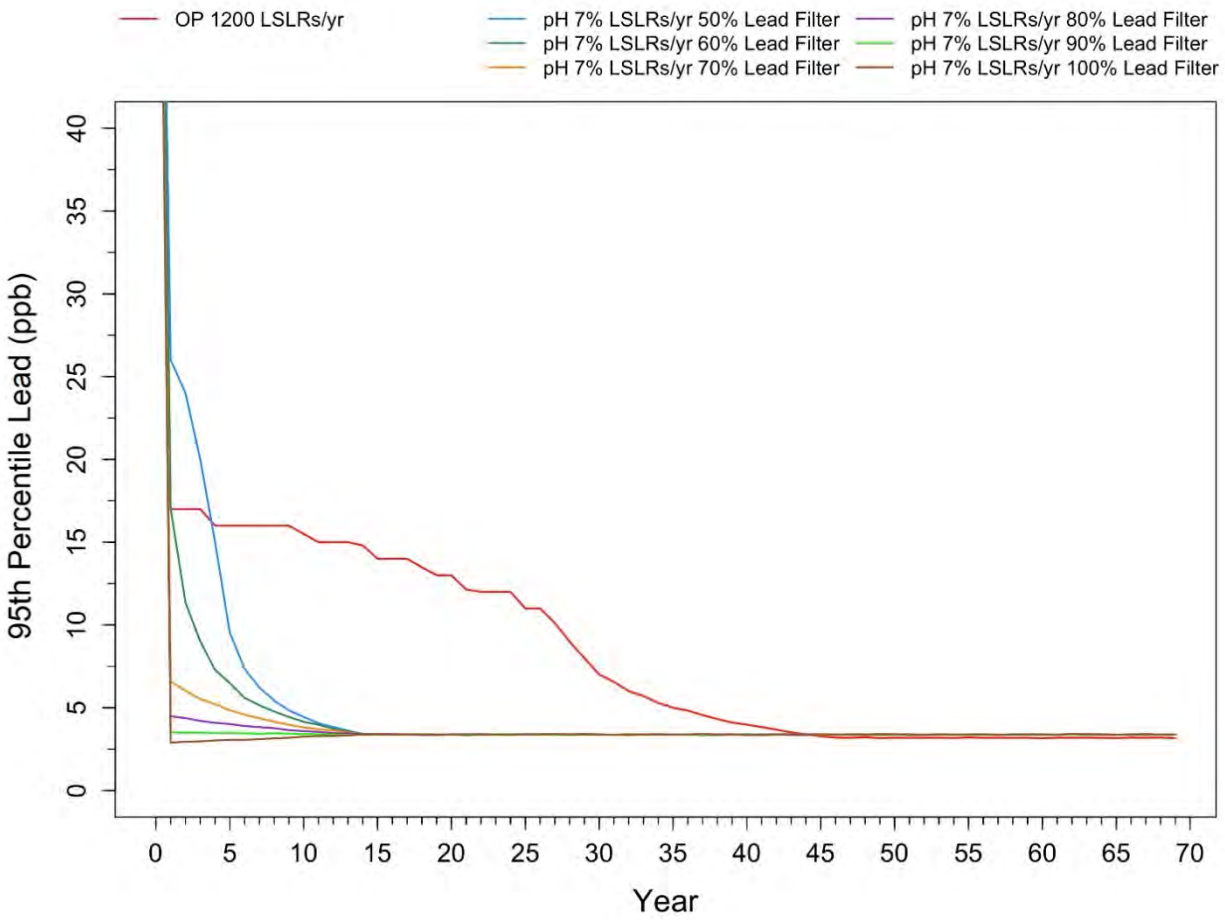


Figure 6 95th percentile lead concentration over time with number of lead service lines changed to 55,000



Each of the previous plots is a statistical summary of the data for every year. For a better understanding of the actual lead concentrations, the distribution of lead release for select years is shown in Figure 7 with each service line material in a different color. The y-axis is cropped at a count of 10,000 due to the high number of services with lead levels below the detection limit. Year 1 shows the lead concentrations without a lead reduction strategy. Year 2 shows the immediate impacts of each lead reduction strategy. For OCCT, the shift to 5–25 ppb in lead service line concentrations is due to the implementation of orthophosphate treatment. For the LRP scenario, the lead service line distribution shifts to a higher range of 10–50 ppb. However, the counts in this distribution are lower because 60% are served by lead filters, which result in a release of 1 ppb. In addition, both scenarios have fewer lead service lines due to replacement. In Year 16, all lead service lines have been replaced in the LRP scenario. Therefore, the high lead concentrations are eliminated. For the OCCT scenario, there are still an estimated 56,000 lead service lines remaining, which leaves a distribution of lead service lines lead release from 5–25 ppb. However, higher lead release is also observed. In Year 63, all lead service lines have been replaced in the OCCT scenario. High lead release has been eliminated in both scenarios. The difference between the two CCT techniques is visible in the remaining bars, with the OCCT distribution shifted slightly left of the LRP distribution. More years are shown in the Appendix.

Figure 7 Lead concentration distribution for select years at 60% filter adoption

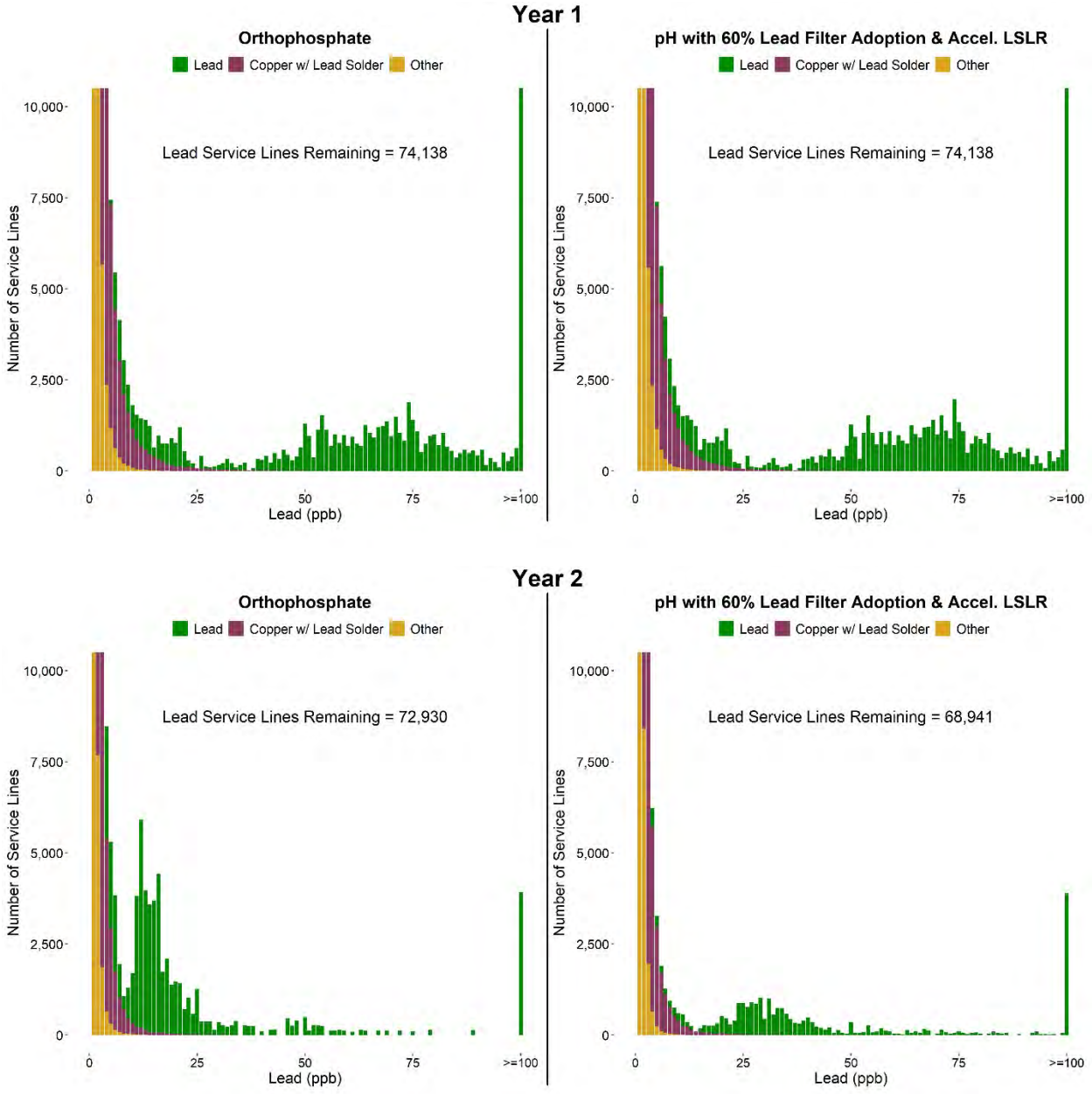
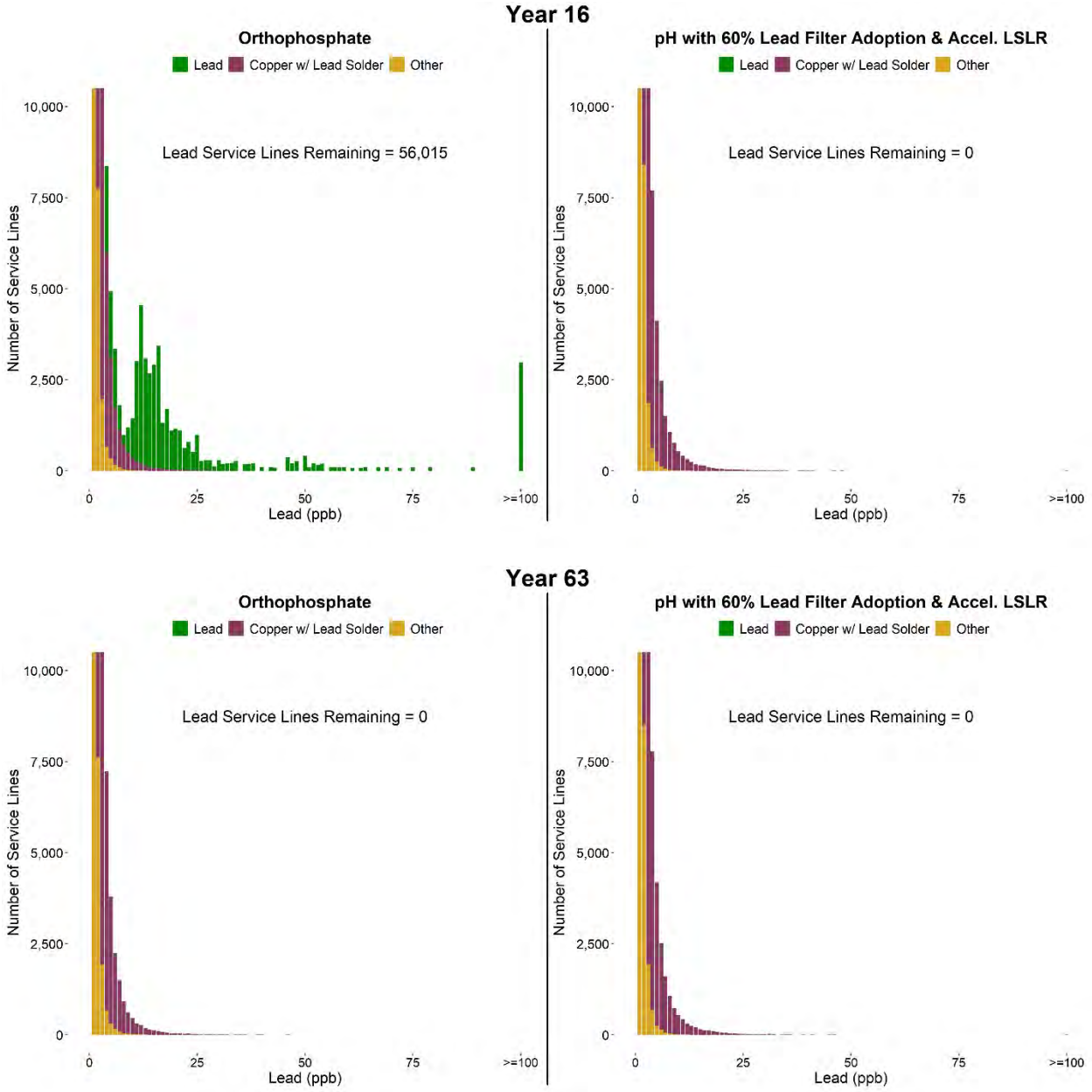


Figure 7 Lead concentration distribution for select years at 60% filter adoption



Conclusions

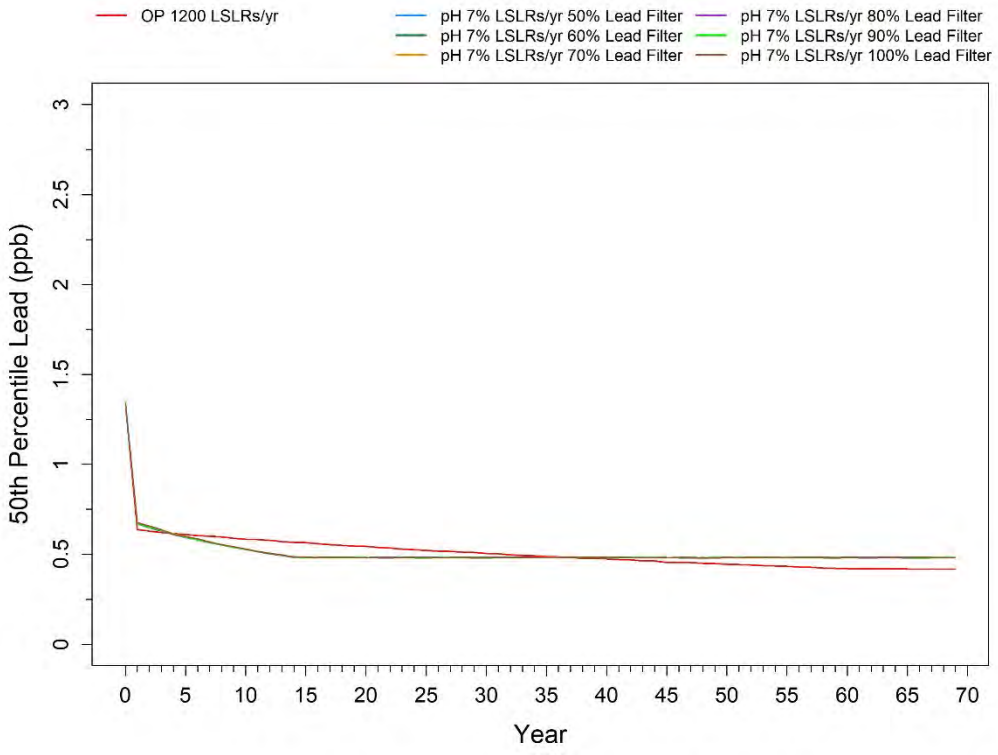
Implementing either OCCT or the proposed LRP conditions achieves significant public health protection by limiting lead exposure at Denver Water connections. At lead filter adoption of 65% and greater, implementing the LRP conditions achieves equivalent or greater lead reductions than OCCT implementation alone.

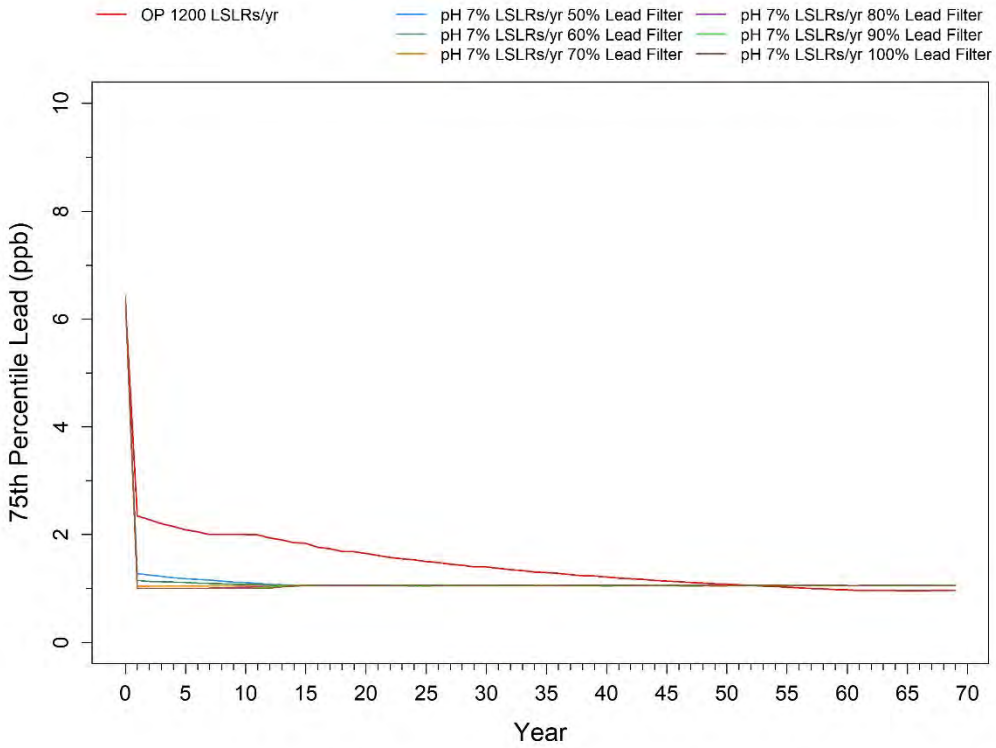
References

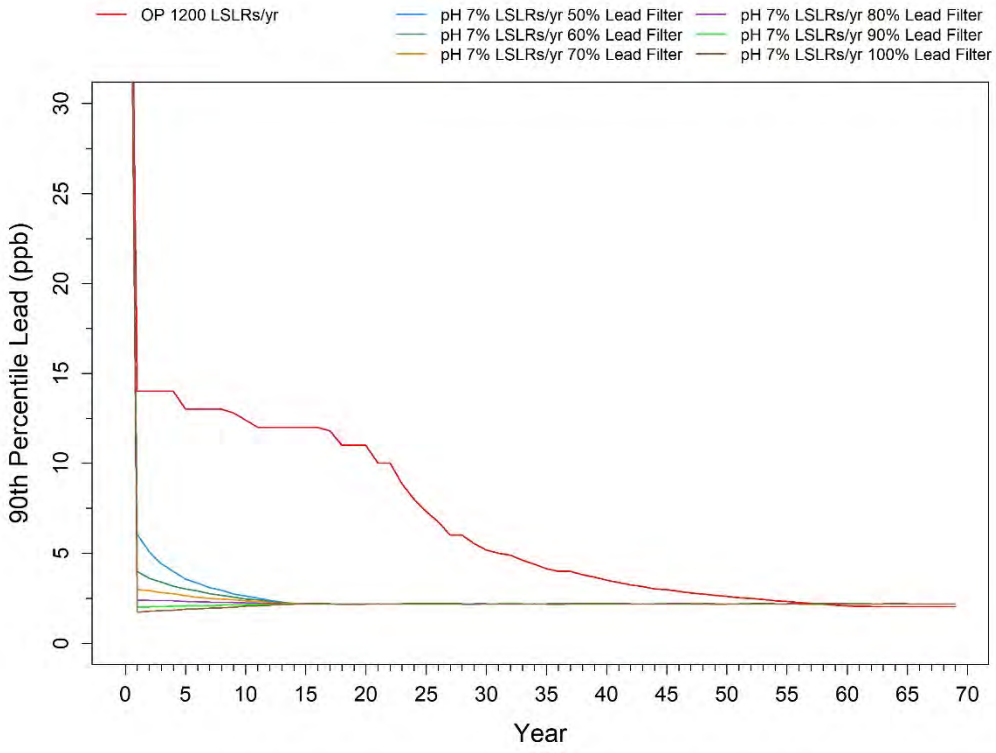
Bosscher, V., Lytle, D. A., Schock, M. R., Porter, A., Del Toral, M. (2019). POU water filters effectively reduce lead in drinking water: a demonstration field study in Flint, Michigan. *Journal of Environmental Science and Health* 54(5) 484 – 493.

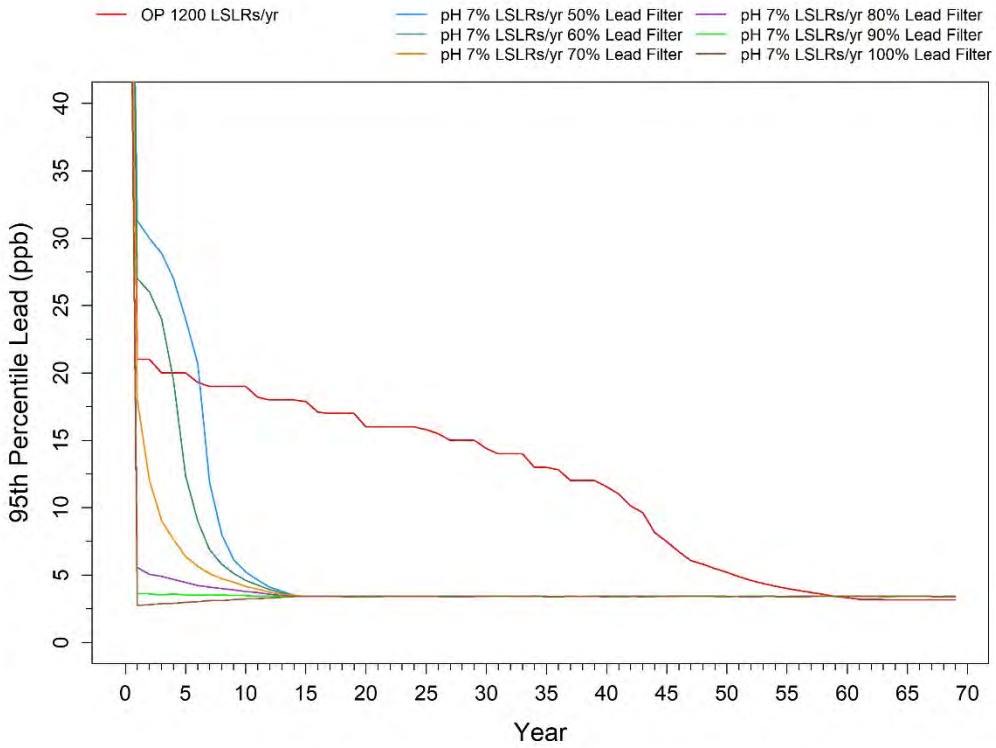
Appendix A: Additional Model Outputs

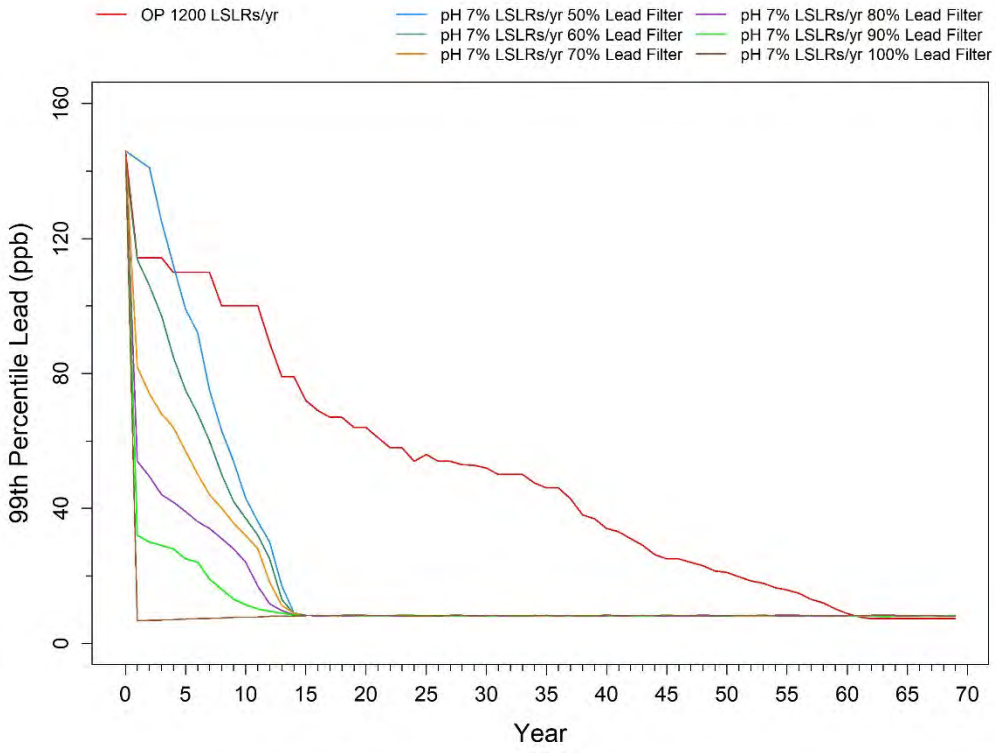
50th, 75th, 90th, 95th, and 99th percentile lead concentration over time



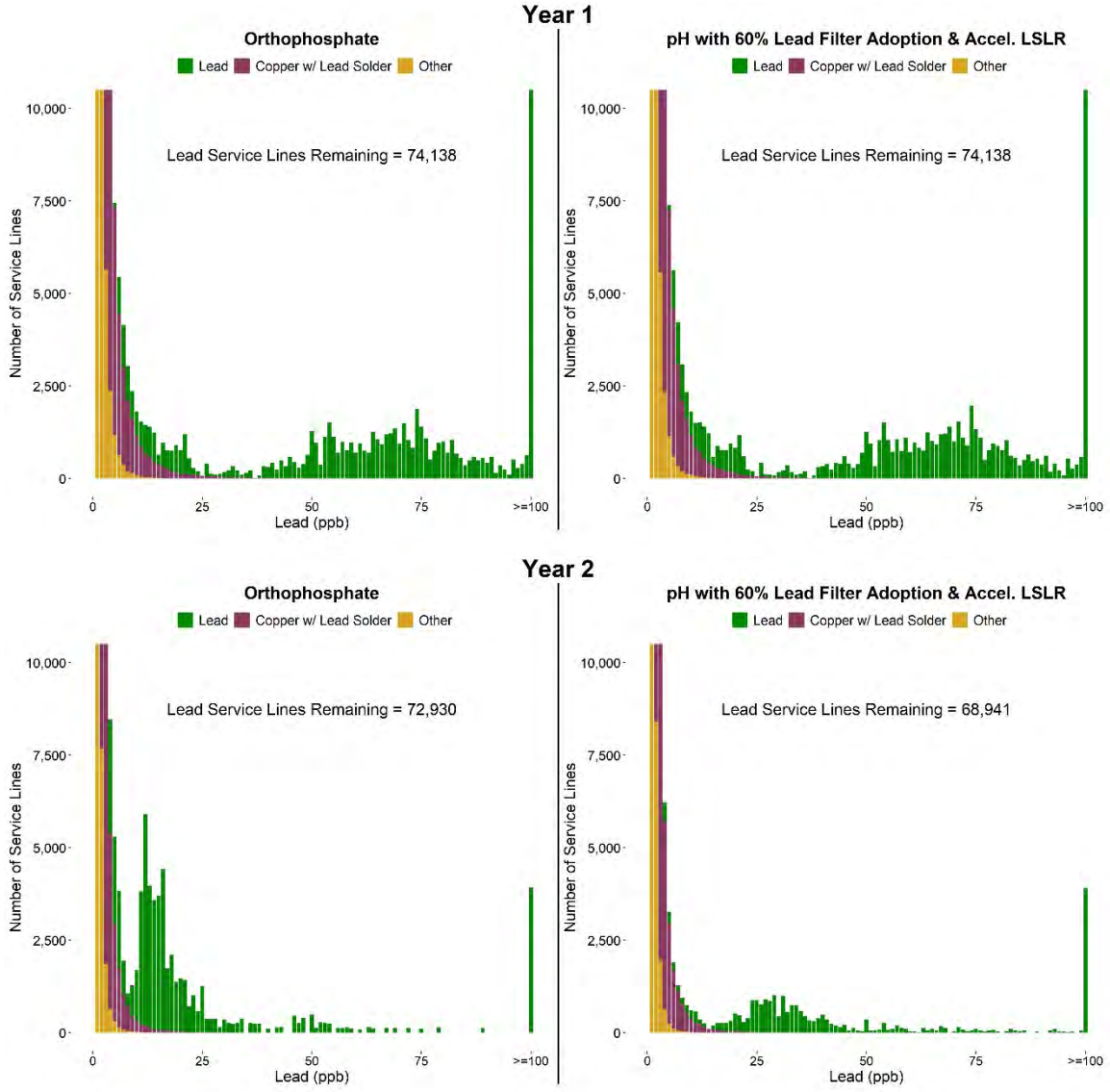

OP 1200 LSLRs/yr
pH 7% LSLRs/yr 50% Lead Filter
pH 7% LSLRs/yr 60% Lead Filter
pH 7% LSLRs/yr 70% Lead Filter
pH 7% LSLRs/yr 80% Lead Filter
pH 7% LSLRs/yr 90% Lead Filter
pH 7% LSLRs/yr 100% Lead Filter
75th Percentile Lead (ppb)
0
2
4
6
8
10
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70
Year

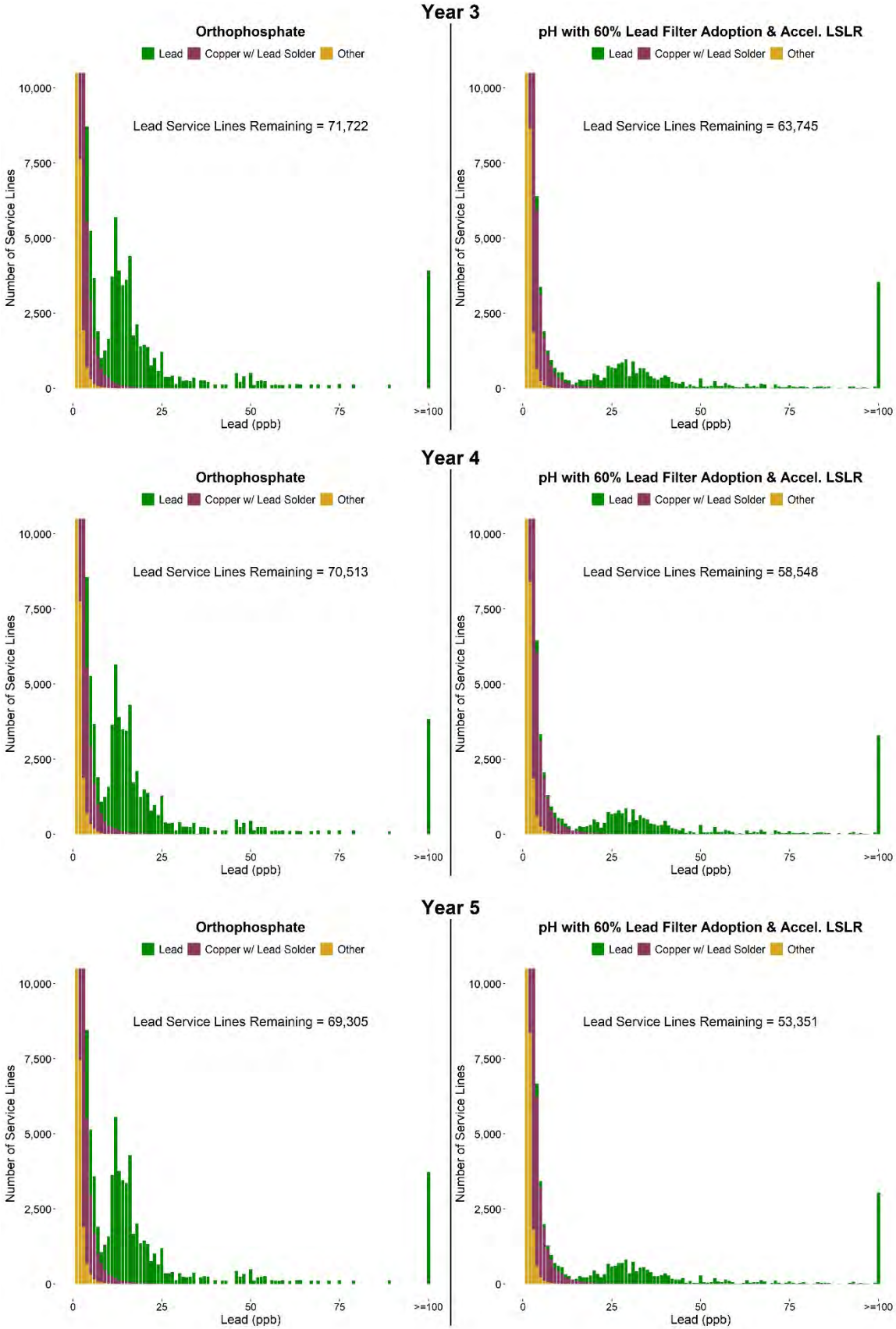

OP 1200 LSLRs/yr
pH 7% LSLRs/yr 50% Lead Filter
pH 7% LSLRs/yr 60% Lead Filter
pH 7% LSLRs/yr 70% Lead Filter
pH 7% LSLRs/yr 80% Lead Filter
pH 7% LSLRs/yr 90% Lead Filter
pH 7% LSLRs/yr 100% Lead Filter
90th Percentile Lead (ppb)
0
5
10
15
20
25
30
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70
Year

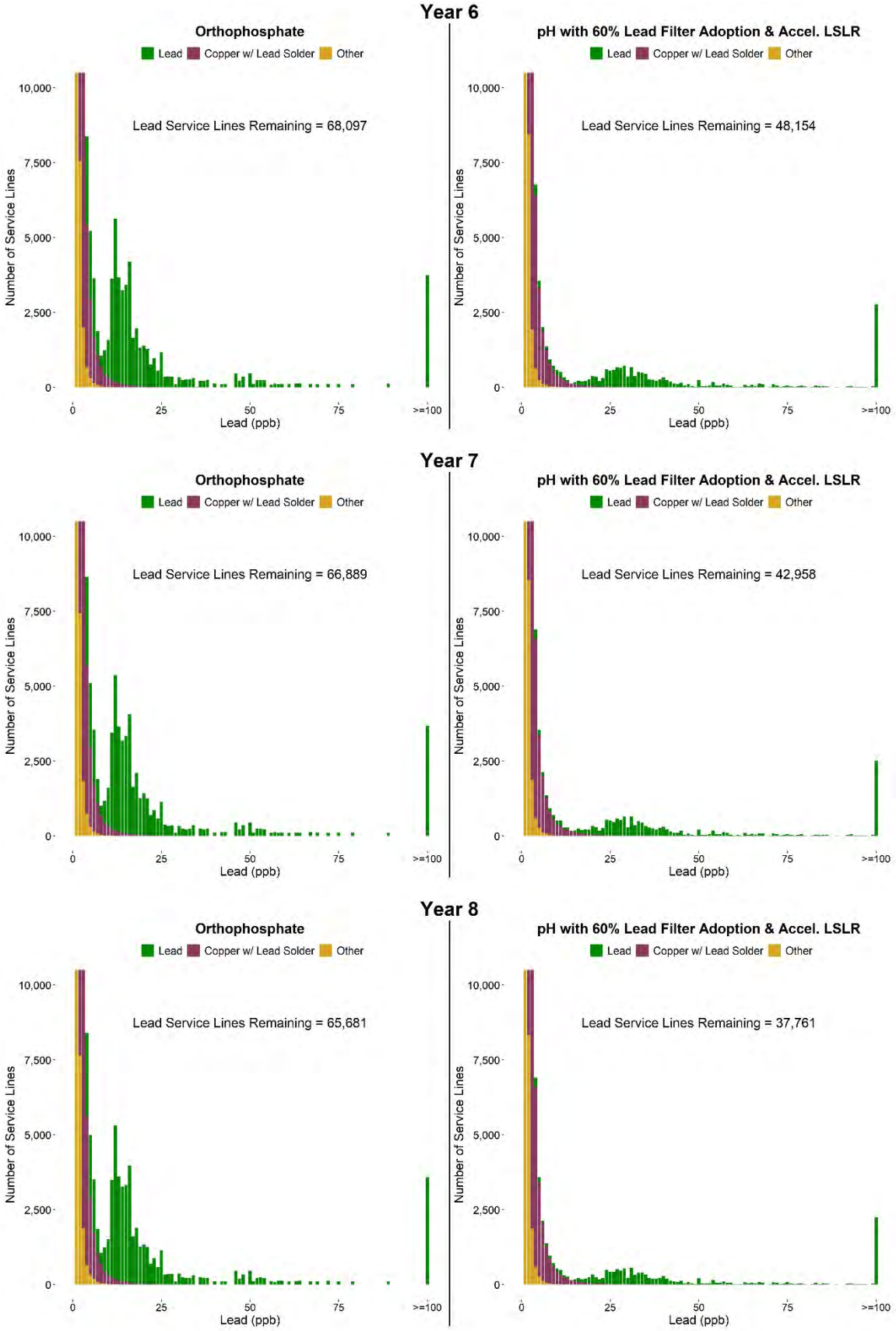

OP 1200 LSLRs/yr
pH 7% LSLRs/yr 50% Lead Filter
pH 7% LSLRs/yr 60% Lead Filter
pH 7% LSLRs/yr 70% Lead Filter
pH 7% LSLRs/yr 80% Lead Filter
pH 7% LSLRs/yr 90% Lead Filter
pH 7% LSLRs/yr 100% Lead Filter
95th Percentile Lead (ppb)
0
5
10
15
20
25
30
35
40
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Year

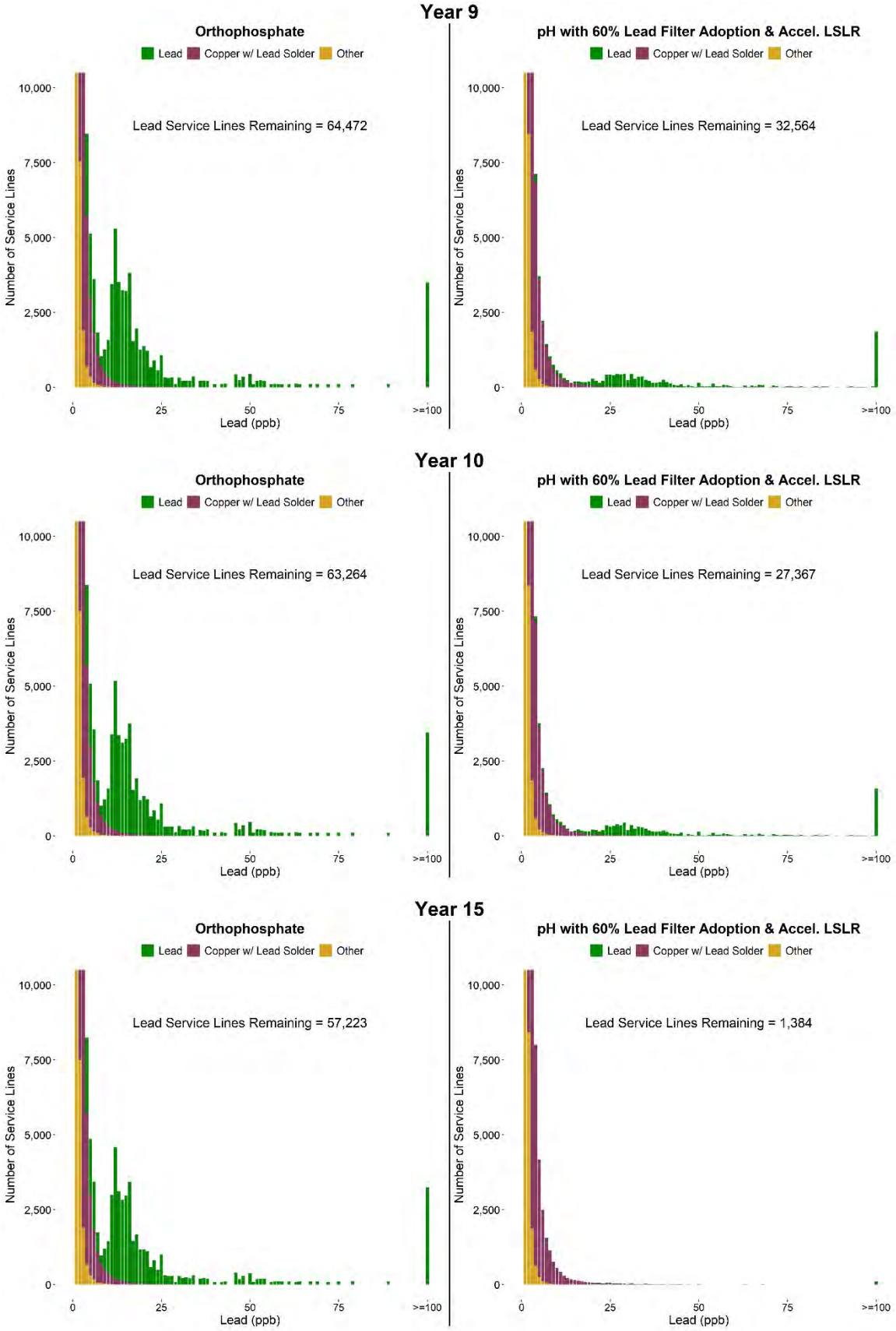

OP 1200 LSLRs/yr
pH 7% LSLRs/yr 50% Lead Filter
pH 7% LSLRs/yr 60% Lead Filter
pH 7% LSLRs/yr 70% Lead Filter
pH 7% LSLRs/yr 80% Lead Filter
pH 7% LSLRs/yr 90% Lead Filter
pH 7% LSLRs/yr 100% Lead Filter
99th Percentile Lead (ppb)
0
40
80
120
160
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Year

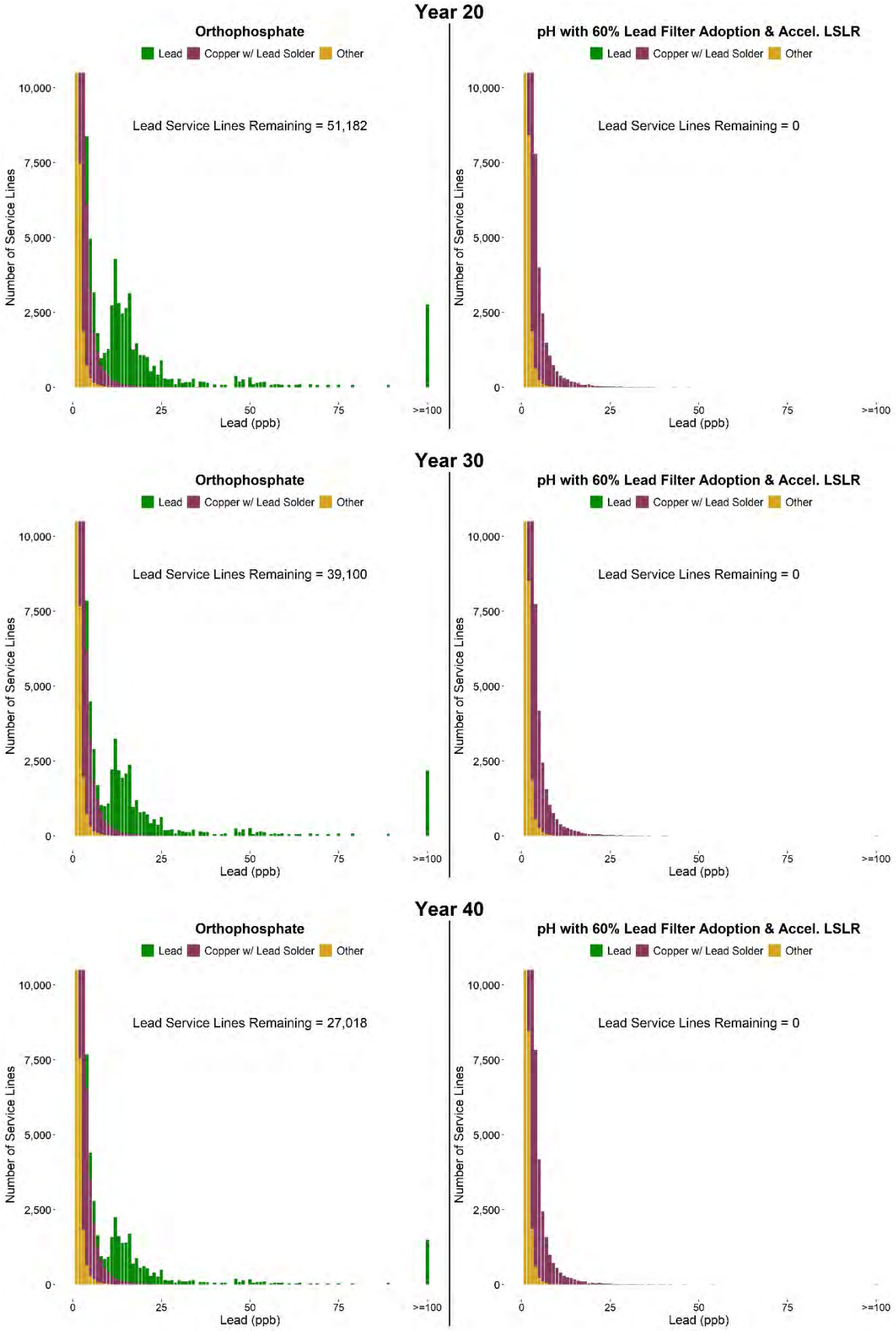
Distribution of lead concentrations by year

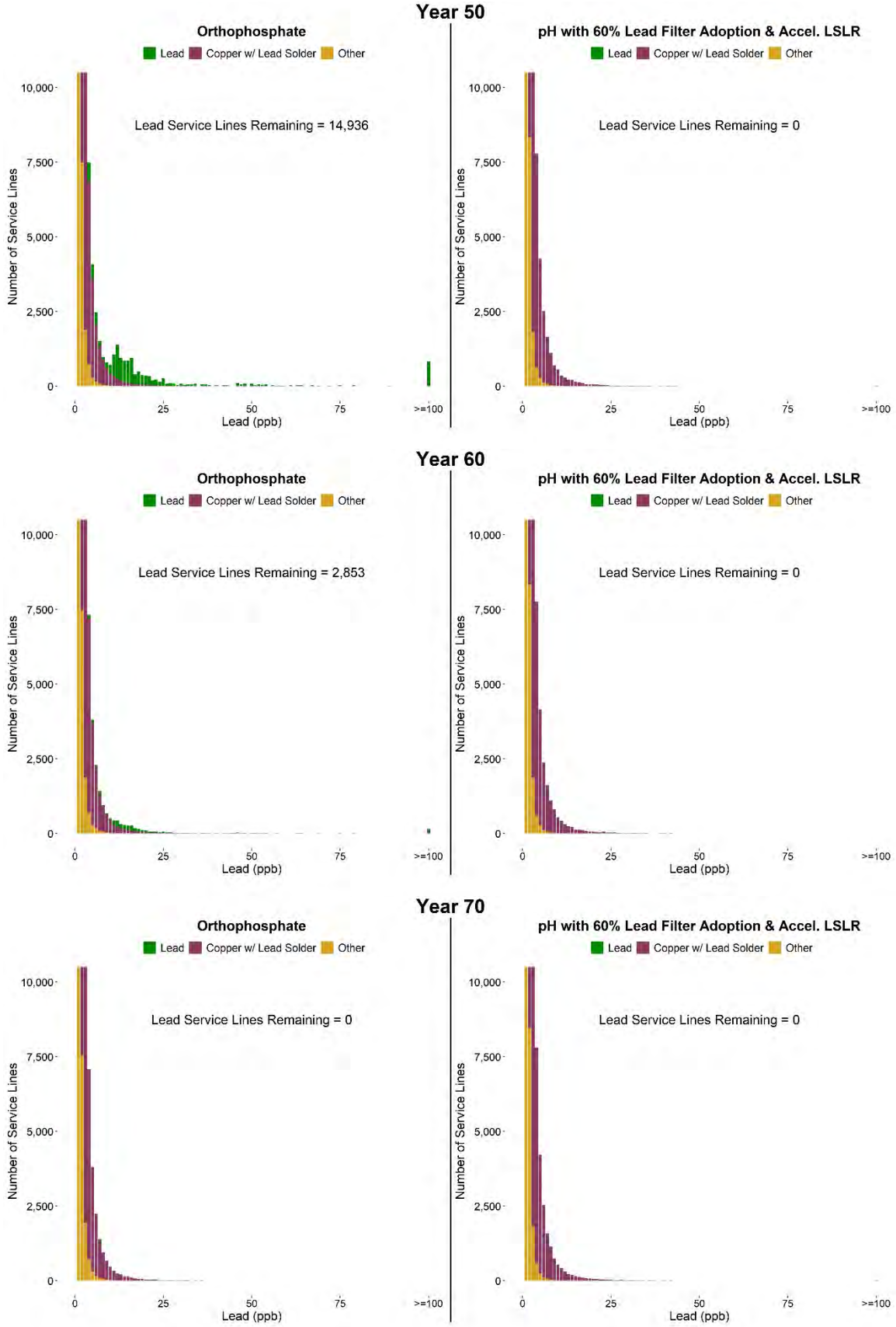



Year 3
Orthophosphate
Lead
Copper w/ Lead Solder
Other
Lead Service Lines Remaining = 71,722
Number of Service Lines
Lead (ppb)
pH with 60% Lead Filter Adoption & Accel. LSLR
Lead Service Lines Remaining = 63,745
Year 4
Lead Service Lines Remaining = 70,513
Lead Service Lines Remaining = 58,548
Year 5
Lead Service Lines Remaining = 69,305
Lead Service Lines Remaining = 53,351
10,000
7,500
5,000
2,500
0
25
50
75
>=100


Year 6
Orthophosphate
Lead
Copper w/ Lead Solder
Other
Lead Service Lines Remaining = 68,097
Number of Service Lines
Lead (ppb)
pH with 60% Lead Filter Adoption & Accel. LSLR
Lead Service Lines Remaining = 48,154
Year 7
Lead Service Lines Remaining = 66,889
Lead Service Lines Remaining = 42,958
Year 8
Lead Service Lines Remaining = 65,681
Lead Service Lines Remaining = 37,761
10,000
7,500
5,000
2,500
0
25
50
75
>=100


Year 9
Orthophosphate
Lead
Copper w/ Lead Solder
Other
Lead Service Lines Remaining = 64,472
Number of Service Lines
Lead (ppb)
pH with 60% Lead Filter Adoption & Accel. LSLR
Lead Service Lines Remaining = 32,564
Year 10
Lead Service Lines Remaining = 63,264
Lead Service Lines Remaining = 27,367
Year 15
Lead Service Lines Remaining = 57,223
Lead Service Lines Remaining = 1,384
10,000
7,500
5,000
2,500
0
25
50
75
>=100


Year 20
Orthophosphate
Lead
Copper w/ Lead Solder
Other
Lead Service Lines Remaining = 51,182
Number of Service Lines
Lead (ppb)
pH with 60% Lead Filter Adoption & Accel. LSLR
Lead Service Lines Remaining = 0
Year 30
Lead Service Lines Remaining = 39,100
Year 40
Lead Service Lines Remaining = 27,018
10,000
7,500
5,000
2,500
0
25
50
75
>=100


Year 50
Orthophosphate
Lead
Copper w/ Lead Solder
Other
Lead Service Lines Remaining = 14,936
Number of Service Lines
Lead (ppb)
pH with 60% Lead Filter Adoption & Accel. LSLR
Lead Service Lines Remaining = 0
Year 60
Lead Service Lines Remaining = 2,853
Year 70

Appendix B: Modeling Approach, Choices, and Assumptions

Introduction

This appendix describes the approach, choices, and assumptions used in Corona's simulations of corrosion control and lead service line (LSL) replacement for Denver Water's (DW's) service area.

Modeling is divided into two major components:

- Immersion study data analysis (bootstrap) conducted to better characterize variability in treatment technique performance, and
- Simulations (Monte Carlo) for lead risk reduction strategies (combinations of treatment strategies and lead service line reduction scenarios).

Models were programmed in the open source R environment.

Simulation Description

Pre-treatment Data Inputs (First Year)

- **Lead Service Lines:**
    - **Marston Source:** For each Denver Water service connection identified as having a lead service line and served by Marston, a random sample is drawn from the Marston pre-treatment pipe rack lead concentration data.
    - **Moffat Source:** For each connection identified as having a lead service line and served by Moffat, a random sample is drawn from the Moffat pre-treatment pipe rack lead concentration data.
    - **Blended Source:** For service connections in the blended region (receiving water from Marston and Moffat), samples are drawn from either Marston or Moffat untreated pipe rack lead concentration data. The fraction of samples drawn from the Marston pipe rack is equal to the number of lead service lines in the Marston zone divided by the total lead service lines in the Marston and Moffat zones. Inversely, the fraction of samples drawn from the Moffat pipe rack is equal to the number of lead service lines in the Moffat zone divided by the total lead service lines in the Marston and Moffat zones.
- **Copper with Lead Solder**:
    - **Marston Source**: For each service connection identified as having copper with lead solder and served by Marston, a random sample is drawn from the lognormal distribution fit to the LCR lead concentration data for taps identified as copper with lead solder served by Marston.
    - **Moffat Source**: For each connection identified as having copper with lead solder and served by Moffat, a random sample is drawn from a lognormal distribution fit to LCR lead concentration data for taps identified as copper with lead solder served by Moffat.
    - **Blended Source**: For each service connection identified as having copper with lead solder in the blended region, a random sample is drawn from a lognormal distribution fit to LCR lead concentration data for taps identified as copper with lead solder in the blended region.
- **Other Material**:
    - For each service connection identified as having other material, a random sample is drawn from the lognormal distribution fit to the LCR data for taps identified as other. A single distribution is used for "other materials" because the number of samples is too low to stratify amongst the Marston and Moffat service areas.

Post Treatment Data Inputs for OCCT (After First Year)

- **Lead Service Lines:**
  - **Marston Source:** For each service connection identified as having a lead service line and served by Marston, a random sample is drawn from the Marston orthophosphate pipe rack lead concentration data during the post-treatment period. During this period, orthophosphate was being dosed at either 3 mg/L or 2 mg/L.
  - **Moffat Source:** For each service connection identified as having a lead service line and served by Moffat, a random sample is drawn from the Moffat orthophosphate pipe rack lead concentration data during the post-treatment period. During this period, orthophosphate was being dosed at either 3 mg/L or 2 mg/L.
  - **Blended Source:** For each service connection identified as having a lead service line in the blended region, a random sample is drawn from either the Marston or Moffat orthophosphate pipe rack lead concentration data during the post-treatment period. The percentages of samples drawn from the Marston pipe rack data and from the Moffat pipe rack data for the post-treatment period are consistent with those for the pre-treatment period, as described above.
- **Copper with Lead Solder:**
  - **Marston Source:** For each service connection identified as having copper with lead solder and served by Marston, a random sample is drawn from a distribution of percent lead reduction data for the CuLS Marston orthophosphate immersion study. The selected percent reduction is then multiplied by the connection's assigned pre-treatment lead concentration to determine the post-treatment lead concentration.
  - **Moffat Source:** For each service connection identified as having copper with lead solder and served by Moffat, a random sample is drawn from a distribution of percent lead reduction data for the CuLS Moffat orthophosphate immersion study. The selected percent reduction is then multiplied by the connection's assigned pre-treatment lead concentration to determine the post-treatment lead concentration.
  - **Blended Source:** For each service connection identified as having copper with lead solder in the blended region, a random sample is drawn from the CuLS blended orthophosphate immersion study. The selected percent reduction is then multiplied by the connection's assigned pre-treatment lead concentration to determine the post-treatment lead concentration.
- **Other Material:**
  - **Marston Source:** For each service connection identified as having other material and served by Marston, a random sample is drawn from a distribution of percent lead reduction data for the CuLS Marston orthophosphate immersion study. The selected percent reduction is then multiplied by the connection's assigned pre-treatment lead concentration to determine the post-treatment lead concentration.
  - **Moffat Source:** For each service connection identified as having other material and served by Moffat, a random sample is drawn from a distribution of percent lead reduction data for the CuLS Moffat orthophosphate immersion study. The selected percent reduction is then multiplied by the connection's assigned pre-treatment lead concentration to determine the post-treatment lead concentration.
- **Blended Source:** For each service connection identified as having other material in the blended region, a random sample is drawn from the CuLS blended orthophosphate immersion study. The selected percent reduction is then multiplied by the connection's assigned pre-treatment lead concentration to determine the post-treatment lead concentration.

- **Lead Service Line Replacement:** Each year, 1,200 lead service line connections are randomly selected for lead service line replacement. For each of these connections, the lead concentration is replaced by a random sample from the pre-treatment copper with lead solder distribution. The line is then categorized as copper with lead solder and follows the post-treatment rules for copper with lead solder described below.

Post Treatment Data Inputs for LRP (After First Year)

- **Lead Service Lines:**
    - **Marston Source:** For each service connection identified as having a lead service line and served by Marston, a random sample is drawn from the Marston pH pipe rack lead concentration data during the post-treatment period. During this period, the target pH was 8.8.
    - **Moffat Source:** For each service connection identified as having a lead service line and served by Moffat, a random sample is drawn from the Moffat pH pipe rack lead concentration data during the post-treatment period. During this period, the target pH was 8.8.
    - **Blended Source:** For each service connection identified as having a non-lead service line in the blended region, a random sample is drawn from either the Marston or Moffat pH pipe rack lead concentration data during the post-treatment period. The percentages of samples drawn from the Marston pipe rack data and from the Moffat pipe rack data for the post-treatment period are consistent with those for the pre-treatment period, as described above.
- **Copper with Lead Solder:**
    - **Marston Source:** For each service connection identified as having copper with lead solder and served by Marston, a random sample is drawn from a distribution of percent lead reduction data for the CuLS Marston pH immersion study. The selected percent reduction is then multiplied by the connection's assigned pre-treatment lead concentration to determine the post-treatment lead concentration.
    - **Moffat Source:** For each service connection identified as having copper with lead solder and served by Moffat, a random sample is drawn from a distribution of percent lead reduction data for the CuLS Moffat pH immersion study. The selected percent reduction is then multiplied by the connection's assigned pre-treatment lead concentration to determine the post-treatment lead concentration.
    - **Blended Source:** For each service connection identified as having copper with lead solder in the blended region, a random sample is drawn from a distribution of percent lead reduction data for the CuLS blended pH immersion study. The selected percent reduction is then multiplied by the connection's assigned pre-treatment lead concentration to determine the post-treatment lead concentration.
- **Other Material:**
    - **Marston Source:** For each service connection identified other and served by Marston, a random sample is drawn from a distribution of percent lead reduction data for the CuLS Marston pH immersion study. The selected reduction is then multiplied by the connection's assigned pre-treatment lead concentration to determine the post-treatment lead concentration.
    - **Moffat Source:** For each service connection identified as other and served by Moffat, a random sample is drawn from a distribution of percent lead reduction data for the CuLS Moffat pH immersion study. The selected percent reduction is then multiplied by the

connection's assigned pre-treatment lead concentration to determine the post-treatment lead concentration.

- **Blended Source:** For each service connection identified as other in the blended region, a random sample is drawn from a distribution of percent lead reduction data for the CuLS blended pH immersion study. The selected percent reduction is then multiplied by the connection's assigned pre-treatment lead concentration to determine the post-treatment lead concentration.

- **All Sources (Lead Filter):** Denver Water will provide each household with a lead service line with a lead filter. The model is run with lead filter adoption rates, *p*, of 50%, 60%, 70%, 80%, 90% and 100%. For each adoption rate scenario, *p*% of the lead service line connections are randomly sampled and the assigned lead concentration is replaced with 1 ppb to account for the lead reduction achieved by the lead filter.
- **Lead Service Line Replacement:** Each year, 7% of the total lead service lines (7% of 74,138 lead service lines = 5,190 replacements per year) are randomly selected for lead service line replacement. For each of these connections, the post-treatment lead concentration is replaced by a random sample from the pre-treatment copper with lead solder distribution. The line is then categorized as copper with lead solder and follows the post-treatment rules for copper with lead solder described below.

Estimating the Reduction in Lead Release (Immersion Study Data Analyses)

Approach

1. Data used in the bootstrap analysis are immersion study data for periods of stable operation. All immersion study data for CuLS coupons from these periods are retained.
   1.1. The immersion study included CuLS coupons for the Marston plant and for the Moffat plant. For both Marston and Moffat CuLS coupons, data from June 7, 2019 through July 5, 2019 were used. The CuLS coupons included control coupons, coupons with orthophosphate treatment, and coupons with pH treatment.
2. For each plant, draw a sample from the control coupon lead concentration data and a sample from the treatment, either orthophosphate treatment or pH treatment, coupon lead concentration data. The size of the control sample is equal to the number of control data and the size of the treatment sample is equal to the number of treatment data.
3. Calculate the reduction in lead concentration for the control and treatment samples for the coupon. Reduction calculated as the difference in the expected values for a lognormal distribution of the control and treatment samples as a percent of the expected value of the lognormal distribution of control samples.
4. In some case, negative reductions were observed. Because increases in lead concentrations observed in the pilot rack and immersion study were assumed to due to other factors and not as a result of CCT, these values were changed to zero.
5. Steps 2 - 4 were repeated 1,000 times for each treatment.
6. The distribution of reductions for a given treatment is given by the combination of reductions for the 1,000 reduction estimates for a given plant and a given treatment. This resulted in 4 output files, each with 1,000 potential reduction and all used in the Monte Carlo analysis:
   6.1. Moffat plant, OP treatment
   6.2. Moffat plant, pH adjustment
   6.3. Marston plant, OP treatment
   6.4. Marston plant, pH adjustment

Choices and Underlying Assumptions

1. Assume coupons and operating conditions for coupons are representative of pipes and operating conditions for a given service area (Moffat or Marston).
2. Assume that sufficient data were collected from immersion study to account for seasonal differences in corrosion control performance.
3. Assume data are lognormally distributed and calculate reduction based on the difference in the expected value for lognormal distribution for control and treatment data.
4. 1,000 samples per plant and treatment is sufficient for establishing the range of reductions that might have been observed for a pipe carrying water from that plant with the specified treatment.

Lead Risk Reduction Strategy Simulations

Approach

1. Create virtual customers/connections
   1.1. 74,138 lead service lines, distributed following source of supply ratios throughout the service area. (Marston only, Moffat only and Blend).
2. Lead concentration for a given service connection is sampled randomly from the appropriate distribution every year.
   2.1. For lead service line connections, lead concentration is sampled from pipe rack data.
      2.1.1. For connections served exclusively by the Marston or Foothills plant, lead service line lead concentration is sampled from the Marston plant pipe rack data. The following data are sampled:
         2.1.1.1. All post-stabilization control pipe data (both the pre-treatment and post-treatment period)
         2.1.1.2. All post-stabilization, pre-treatment data (all pipes)
      2.1.2. For connections served exclusively by the Moffat plant, lead service line lead concentration is sampled from the Moffat pipe rack data. The following data are sampled.
         2.1.2.1. All post-stabilization control pipe data (both the pre-treatment and post-treatment period)
         2.1.2.2. All post-stabilization, pre-treatment data (all pipes)
      2.1.3. For connections in blended areas, the connection is randomly assigned a “dominant” plant based on the proportion of connections serving each service area in the compliance and customer requested sample data. Lead concentration is drawn from pipe rack data for the assigned plant as described above.
   2.2. For CuLS and other connections, lead concentration is drawn from a random distribution corresponding to the distribution that fit the compliance data for the corresponding service area (Marston, Moffat or Blend) and material. Best fit distributions were developed separately from the Monte Carlo simulation and via maximum likelihood estimation (mle). The median lead concentration was used for addresses with more than one lead concentration in the compliance and customer requested data set.
3. In each simulation year, lead service lines can be removed, lead filters can be adopted, and treatment can be applied. There are two treatment options: orthophosphate addition and pH adjustment.
   3.1. Orthophosphate treatment is assumed to be fully implemented by March 20, 2020, which is the start of year 1 of the simulation. Under the orthophosphate treatment option, the annual lead service line replacement rate is N=1,200 and no lead filters are provided by Denver Water.
   3.2. pH addition is assumed fully implemented by the start of year 1 of the simulation. Under pH treatment option, the annual lead service line replacement rate is 7% of the total 74,138 lead service lines at the start of the simulation, N=5,190. Lead filters are provided to all addresses

with a lead service line. The lead filter adoption rate is equal to *p*%, which is varied from 50% to 100%.

3.3. Lead service line replacement is assumed to begin in year 1 of the simulation.

4. Lead concentrations are assigned or calculated for each virtual service connection for each simulation year.
   4.1. Before initiation of treatment, there is no reduction in lead concentration (i.e., the lead concentration is the same as the concentration assigned in step 2) for any connection.
   4.2. After treatment:
      4.2.1. Lead concentrations for lead service lines are sampled from the post-treatment, post-stabilization pipe rack data for the chosen treatment strategy and for the plant serving the address.
      4.2.2. Lead concentrations for non- lead service line connections are estimated as the pre-treatment lead concentration (from 2.2) minus a percent reduction drawn from the distribution of reductions from immersion study data for the plant serving the address and treatment type (i.e., from the results of the bootstrap analysis described above).
5. Lead service lines are removed at a specified rate at the beginning of each simulation year. In the simulation, lead service line addresses are reassigned as CuLS addresses.
   5.1. Addresses are converted from lead service lines to CuLS at random. At the beginning of each simulation year, a random value from a uniform distribution between 0 and 1 is assigned to each lead service line, and the N addresses with the highest random values are converted from a lead service line to a CuLS, where N is the annual replacement rate.
   5.2. Pre-treatment lead concentration for lead service line addresses converted to CuLS are drawn from the appropriate distribution (as described in 2.2). Post-treatment lead concentration for lead service line addresses converted to CuLS are assigned in the same way as for other CuLS addresses (as described in 4.2.2).
6. Lead filter adoption is randomly assigned, based on the lead filter adoption rate (*p*%), to addresses with lead service lines. A random value from a uniform distribution between 0 and 1 is assigned to each address with a lead service line and the *p*% of the addresses with the highest random values are assumed to have an adopted lead filter. The lead concentration for these addresses are reassigned as 1 ppb.
7. The simulation continues for 70 years. Statistics are output for each simulation. Those statistics include median, 75th, 90th, 95th and 99th percentile lead concentrations, the number of addresses with lead concentration exceeding some threshold (typically 15 ppb) and the proportion of addresses exceeding the threshold.

Choices and Assumptions

1. Assume that lead concentrations observed in pipe racks are indicative of worst-case concentrations that could be observed (and ingested) for connections with lead service lines.
2. Assume that distributions fit to first-draw compliance sample data adequately characterize the distribution of lead concentrations for CuLS and other connections and provide a realistic indication of lead concentrations in water that could be ingested (brass fittings and lead solder are closer to taps and lead releases from them are more likely to be caught in a first-draw sample).
   2.1. For addresses with multiple observations, assume that median lead concentration for that address is representative.
3. Assume that reductions in lead observed in immersion studies for CuLS also apply to other materials and real service connections and plumbing.
4. Lead filters are provided to all Denver Water customers with lead service lines and if adopted, the lead filter removes the customers' lead exposure (i.e. lead concentration = 1 ppb at addresses with

lead service lines and adopted lead filters). Lead filters distributed to non- lead service line customers will occur but are not considered in the analysis.

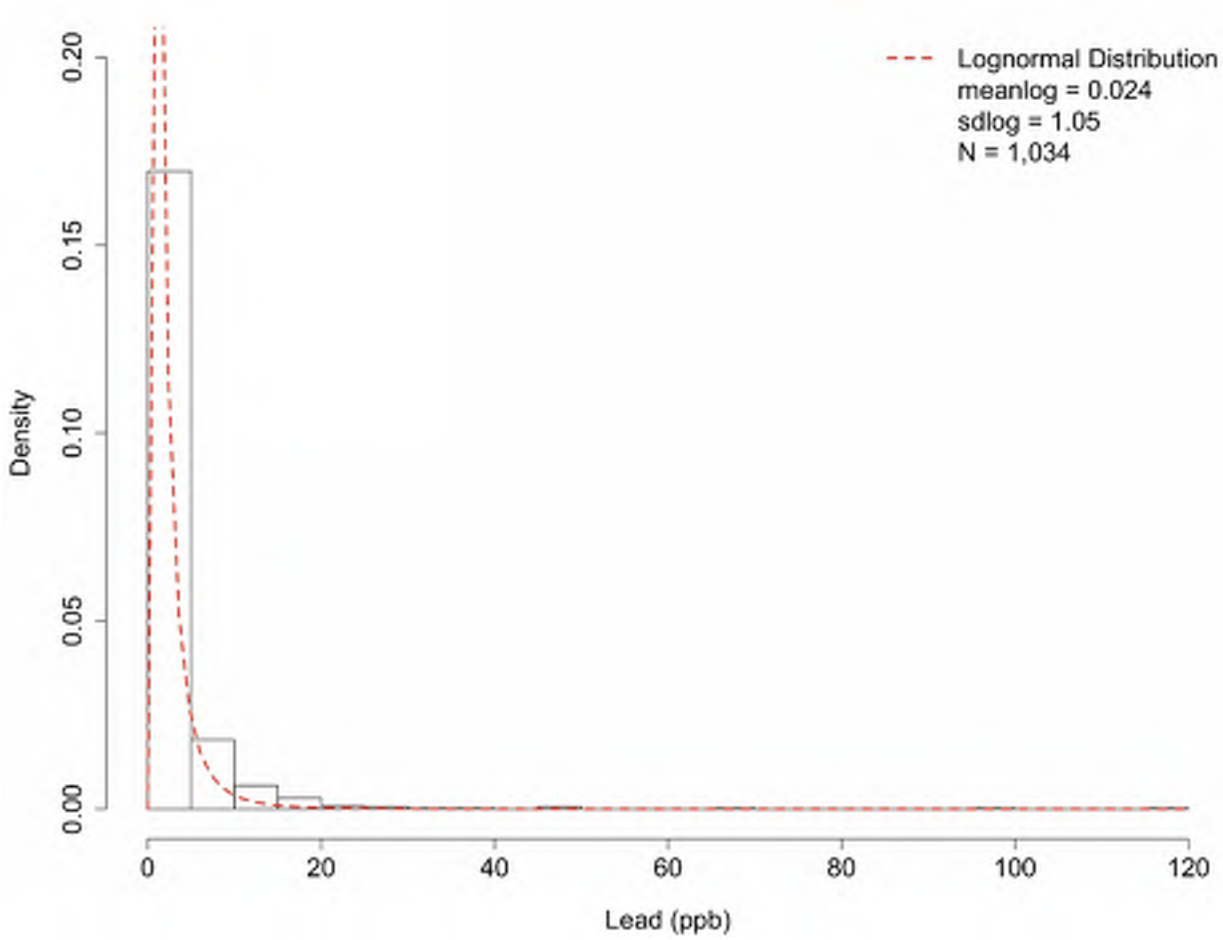
5. Choices:
   5.1. Treatment strategy (none, OP addition, pH adjustment)
   5.2. Lead service line replacement rate (# pipe/year)
   5.3. Lead filter adoption rate (% of addresses where customers adopt lead filter)

Appendix C: Model Input Data Distributions

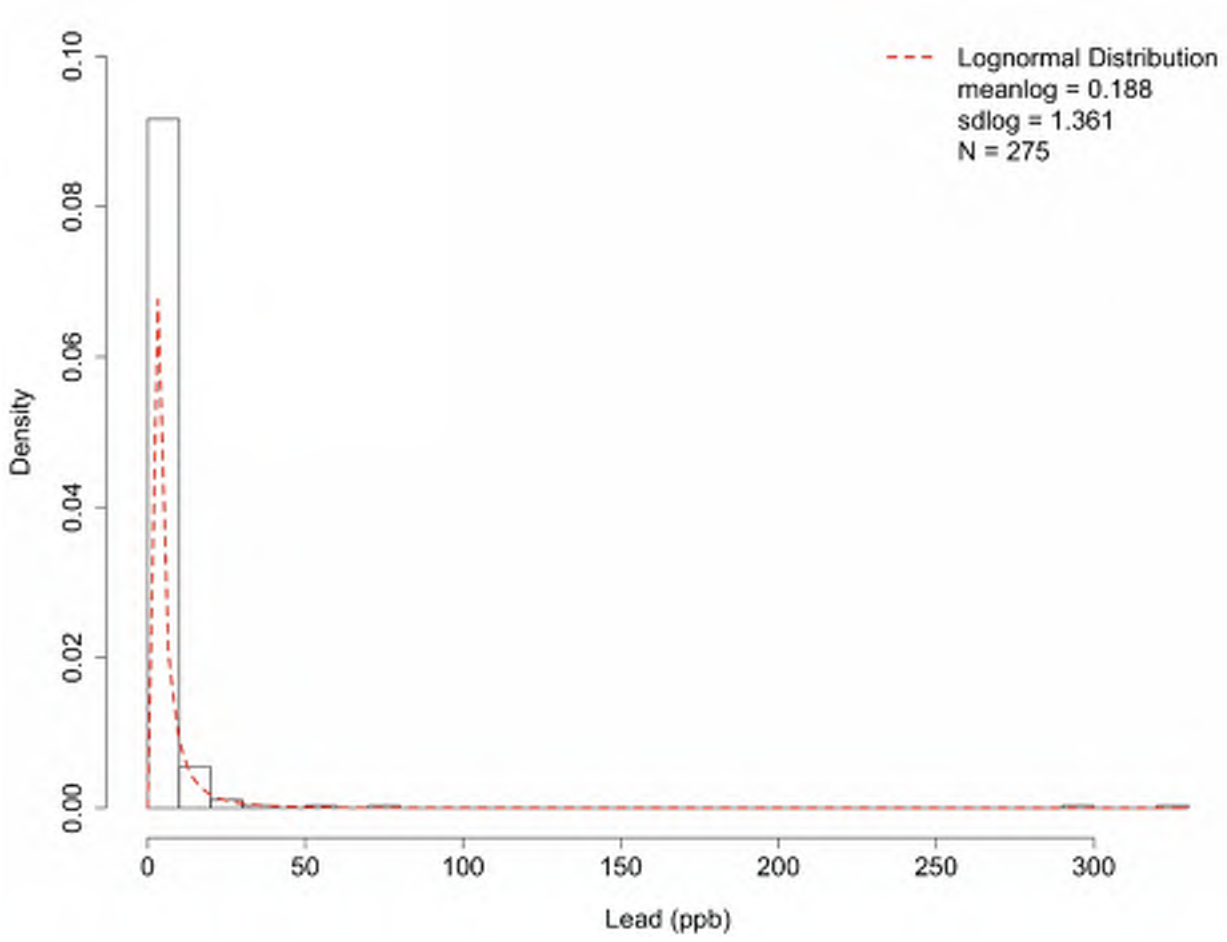
Input Data for CuLS

For CuLS, the model uses lead concentrations drawn from a distribution fitted to the lead concentrations sampled in the distribution system from CuLS. In the LCR data set, there are a total of 2,403 lead concentrations data records for 1,243 addresses over a period from June 2000 through July 2019. A subset of these data was created by taking the median lead concentration for each address. Distributions were fit to the subset of median lead concentrations for each service area (Marston, Moffat or Blend). The following figures show histograms of the median lead concentration data for each address with the best-fit distribution.

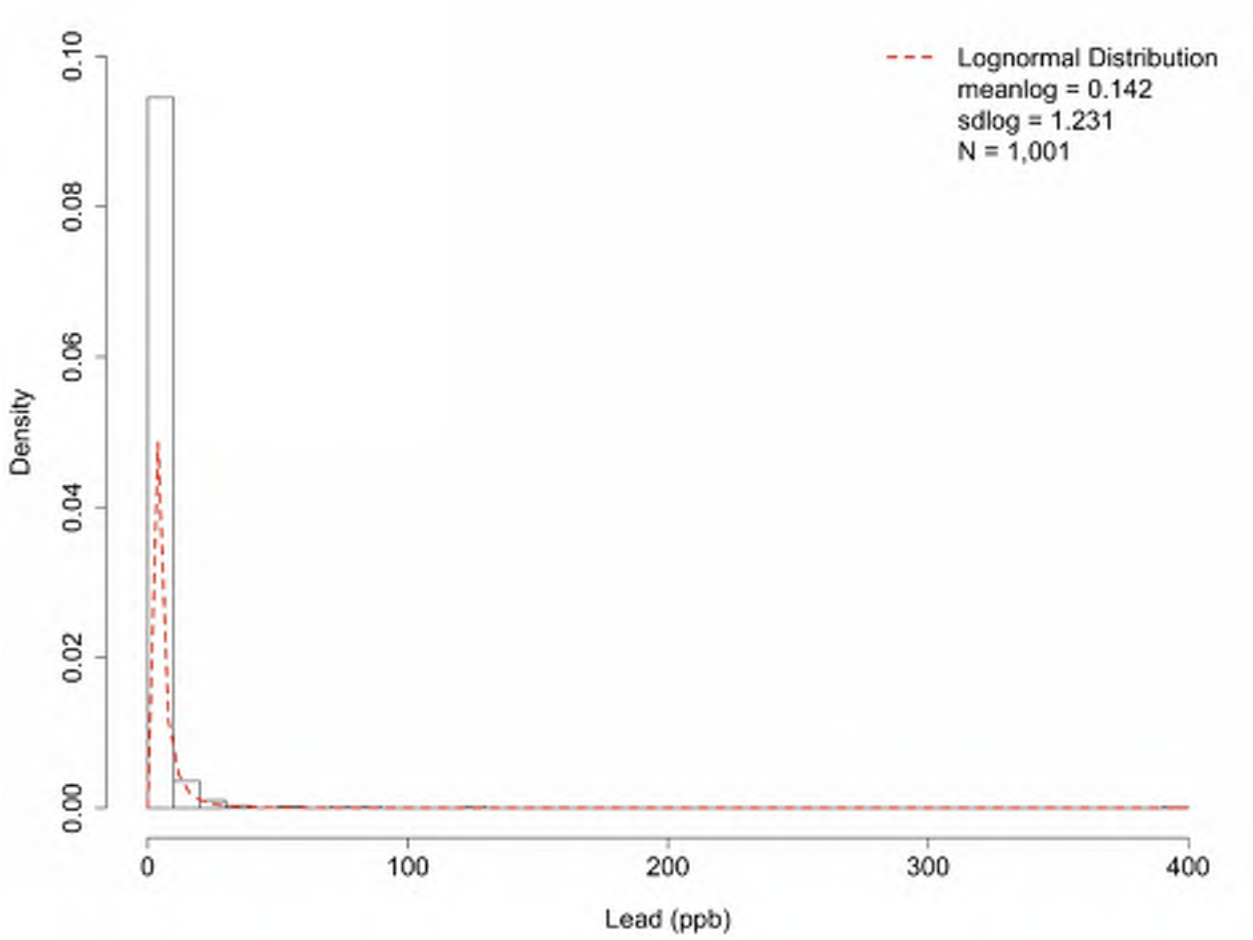
Marston Service Area



Moffat Service Area



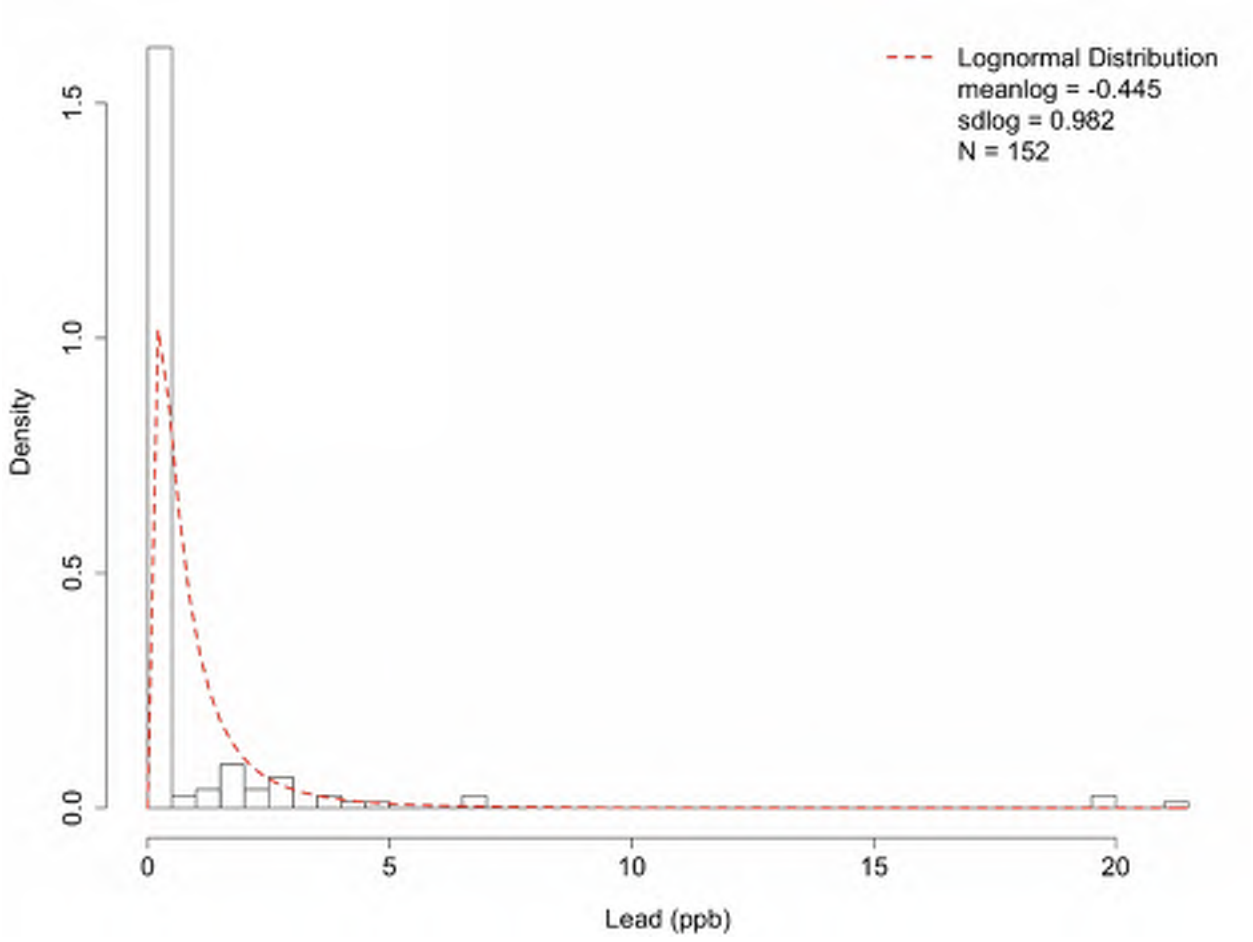
Blend Service Area



Input Data for Other Service Lines

For other service lines, the model uses lead concentrations drawn from a distribution fitted to the lead concentrations sampled in the distribution system from other service lines. In the LCR data set, there are a total of 152 lead concentrations data records for 133 addresses over a period from August 2010 through July 2019. A subset of these data was created by taking the median lead concentration for each address. Distributions were fit to the median lead concentrations for the entire distribution system. Distributions were not fit separately for different service zones (Marston, Moffat, Blend) due to limited data availability. The following figure shows a histogram of the median lead concentration data for each address with the best-fit distribution.

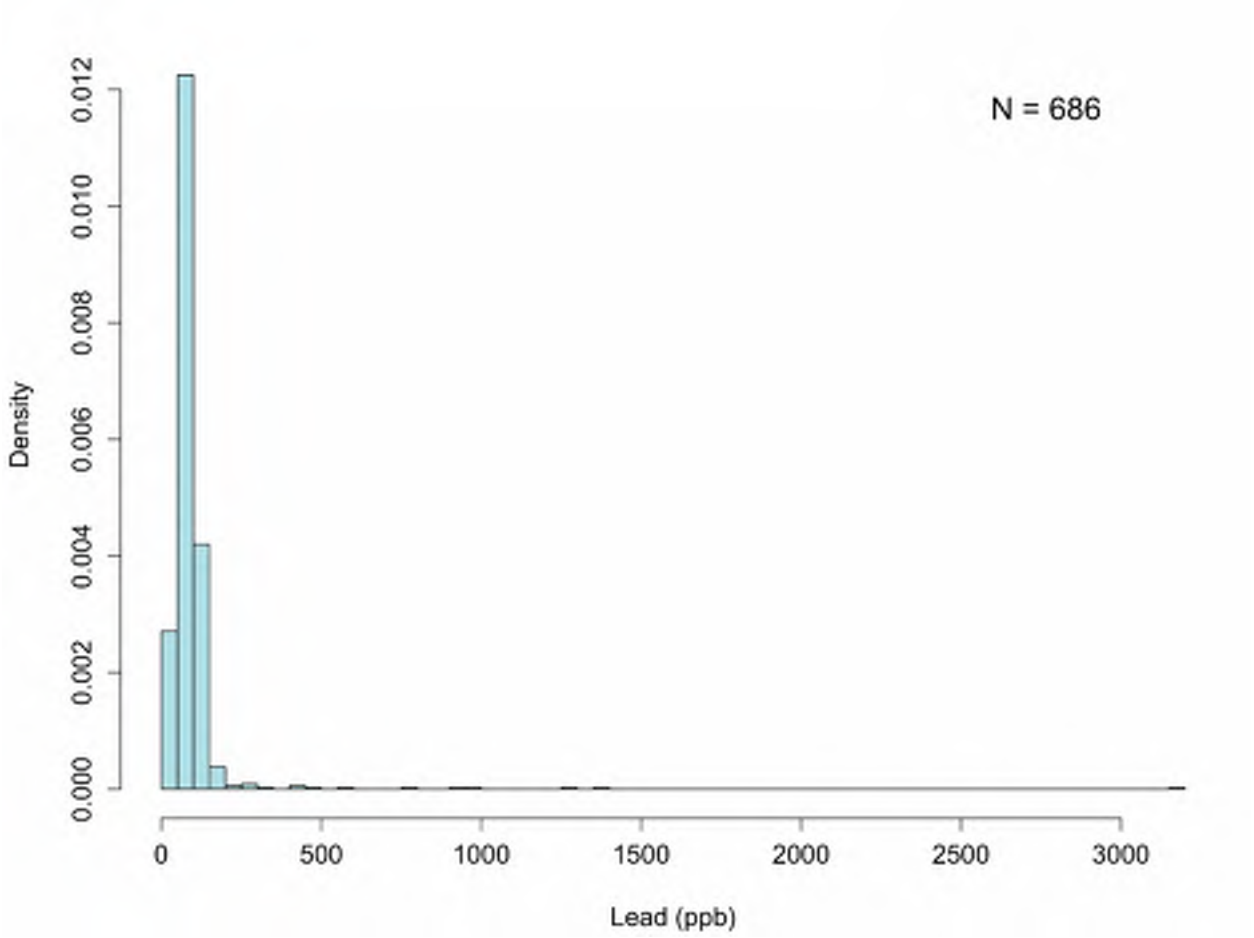
Entire Distribution System



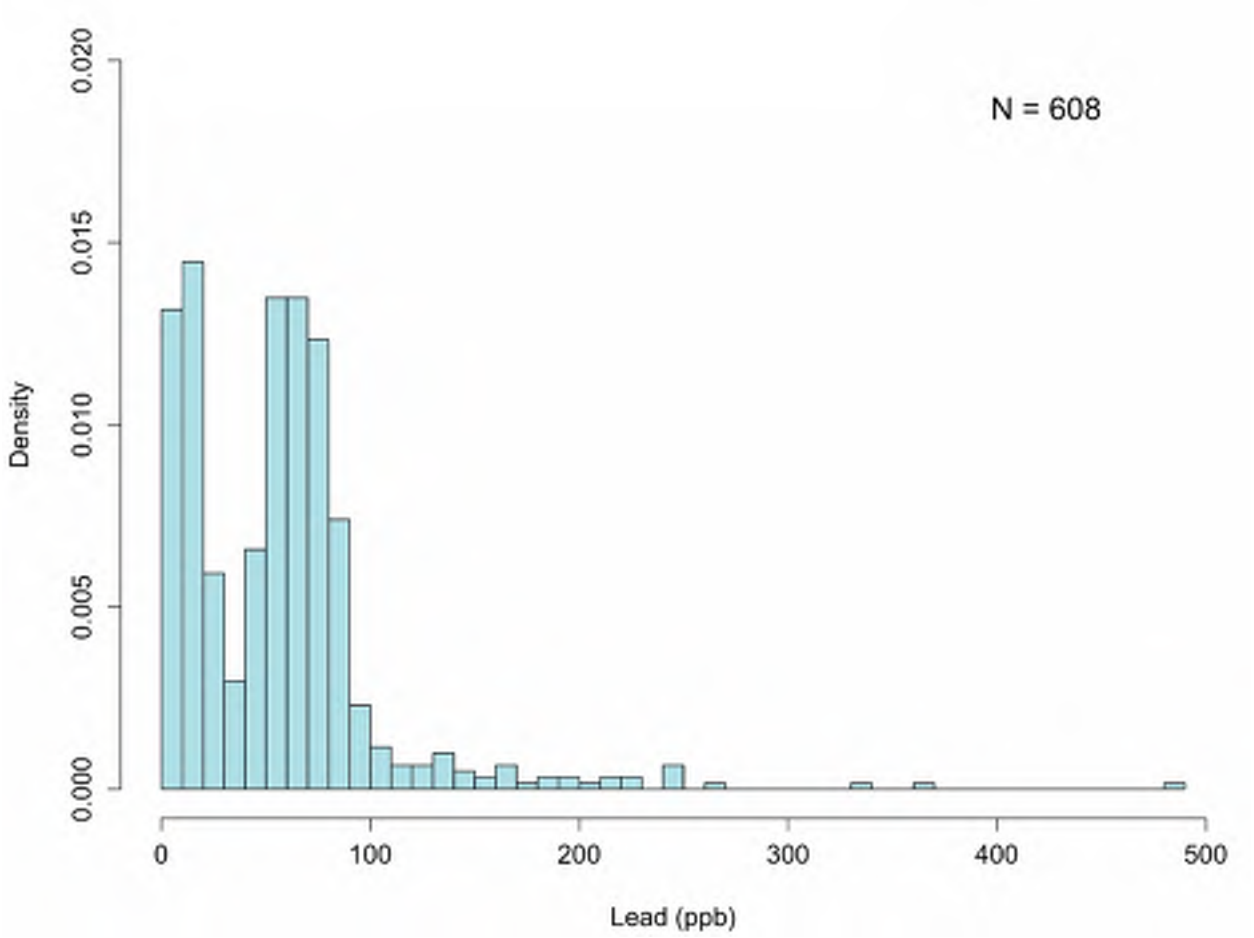
Input Data for Lead Service Lines

For lead service lines, the model uses lead concentration data from the pipe racks. For the first year, prior to the start of treatment, the model uses pipe racks lead concentration data from the Pre-Treatment period for the Control, Orthophosphate, and pH racks. To model lead concentrations after orthophosphate or pH treatment are implemented, the model uses input data from the pipe racks during the Post-Treatment period from the Orthophosphate racks and the pH racks, respectively.

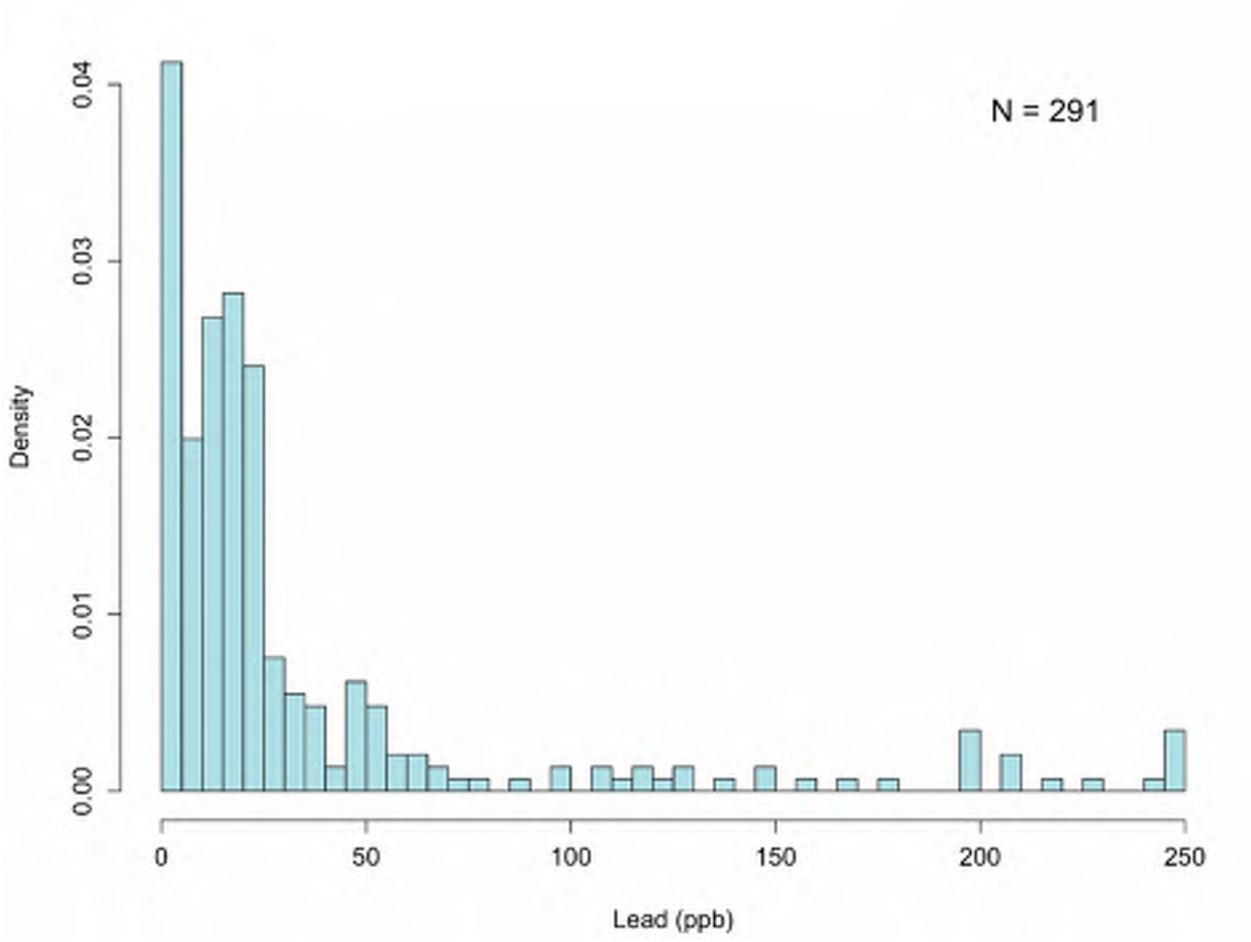
Marston No Treatment (Pre-Treatment):



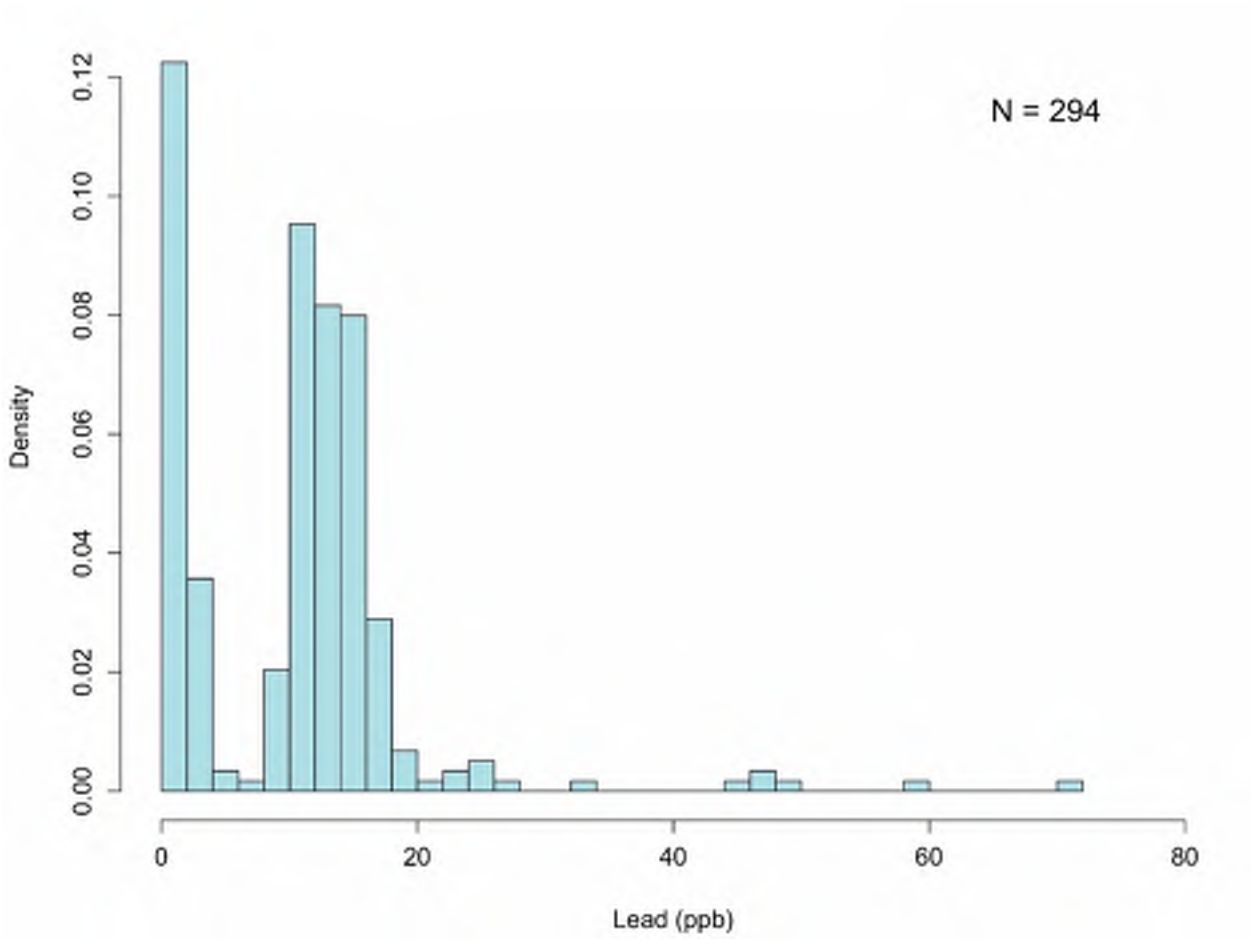
Moffat No Treatment (Pre-Treatment):



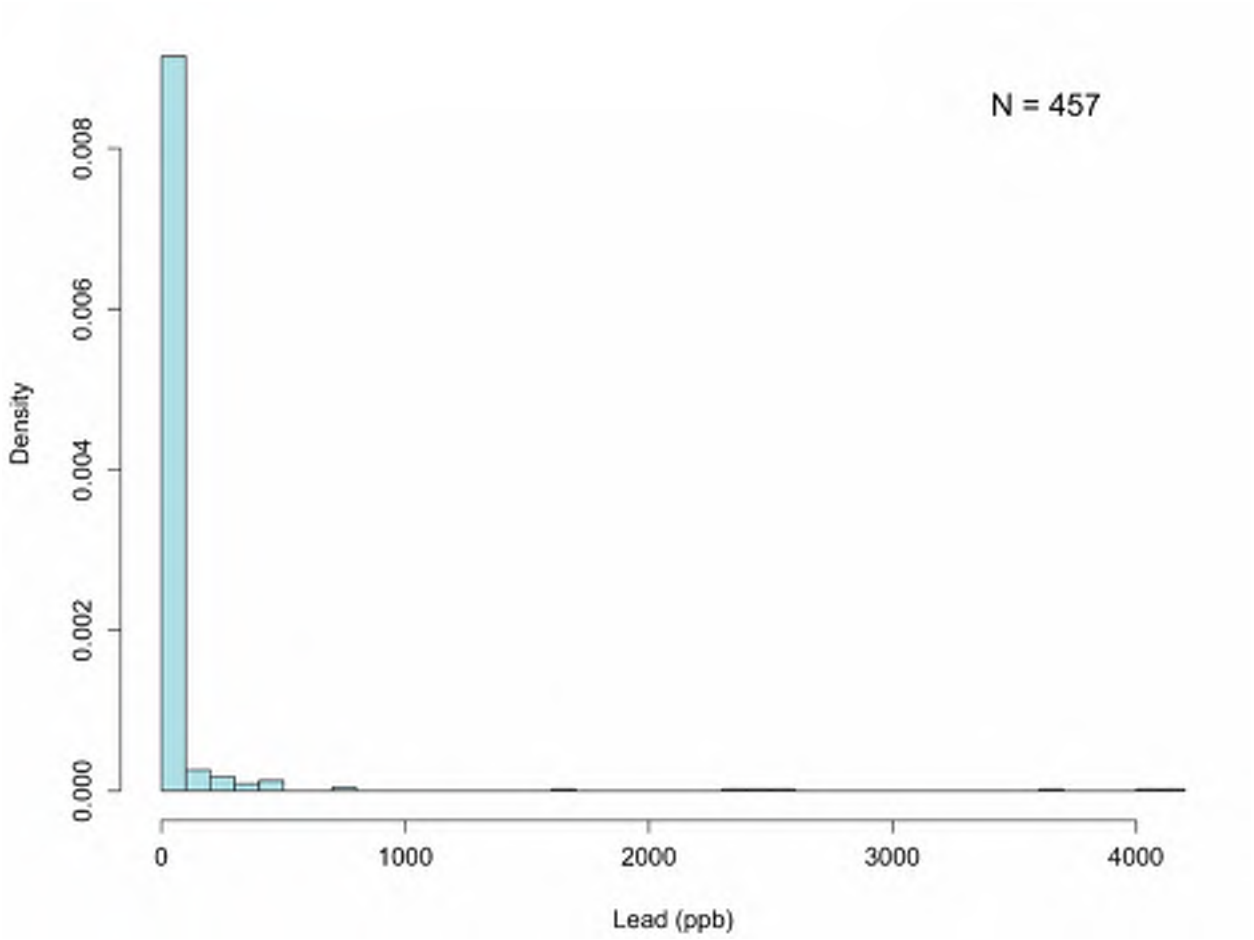
Marston Orthophosphate Treatment:



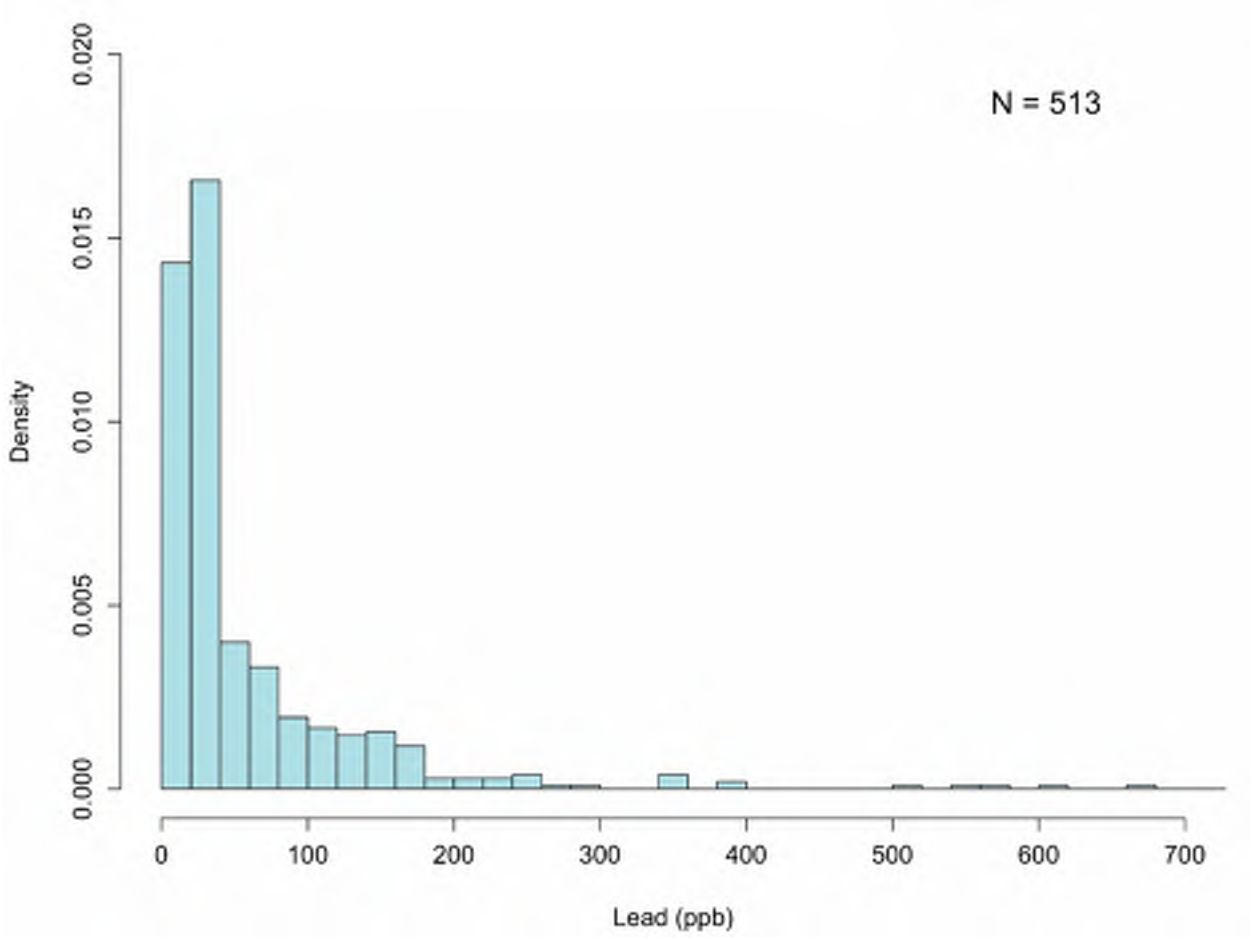
Moffat Orthophosphate Treatment:



Marston pH Treatment:



Moffat pH Treatment:



APPENDIX II.B - LEAD PILOT RESULTS

September 2019

DENVER WATER

Appendix II.B:

Lead Pilot Results

Date: Revised August 16, 2019
May 15, 2019

To: Denver Water

From: Corona Environmental Consulting, LLC

This appendix reports data from the two lead service line pilots located at Marston and Moffat treatment plants. These two sites were chosen to represent the South Platte River and the Fraser River which are the two major water supplies to the Denver Water system. Although the Foothills plant produces the most water, it is also located on the South Platte Supply with very similar water quality to Marston. Detailed information on the design and initial operation of the pilots can be found in Denver Water's "Optimal Corrosion Control Treatment Report," dated September 20, 2017.

The Marston pilot started operation in October of 2015, Moffat in May of 2016 with both plants continuing in operation at the time of this report. Average and ranges of influent water quality parameters over the period of operation are presented in Table 1.

Table 1. Summary of Influent Water Quality.

Parameter	**Marston Influent** Avg. (range)	**Moffat Influent** Avg. (range)
Temperature (°C)	13 (4-25)	12 (5-21)
pH	7.8 (7.4-9.1)	7.8 (7.2-8.3)
Alkalinity (mg/L as $CaCO_3$)	64 (36-83)	39 (14-70)
Calcium (mg/L)	30 (7-41)	16 (1-36)
Magnesium (mg/L)	8.0 (1.7-10.8)	2.9 (0.3-9.2)
Conductivity (µS/cm)	325 (35-450)	152 (92-330)
Total Chlorine (mg/L)	1.34 (0.03-8.00)	1.40 (0.12-1.78)

Each pilot consists of four racks of three whole lead service lines (and one segmented service line not included in sampling). Each pipe is run for three flow and stagnation cycles each day. The flow period is two hours, followed by a 5-hour stagnation period, then a 1-hour sampling period. Feedwater is supplied from the distribution system and piped back to the pilot rigs.

The Rack 1 is the control rack, which has no adjustment to water quality. The Rack 2 tests corrosion control using orthophosphate addition which was started at 3 mg/L as PO_4 and reduced over time. Orthophosphate was dosed as phosphoric acid and the pH was returned to match the existing distribution system of 7.8 with caustic soda. Rack 3 originally tested silicate addition but was later

transitioned to an additional orthophosphate test where the test began at 1 mg/L as PO_4. Only the orthophosphate data are included in this report for Rack 3. Rack 4 uses pH modification for corrosion control. Target pH of 8.8 and 9.2 were tested using caustic soda as the base.

Rack 3 data through April 25, 2019 and Rack 4 data through May 2, 2019 are included. After this date, pilot operation was modified to begin testing other conditions. These tests are currently underway testing low dose orthophosphate at high pH and transitioning from high pH to orthophosphate should it be necessary in the future. Rack 1 and 2 data through July 18, 2019 are included.

Summaries of the lead release for each pilot are shown in Figure 1 and Figure 2. Lead was analyzed by the ICP/MS direct method EPA 200.8 with a minimum reporting level of 1 ppb (µg/L). Each pipe was run for a conditioning period to stabilize operation after the disturbance of harvesting the lead service lines. These are indicated by the "pre-treatment" gray box. Lead removal is calculated by dividing the median lead during treatment by the median lead during the pretreatment period for each pipe. The three pipes on each rack were averaged to get the values used in the summary figures. The only data excluded from the analysis were periods where the operational targets could not be maintained (i.e. the orthophosphate dose or pH were out of range). These are noted as upset periods indicated with gray rectangles and are discussed in further detail later.

Both plots show that orthophosphate and high pH reduce lead release, with orthophosphate performing better for lead control. An orthophosphate dose of 2 mg/L appears to be equal in performance to 3 mg/L, assuming dosing starts at 3 mg/L. See Corona Technical Memorandum "Reducing Orthophosphate Dose from 3 mg/L to 2 mg/L does not Result in Increased Lead Release in Denver Water Pilot Study" dated 5/24/2019 for additional information. While testing continues, an orthophosphate dose of 1 mg/L does not appear to result in equivalent reduction.

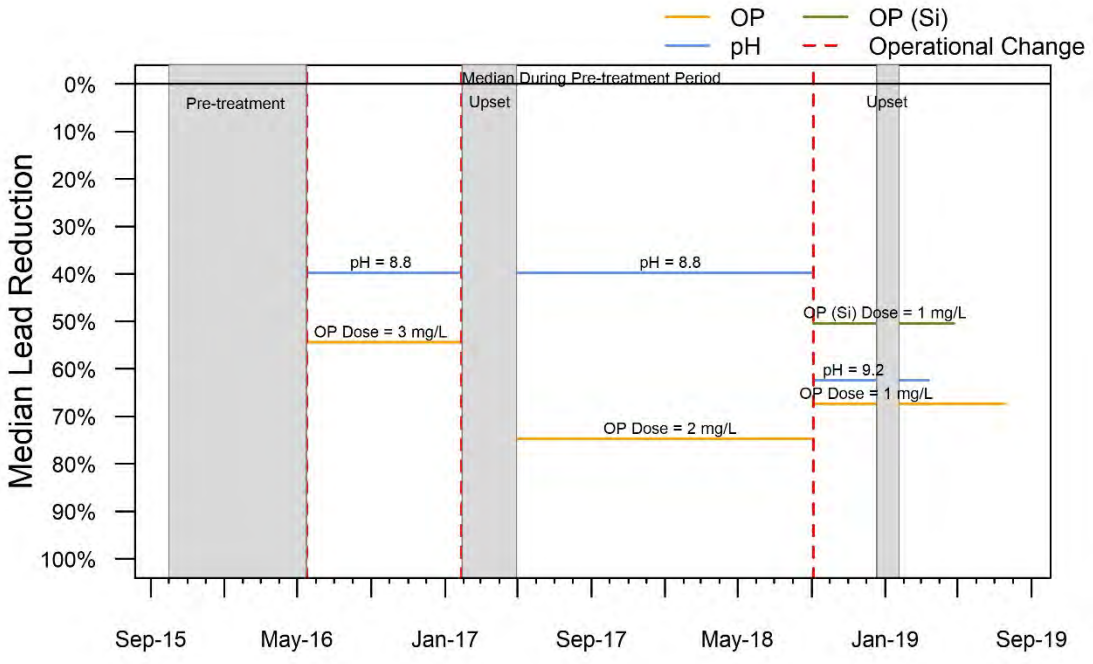


Figure 1: Marston Pilot Summary of Lead Reduction (orthophosphate doses shown measured as PO_4)

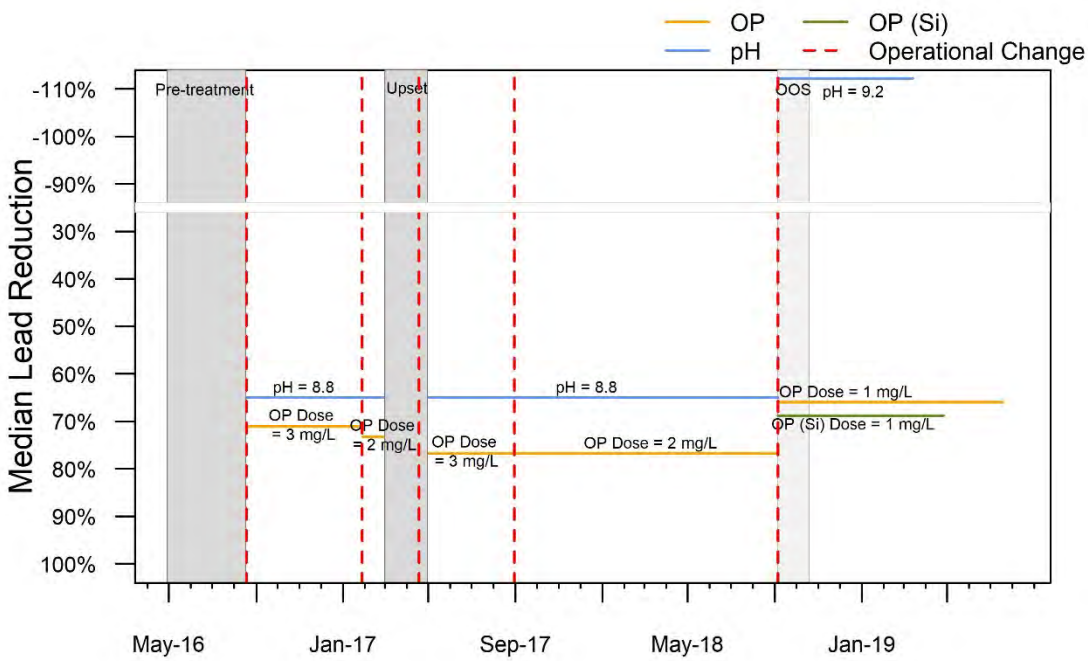


Figure 2: Moffat Pilot Summary of Lead Reduction (orthophosphate doses shown measured as PO_4)

Time series plots of lead release for all treatment conditions for both pilots are shown in Figure 3 through Figure 12. These plots include all data as distinct points with the y-axis in a log scale for lead concentrations to display all the data and demonstrate the pipe-to-pipe variability. Where appropriate, target orthophosphate dose and target pH are shown with a dashed red line.

The Marston pre-treatment period is shown with a gray rectangle in Figure 3 through Figure 7; during this time no chemical was being added. For the orthophosphate racks, shown in Figure 4 and Figure 5, the orthophosphate dose was started at 3 mg/L and stepped down to 2 mg/L then 1 mg/L. The dose was stepped down to determine whether a lower dose provided equivalent corrosion control to the 3 mg/L dose. The former silica orthophosphate racks stepped directly from no orthophosphate to a dose of 1 mg/L. This condition was selected to determine whether starting with a high dose and lowering the dose was equivalent to starting with a lower dose. The pH racks, shown in Figure 6 and Figure 7, ran with a pH setpoint of 8.8 and increased the setpoint to 9.2. The pH was increased to see whether a higher setpoint would provide further corrosion control.

Marston experienced two upset periods, shown with gray rectangles. Both upsets caused increased lead release. Both upsets were due to several minor electrical faults that prevented the pilot from running correctly as scheduled. As shown in the plots, many of the pipes have not returned to pre-upset conditions. This is especially true for pH pipe 4.

Figure 5 shows the orthophosphate measured in the sample after stagnation. This may not be representative of the applied dose early in the test where pipe scales are forming and consuming some phosphate. Overall, the orthophosphate results indicate it was fed consistently and accurately after the initial range finding. Figure 7 shows the measured pH in the sample after stagnation. Results indicate a drop in pH of about 0.3 units over the stagnation period.

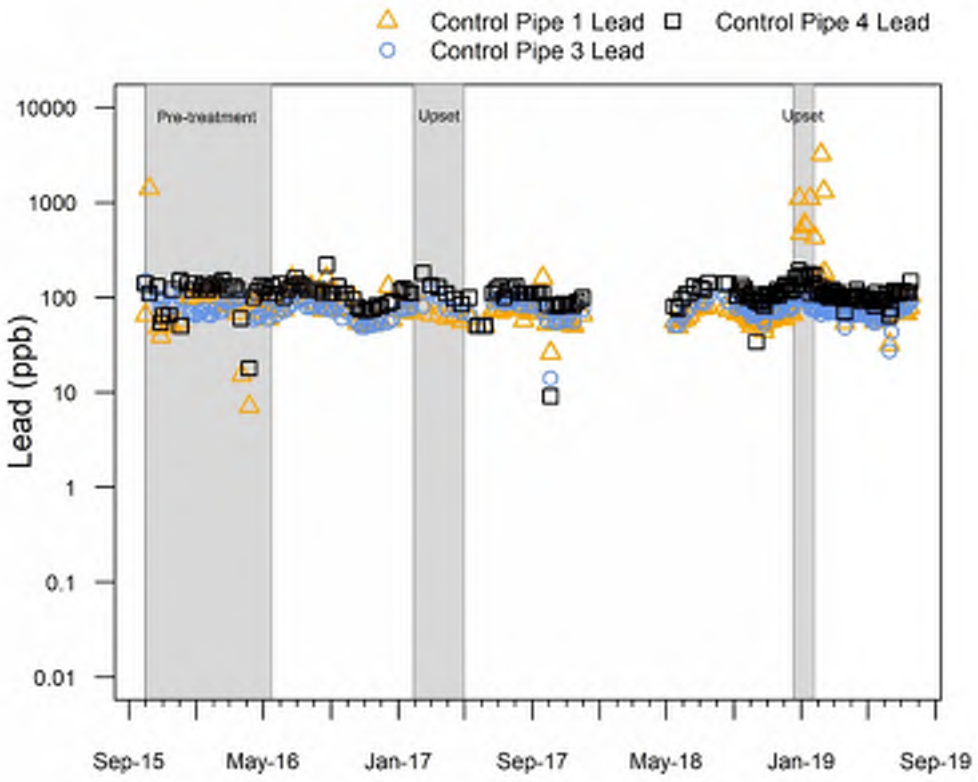


Figure 3: Marston Control Rack - Lead

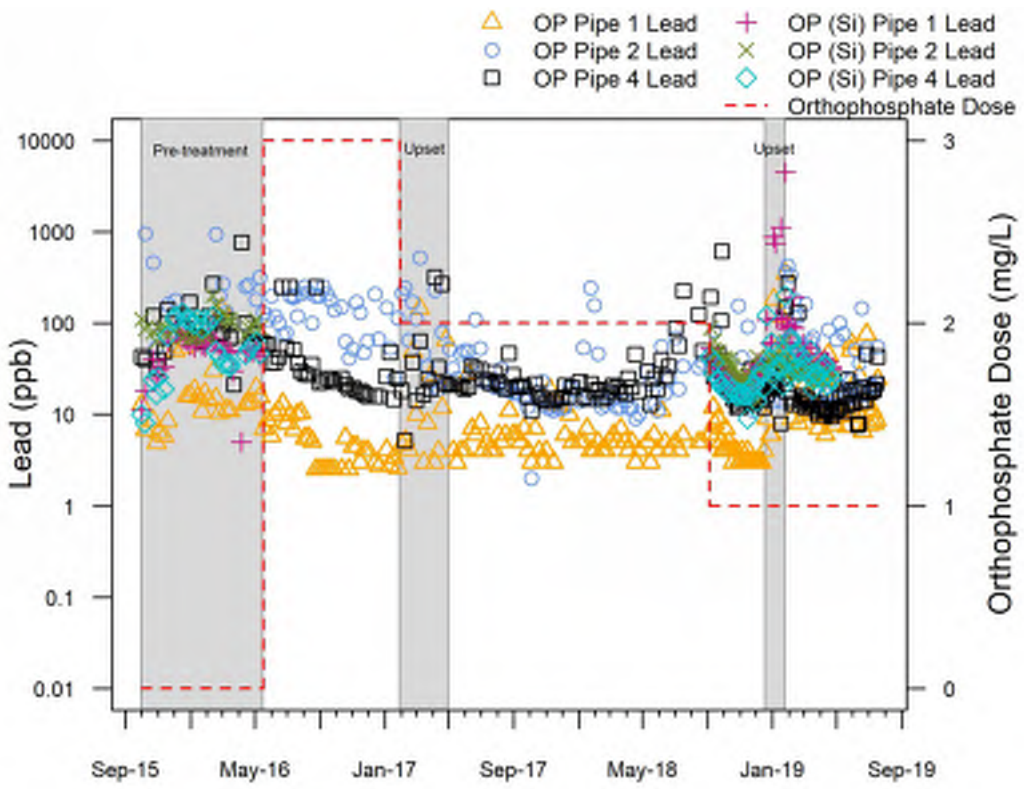


Figure 4: Marston Orthophosphate Racks - Lead

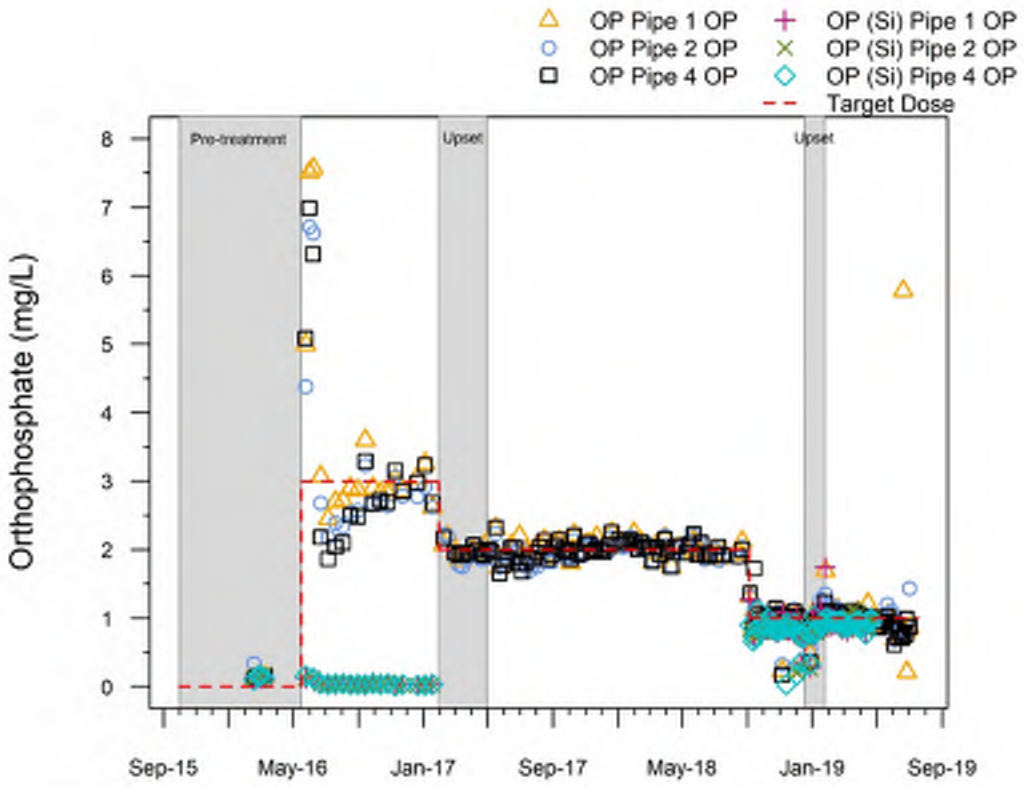


Figure 5: Marston Orthophosphate Racks - Orthophosphate Target Dose and Measured Residual

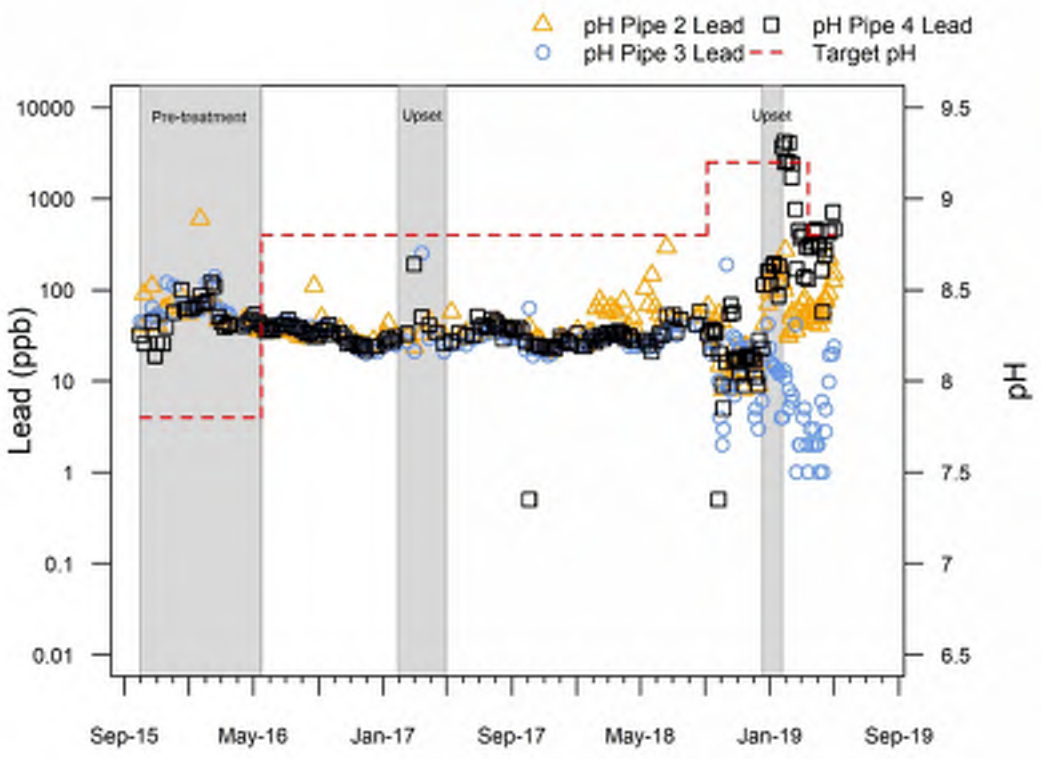


Figure 6: Marston pH Rack - Lead

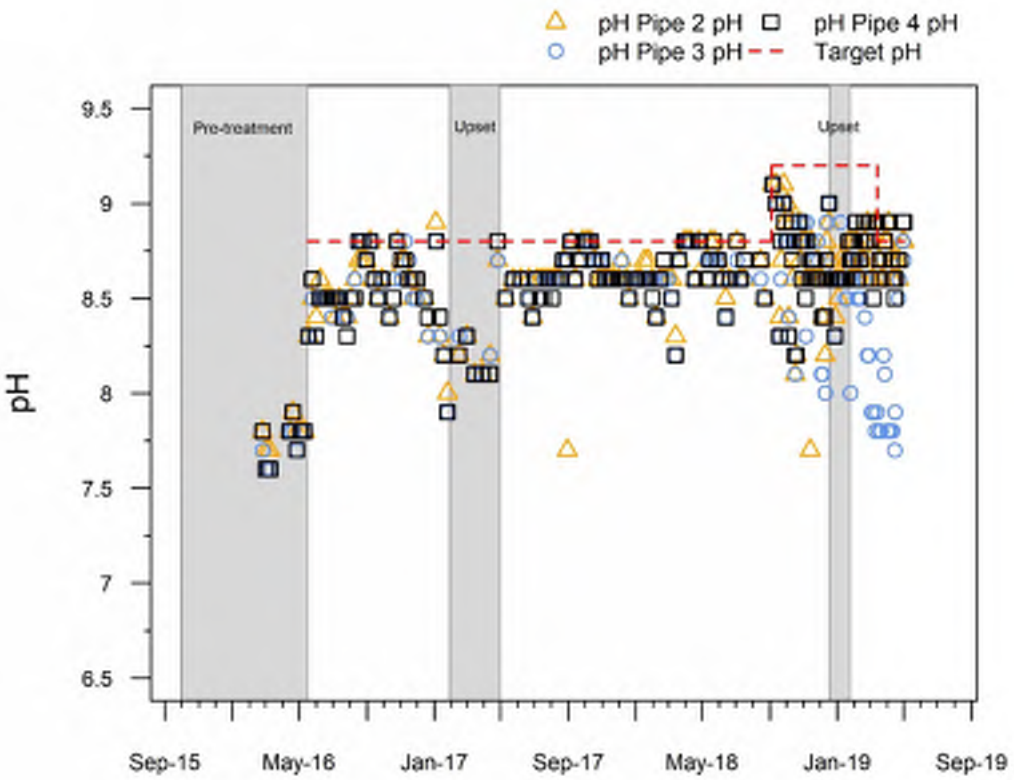


Figure 7: Marston pH Rack – pH Measured Post-stagnation

The Moffat pretreatment period is shown with a gray rectangle in Figure 8 through Figure 12. For the orthophosphate rack, dose was stepped down in a similar manner to Marston. The former silica rack and the pH rack were both controlled the same as Marston. Moffat experienced one upset due to a series of pump failures that resulted in the target conditions not being met. The orthophosphate dose was increased back to 3 mg/L to help stabilize lead release. A second area is highlighted in a light gray box when the Moffat plant was out of service. During this time, the pilot was being fed a water from the distribution fed by the Marston plant. The change in water quality caused a large response in lead release. All pipes (including the controls) saw an increase in lead release during the out of service period and some maintained the higher levels when the out of service period ended. Pipe 1 in the pH rack was affected most drastically. Because all operational parameters were maintained during this period and this is a normal occurrence, these data were included in the analysis.

Figure 10 shows the orthophosphate measured in the sample after stagnation. Like the Marston pilot, the orthophosphate results indicate it was fed consistently and accurately after the initial range finding. Figure 12 shows the measured pH in the sample after stagnation. Results also show some drift in pH but pH was more stable than at Marston.

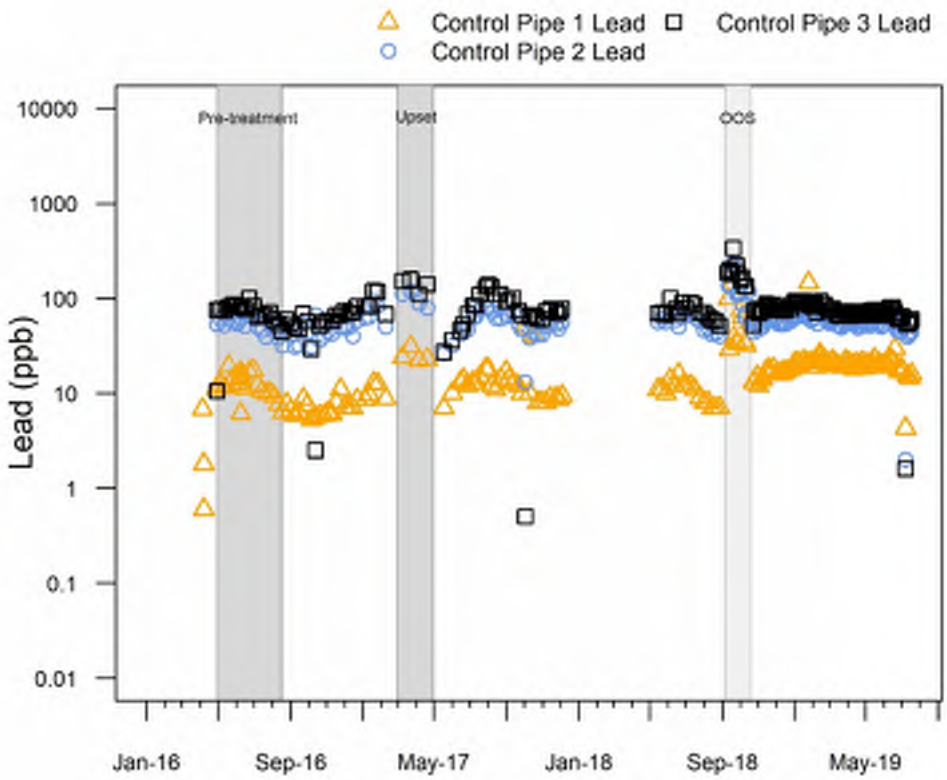


Figure 8: Moffat Control Rack - Lead

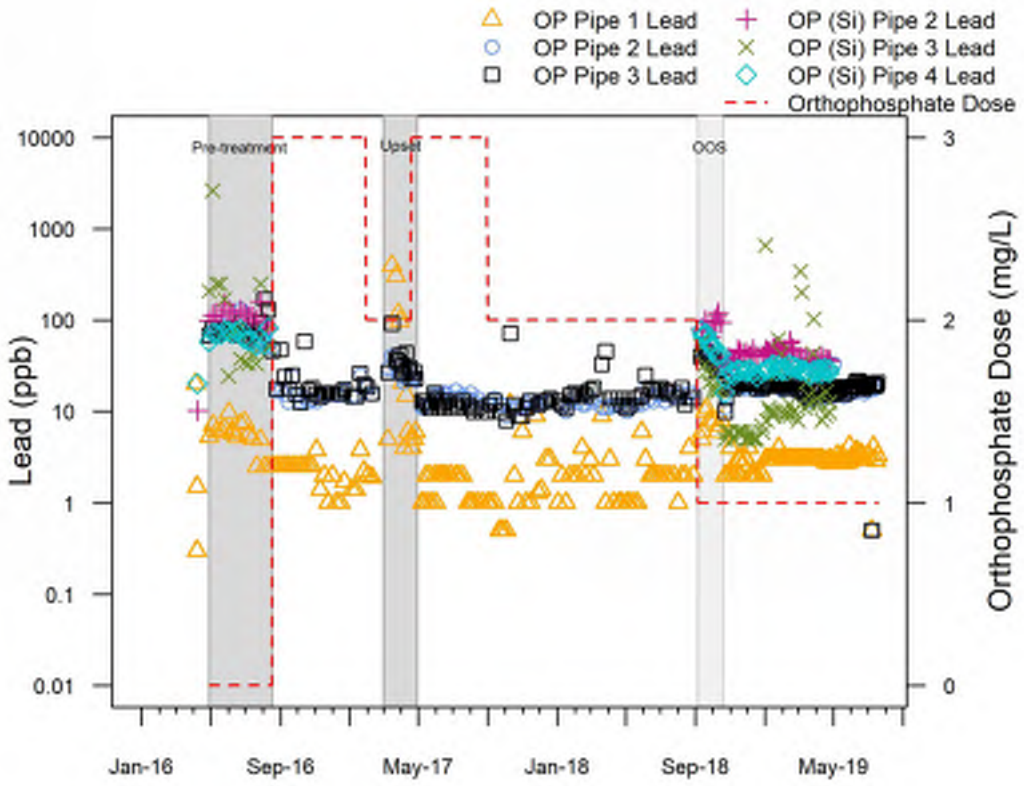


Figure 9: Moffat Orthophosphate Racks - Lead

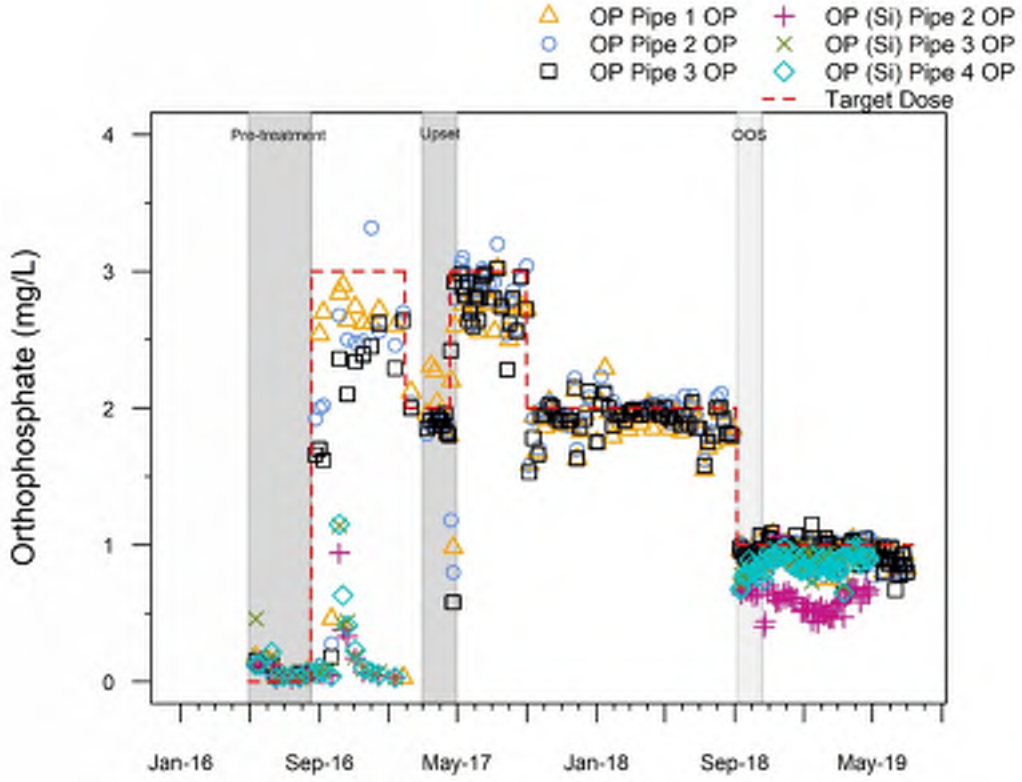


Figure 10: Moffat Orthophosphate Racks - Orthophosphate Target Dose and Measured Residual

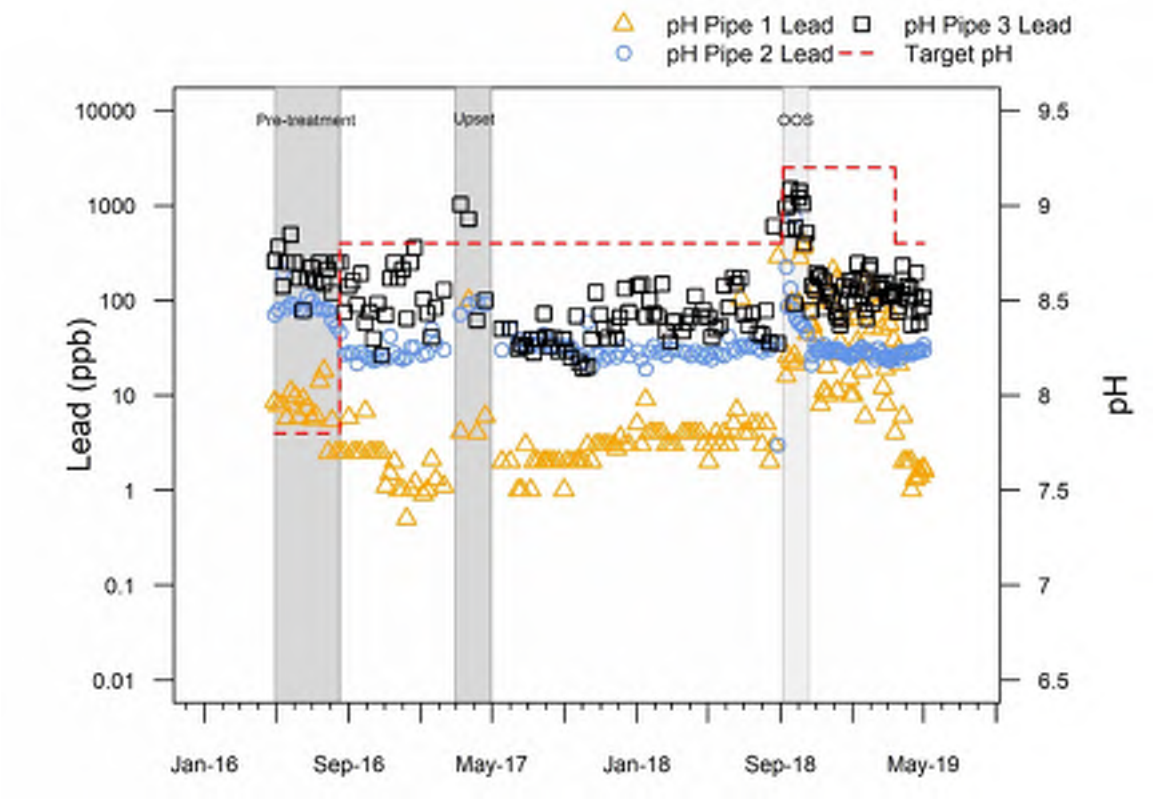


Figure 11: Moffat pH Rack - Lead

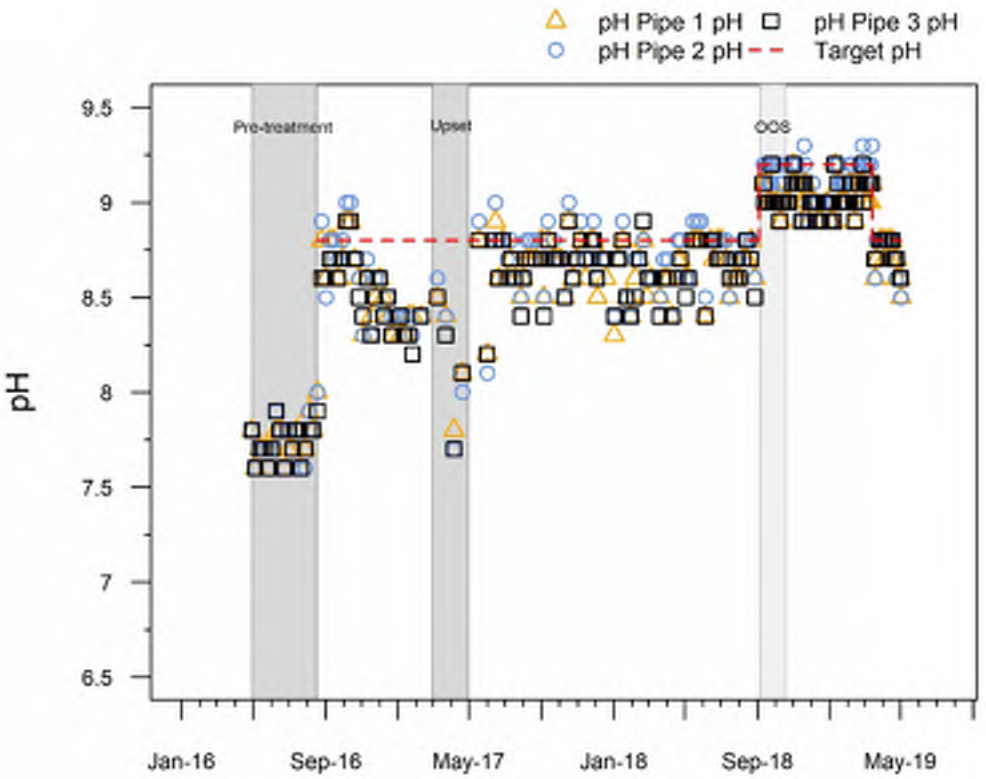


Figure 12: Moffat pH Rack – pH Measured Post-Stagnation

Box plots of lead release under the different treatment conditions are shown in Figure 13 through Figure 24. The quartiles are shown with horizontal lines; the mean is shown with a diamond. The whiskers represent the 5th and 95th percentile. Dots outside the whiskers show individual data points outside this range. The counts for each range of data are shown below the box. All plots use the same y-axis range of 0 to 250 µg/L. Because of high measurements, not all data are shown. Each treatment condition has a matching control box plot. All control box plots use the same data, but the data are split across the different boxes to match the times at which the corresponding treatment conditions were varied. For example, Figure 13 shows the control rack behavior when the OP rack was at 3 mg/L, 2 mg/L, and 1 mg/L.

The box plots are also divided by individual pipe, each shown in a separate pane, which shows the variability in lead release between different pipes under the same conditions. For example, as shown in Figure 14, OP Pipe 1 has always had low lead release in comparison to the other pipes in the pilot, even during pretreatment. Therefore, plotting individual pipes allows comparison of treatment conditions to pretreatment lead release, with each treatment condition shown as a separate box plot. The matching control plots are shown to account for the variability in pilot feed water affecting lead release.

The upset periods were removed from the calculations for all box plots because target operational conditions were not maintained.

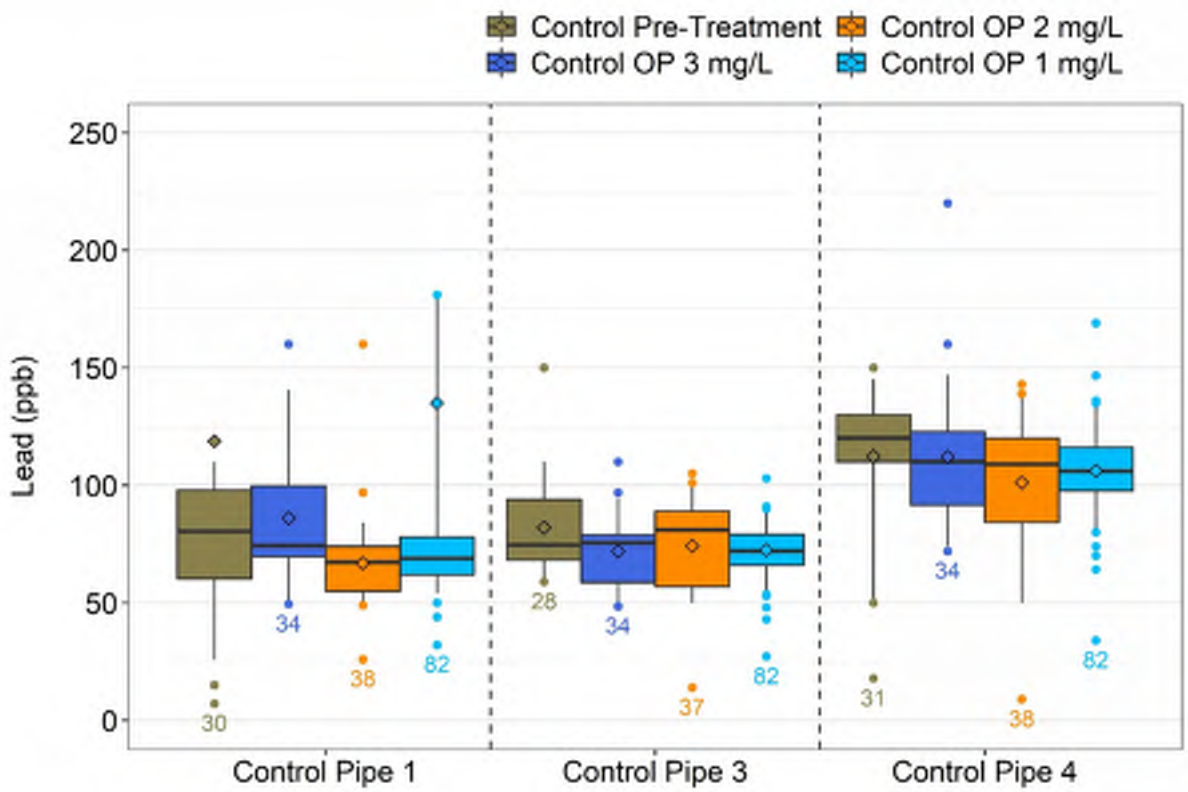


Figure 13: Marston Control Rack - Matching Orthophosphate Operation

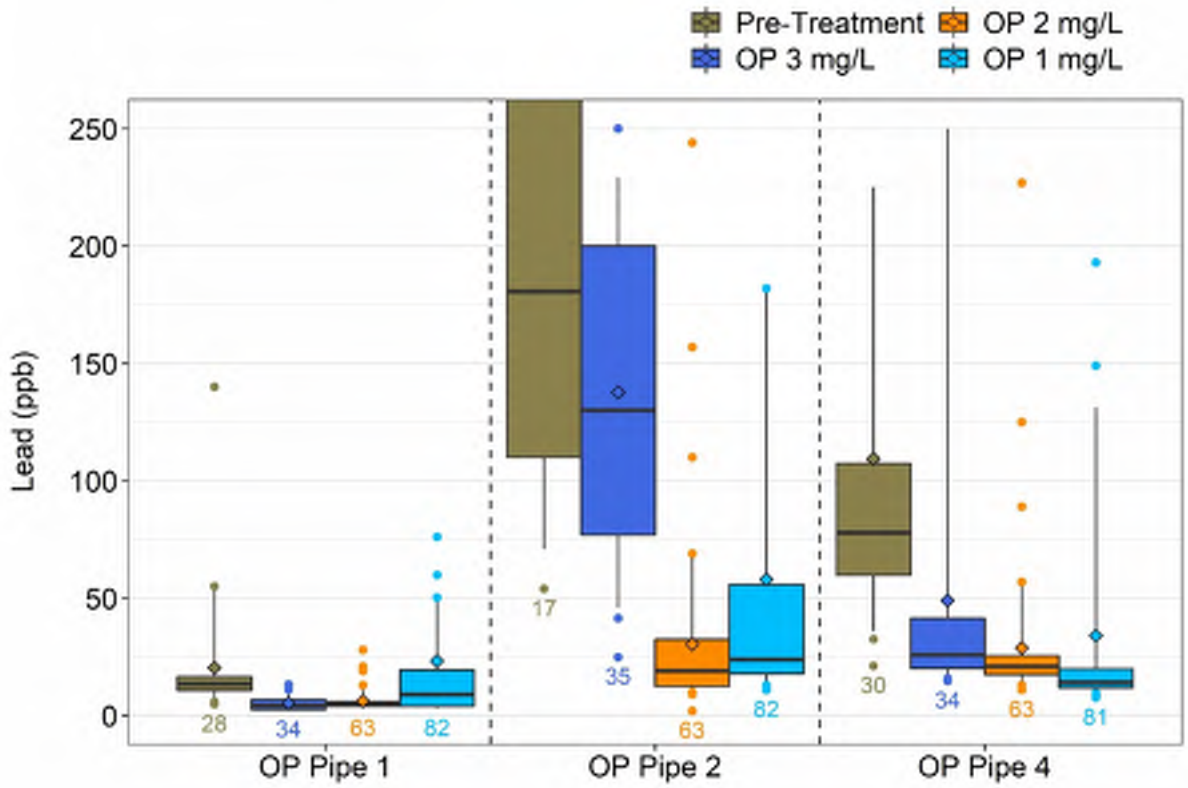


Figure 14: Marston Orthophosphate Doses Tested

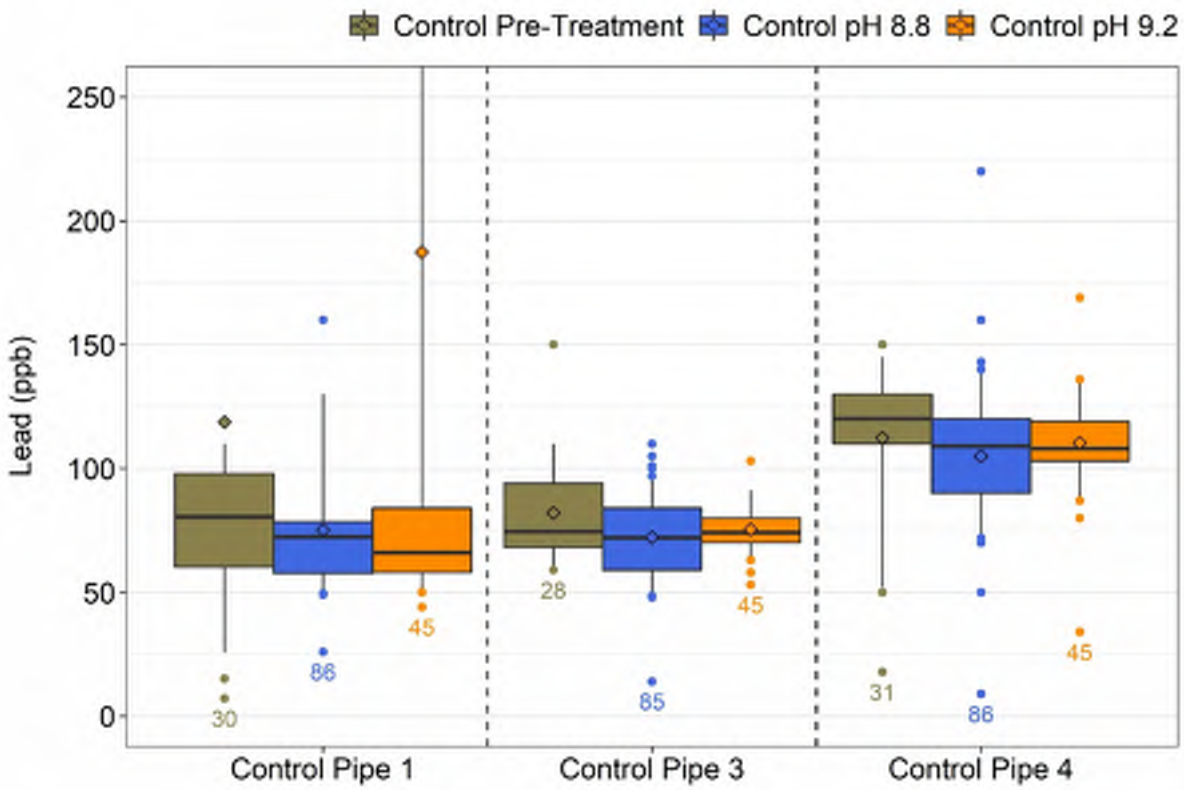


Figure 15: Marston Control Rack - Matching pH Rack Operation

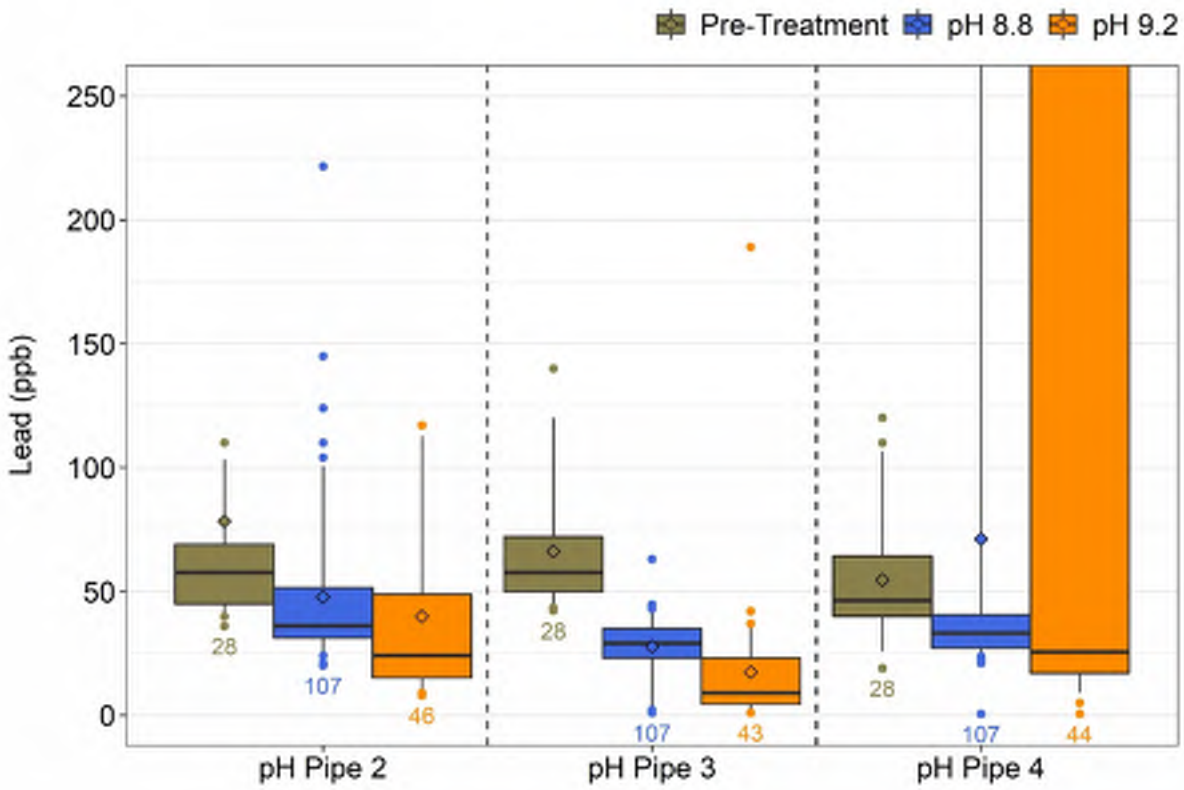


Figure 16: Marston pH Rack Conditions Tested

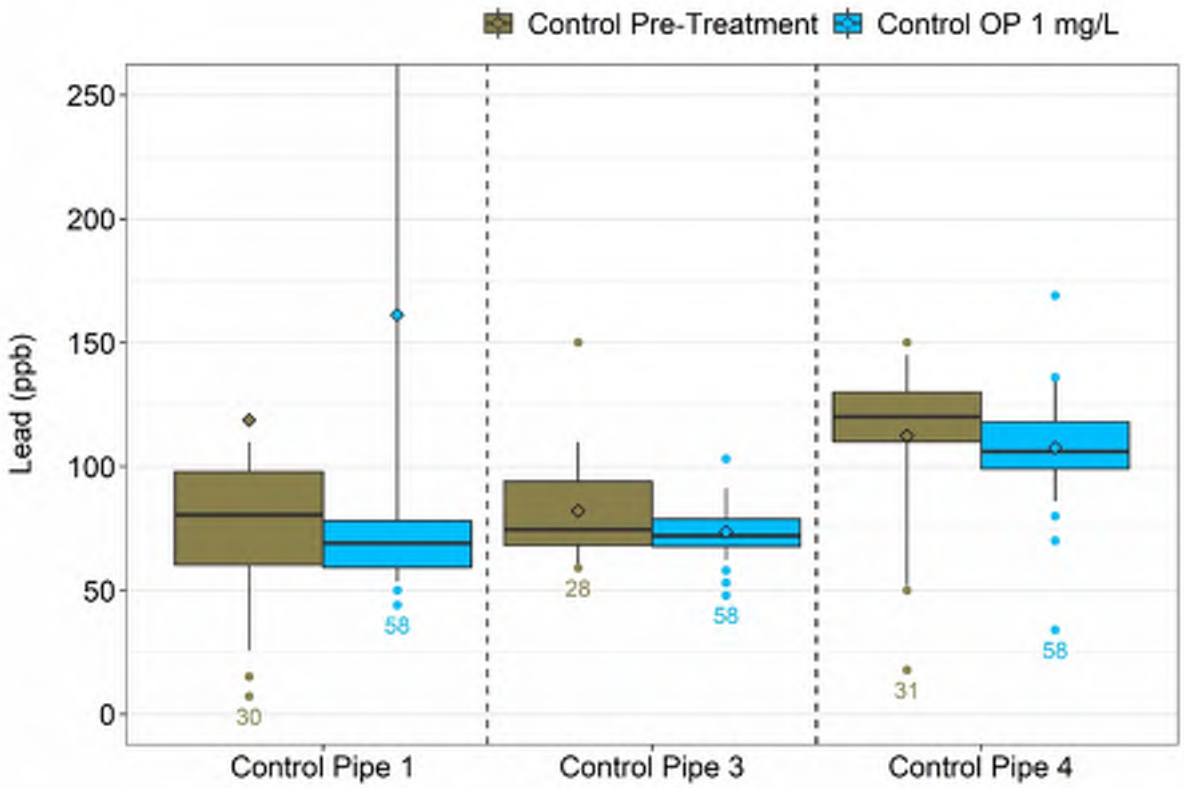


Figure 17: Marston Control Rack - Matching (Si) OP Rack Operation

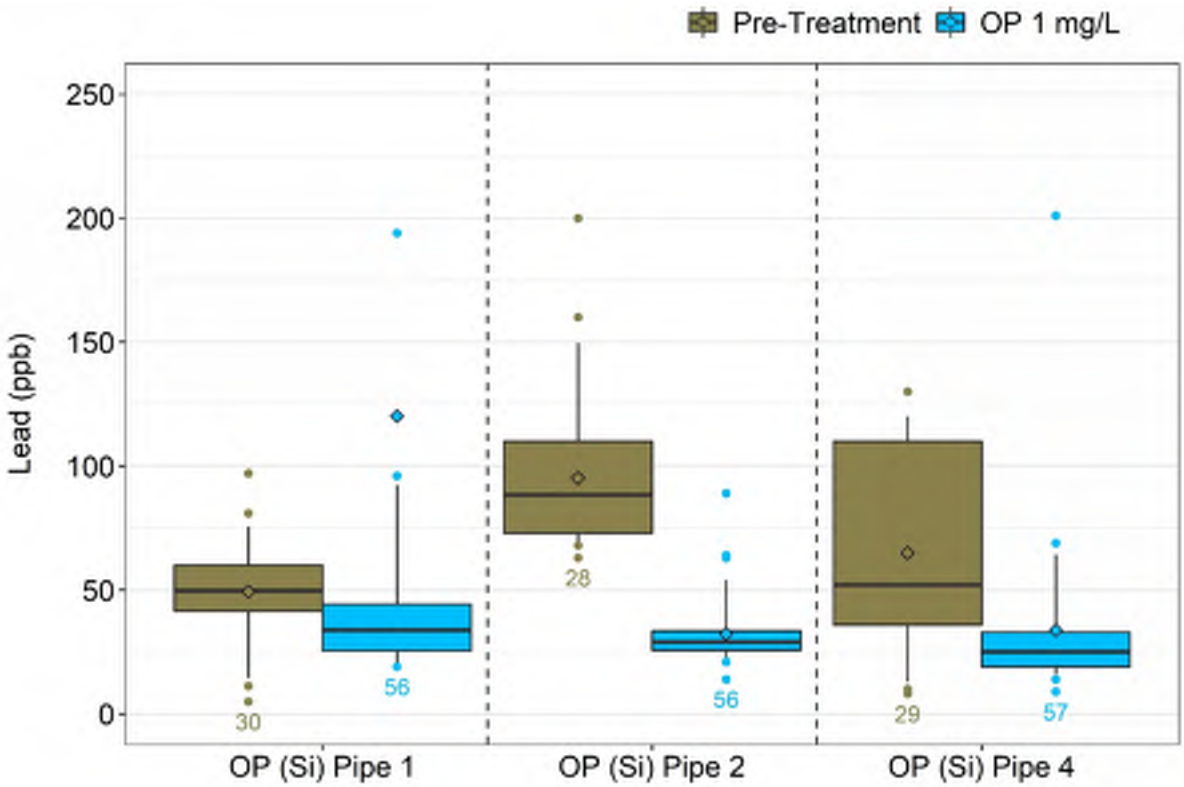


Figure 18: Marston (Si) Orthophosphate Rack Testing Going Directly to a Low Dose

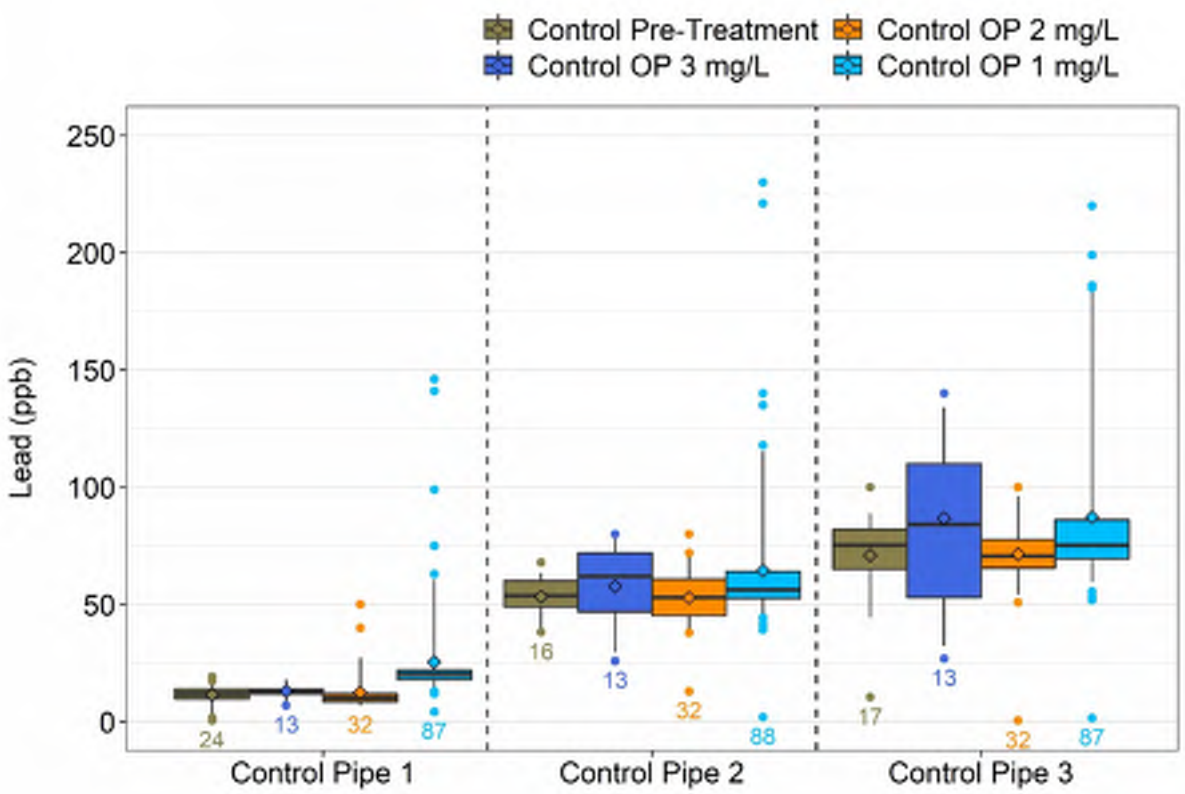


Figure 19: Moffat Control Rack - Matching Orthophosphate Rack Conditions

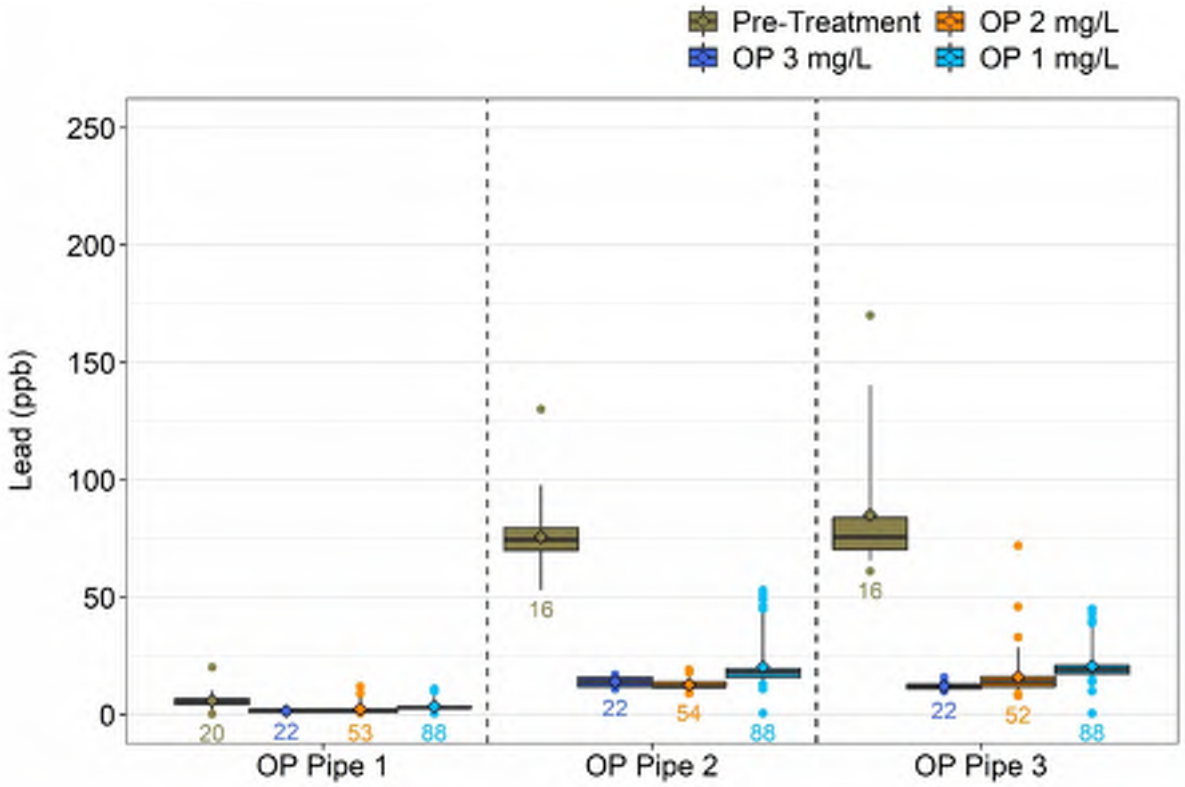


Figure 20: Moffat Orthophosphate Rack Doses Tested

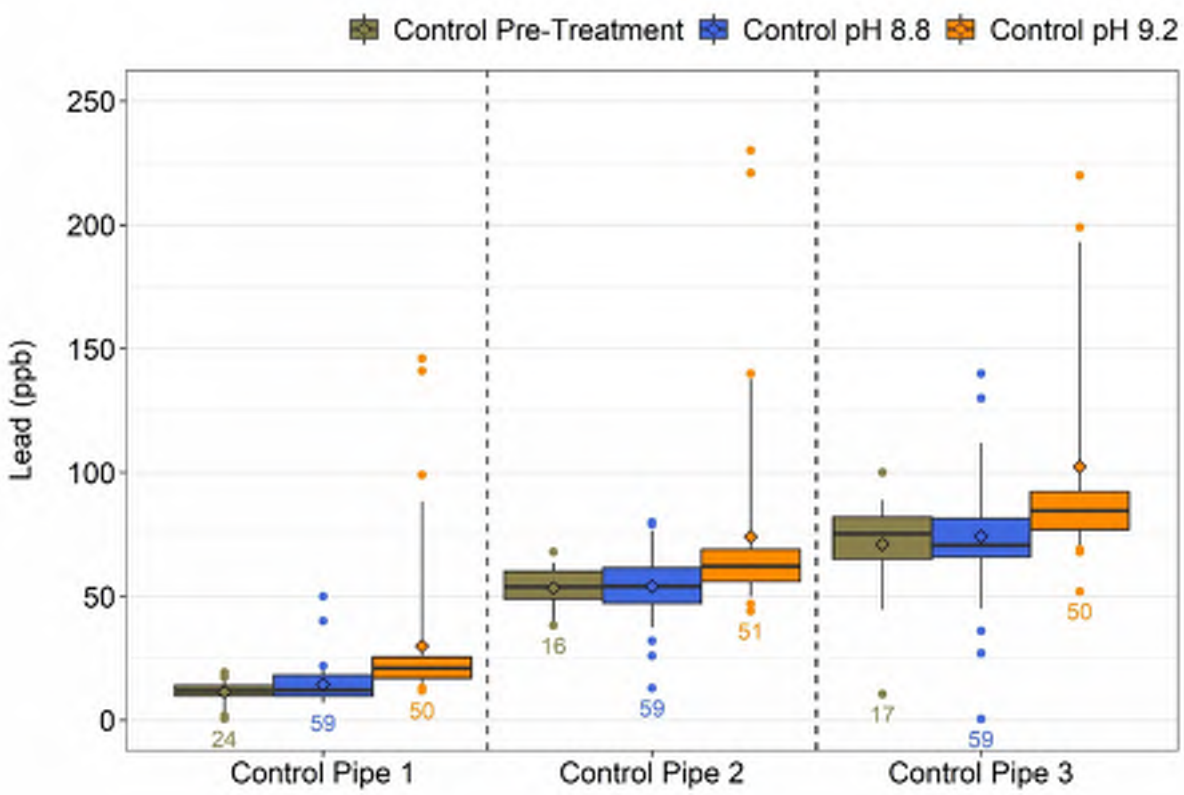


Figure 21: Moffat Control Rack - Matching pH Rack Conditions

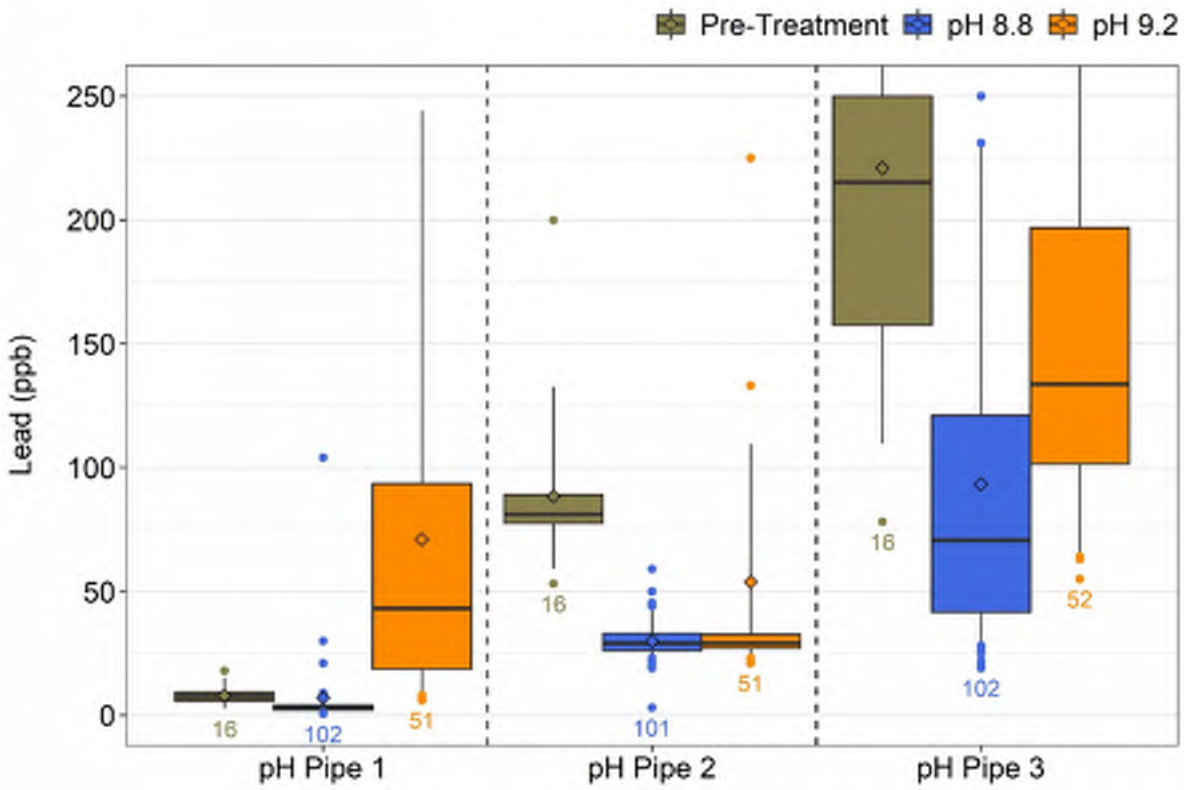


Figure 22: Moffat pH Rack Conditions Tested

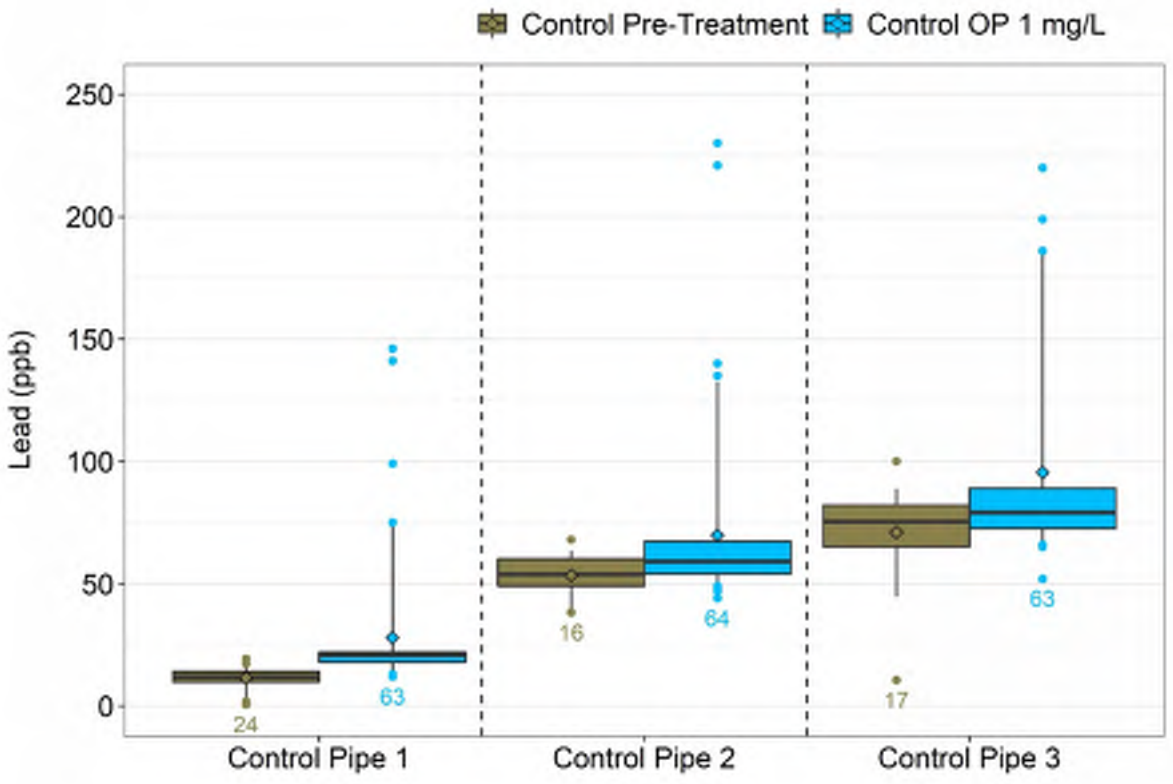


Figure 23: Moffat Control Rack - Matching (Si) Orthophosphate Rack Conditions

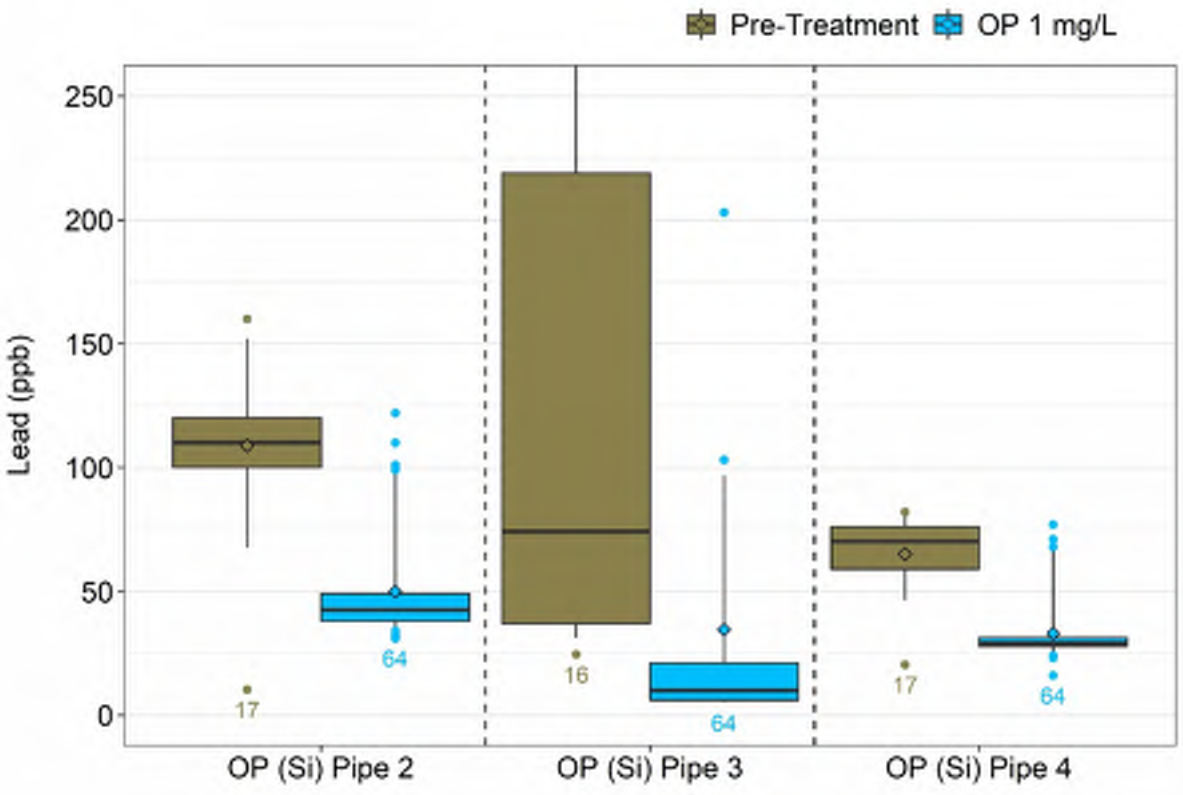


Figure 24: Moffat (Si) Orthophosphate Rack Testing Going Directly to a Low Dose

APPENDIX II.C - REVIEW OF LEAD CONCENTRATION OUTLIERS

September 2019

DENVER WATER

Appendix II.C

Review of Lead Concentration Outliers

Background:

Data from Denver Water's Lead and Copper Rule monitoring efforts at Tier 1 properties with copper piping and lead solder include some results above the action level of 15 ppb. Results from profile testing using a sequential testing protocol[1] confirmed that properties with copper piping and lead solder typically have lead measured up to 5 ppb in the first 1 L sample, followed by lead measured near the method detection limit in subsequent sample volumes. Please refer to Appendix III.E.1 for a detailed discussion of profile testing at copper piping with lead solder homes compared with lead service lines.

Denver Water has an extensive database of results for lead measured from properties with copper piping with lead solder. The purpose of this technical memorandum is to analyze the results from LCR compliance sampling and customer requested sampling to better understand typical lead release at properties identified as copper piping with lead solder homes. Of interest is the frequency with which outliers occur (i.e., when higher than expected lead concentrations are measured) and whether a higher lead concentration is indicative of a source of lead in addition to lead solder. If the source of the lead levels can be better understood, recommendations for follow up sampling and potential mitigation can be identified.

Methods:

Approximately 2,300 samples were included in the analysis of potential outliers:

- LCR compliance sampling at Tier I properties with copper piping and lead solder:
    - 1,184 samples were collected from 1997 through the first half of 2019
    - As these are LCR sites, many properties were sampled repeatedly over this time
    - A 1 L sample was collected after a minimum stagnation period of 6 hours
- Customer requested sampling:
    - All customer requested samples collected from 2016 through the first half of 2019 were reviewed against the Lead Service Line Inventory (see Appendix III.B.2) to identify likely properties with copper piping with lead solder; properties were selected based on the year that the property was constructed (1,196 have a build date from 1952 to 1987)
    - The 3-bottle test was used, with samples collected after a minimum stagnation period of six hours

As the customer is responsible for sample collection, the duration of the stagnation period used before the sample is collected can vary. For this analysis a stagnation period of six hours is assumed.

[1] See Appendix III.E.1. More than 20 aliquots of varying sample volume (125 mL to 1 L) were collected from 16 homes.

The Denver Water lab is certified by the Colorado Department of Public Health and Environment to test lead. All samples for lead are measured using method EPA 200.8. To perform the analysis, half the method detection limit was used for samples where the lead concentration was reported below the method detection limit (i.e., 50% of 1 ppb or 0.5 ppb).

The use of control charts is a commonly used to identify potential outliers in a given dataset. The assumption is that the data follow the behavior of a normally distributed dataset. Results can be used to identify results outside three standard deviations as outliers. Denver Water's LCR compliance data were analyzed using a control chart to identify an outlier result based on exceeding the sum of the average and 1 standard deviation, providing a more conservative approach than the customary three standard deviations.

Both data sets were reviewed to identify properties where:

- Lead was measured greater than 15 ppb in at least one sample at a given property; for customer requested sampling, data for the first bottle (or first draw) were used.
- Lead was measured greater than 5 ppb in at least five samples, where lead was measured on more than one sampling date; this applies mostly to the LCR data set as there were very few sites included in the customer requested sampling for which samples were obtained on multiple sampling.

The sub-set of data were subsequently reviewed for the:

- Build date, to identify homes built from 1951 to 1987.
- Tap date, to identify properties connected to a water main from 1951 to 1987.
- Original water main installation year.
- Additional data on service line material type (original material or an indication that the service line was replaced).

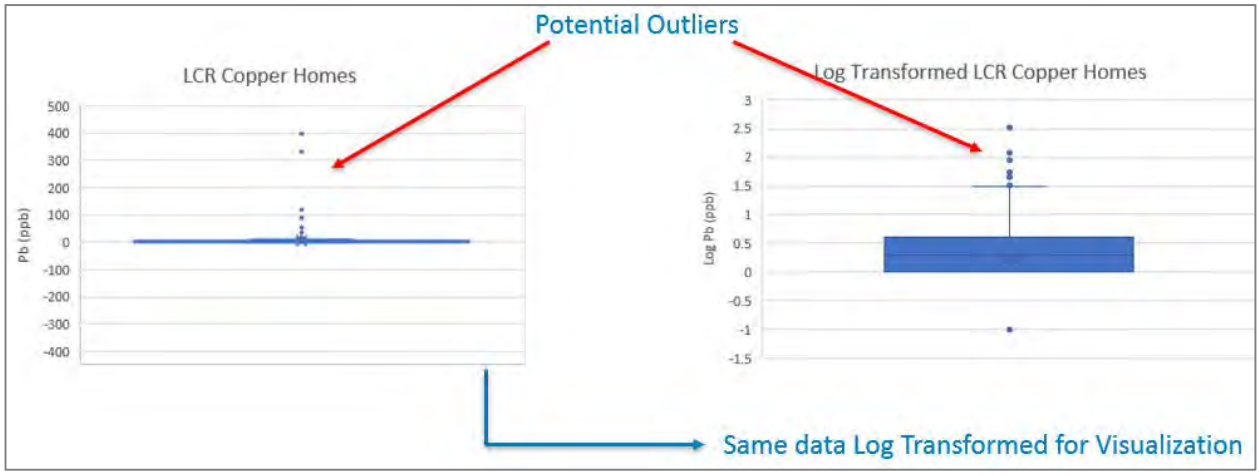
Analysis of LCR Compliance Samples from 1997 to 2019, Copper Piping with Lead Solder

The variability observed in the data available from LCR compliance sampling is shown in Figure 1, with a logarithmic scale used on the vertical axis on the right to exaggerate the details. Of the 1,184 Tier I copper piping with lead solder samples analyzed, 2.5 percent, or 25 samples were above the LCR action level of 15 ppb with the highest concentration reported was 400 ppb.[2] The average was calculated as 4.3 ppb and the standard deviation was 16.6 ppb.

Additional sampling occurred at several of these homes both before and after the reported testing, with lead level results reporting lower, particularly with some of the very high sample results that were originally reported.

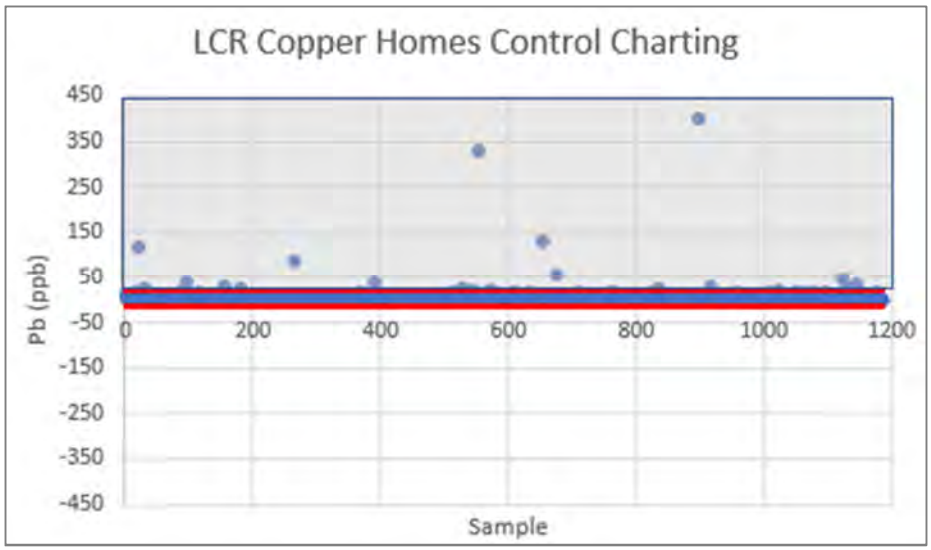
[2] This property was re-sampled and follow-up investigations and it was determined that the original sample had been collected from a tap that had been used for more than six months. Therefore, this outlier can be attributed to sample collection error. With one exception, lead was measured at less than 5 ppb in all other samples collected from 2013 through 2019.

Figure 1: Variability of LCR Compliance Samples Tier 1 Copper Piping with Lead Solder (1997 – 2019)



The same data set is presented using a control chart in Figure 2, based on the application of Gussain Curves which are usually set at ± 3 standard deviations from the mean. However, in this analysis, the control chart was prepared using ± 1 standard deviation.

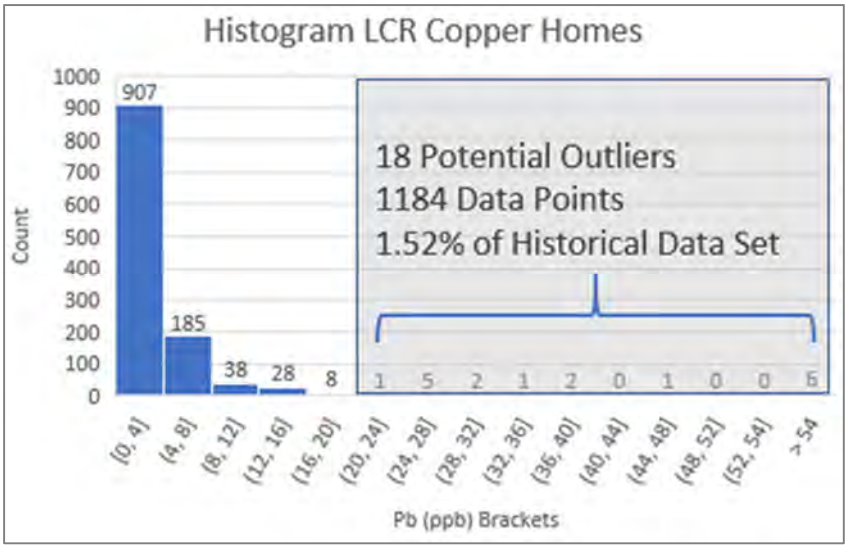
Figure 2: Control Chart Applied to LCR Compliance Samples Tier 1 Copper Piping with Lead Solder (1997 – 2019)



Note: The red lines represent the upper and lower control limits, based on ± 1 standard deviation.

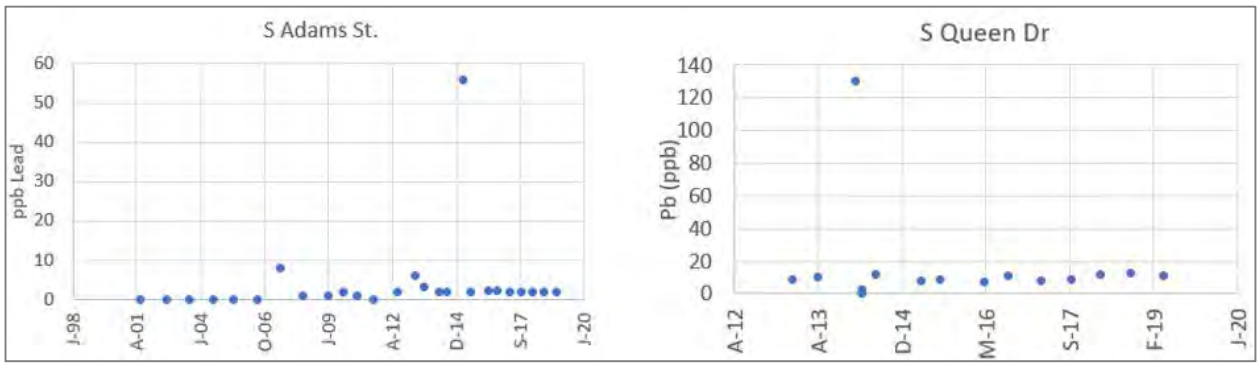
Using ± 1 standard deviation to define the upper and lower control limits is interpreted to mean that the chance is 68.3 out of 100 that the random uncertainty of any single measurement is no more than 1 standard deviation. For the 1997 to 2019 LCR compliance data, the upper control limit is 20.8 ppb, and any result measured greater than this is considered an outlier. Using this definition of outlier, the LCR compliance samples include 18 results greater than 20.8 ppb, or about 1.5% of the dataset. The LCR compliance samples are presented as a histogram in Figure 3 and reveal that the data do not follow a normal distribution (see Figure 3).

Figure 3: Histogram of LCR Compliance Samples Tier 1 Copper Piping with Lead Solder (1997 – 2019)



An example comparing two sites, each with at least one result for which lead was measured above 20 ppb, is presented in Figure 4 to show how the results were interpreted and the proposed follow-up steps to confirm the source of lead at the property. In the example from South Adams Street (shown on the left of Figure 4), only one result out of 26 samples was measured above 20 ppb and all but two of the remaining samples were measured below 5 ppb. The result from this site is considered an outlier, the property appears to be correctly identified as having copper piping with lead solder, and therefore not follow-up action is recommended.

Figure 4: Interpreting Data with at Least One Potential Outlier (Concentration > 20 ppb)

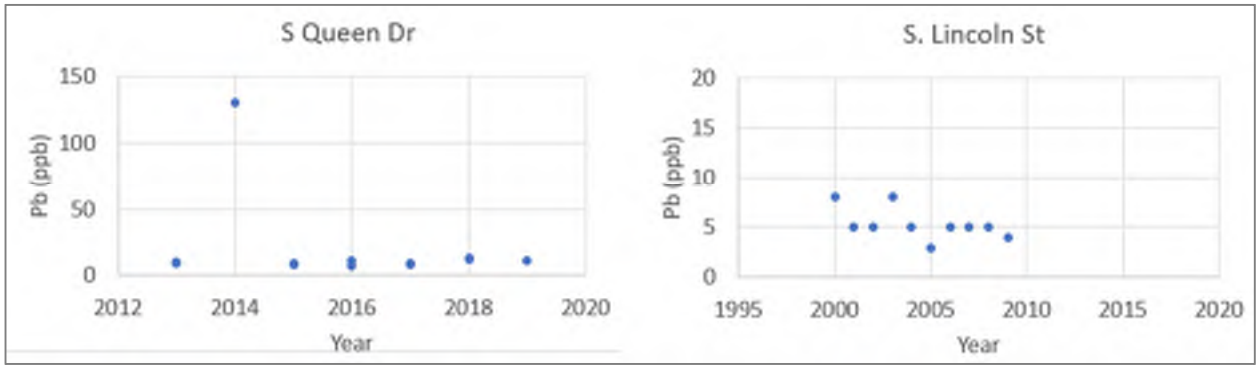


In contrast, the results for the South Queen Drive property shown on the right of Figure 4 prompted a recommendation for additional water quality sampling and field investigations to better understand the source of lead at this property. With one sample measured above 120 ppb, 12 of the 15 samples shown on the right of Figure 4 had lead measured between 7 and 13 ppb.

An example comparing two sites, each which have at least five results greater than 5 ppb, is presented in Figure 5 to show how the results were interpreted and the proposed follow-up steps to confirm the source of lead at the property. For the South Queen Drive results (on the left in Figure 5A), one outlier was measured but lead above 5 ppb was also measured on at least five occasions. In the case of the

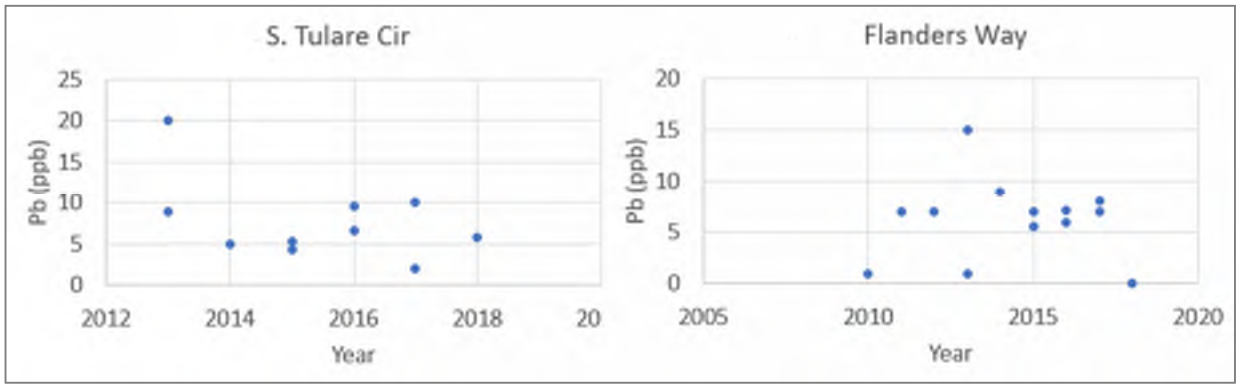
South Lincoln Street property shown in Figure 5A, multiple samples above 5 ppb, were measured. The presence or extent of lead at either of these properties cannot be confirmed from the available data and therefore additional water quality sampling and field investigations are recommended at both properties to better understand the source of lead.

Figure 5A: Interpreting Data with Persistent Lead (Concentration ≥ 5 ppb in at least Five Results)



Two additional sites with persistent lead release are provided as an example in Figure 5B. Persistent lead was measured at both properties and despite a build date of 1984, a source of lead in addition to solder is suspected at the Flanders Way property. Additional water quality sampling and field investigations are recommended for both properties to better understand the source of lead.

Figure 5B: Interpreting Data with Persistent Lead (Concentration ≥ 5 ppb in at least Five Results



In summary, several of the samples collected, analyzed and submitted to CDPHE are suspected to be anomalies, as follow up sampling produced sampling results much lower than the reported sample. Other sites may have full or partial lead service lines given the tap date, home age or main installation year. Water quality testing and filed investigations (such as pot holing and/or visual inspections) are recommended to confirm the service material. While not clearly conclusive, further sampling may confirm that high lead levels at these homes are unusual and can be explained. The homes that had follow up sampling should be contacted to try and gain an understanding as to why the submitted sample yielded such high lead concentrations.

Analysis of Customer Requested Samples from 2016 to 2019, Copper Piping with Lead Solder

Data available from customer requested sampling were also reviewed for outliers and persistent lead release. It is noted that the samples included in this analysis were selected based on historical data

available to describe the characteristics of the property and visual or field investigations have not been performed to confirm the service line material type.

Of the 1,196 customer requested samples included in this review:

- 14 properties were identified for having lead measured that appeared to be an outlier or an indicator of persistent lead.
- Of the 14, 12 properties appeared to have a source of lead in addition to (or instead of) lead solder; additional water quality sampling and field investigations are recommended for these properties.

Analysis when the Two Datasets are Combined:

The results from sampling from both datasets were considered together to better understand the occurrence of outliers, based on all samples collected from customer requested sampling and a sub-set of the LCR compliance samples (2011 to 2019). Although Denver Water has data from LCR compliance sampling dating back to 1997 (1,184 samples), only results from samples collected since 2011 were included in the analysis (635 samples). Results from sampling prior to 2011 are considered less robust: Denver Water may have used different analytical methods with different detection limits, Denver Water's own procedures may have varied, and/or treatment objectives (and the resulting performance) at the three water treatment plants may have changed between 1997 and 2011.

From this, 40 properties were highlighted due to:

- outlier value > 15 ppb (LCR compliance data).
- at least five results ≥ 5 ppb at the same address (LCR compliance data).
- at least one draw from the 3-bottle test with lead > 5 ppb (customer requested data).

Of these 40 properties, 18 appeared to have a source of lead in addition to solder. This includes 6 out of the 26 LCR compliance sampling properties and 12 out of the 14 of the customer requested sampling properties.

Table 2: Outliers Analysis from Copper Piping with Lead Solder Properties

Sample Source	Number of Samples included in Analysis	Estimated Number of Outliers	Samples with Potential Lead Source in Addition to Solder
LCR Compliance Samples (2011 to 2019)	635 samples included in Tier I sampling (1983 to 1987)	26 (or 4.1%)	6* (or 1.0%)
Customer Requested Sampling (2016 to 2019)	1,196 total samples with a build date from 1951 to 1987	14 (or 1.2%)	12* (or 1.0%)
Total	1,831	40 (or 2.2%)	18* (or 1.0%)

* This number is included in the total number of outliers in the column to the left.

In general, both datasets are susceptible to outliers: some samples are true outliers, but some also appear to come from a property with a lead source other than lead solder. For these, additional water quality testing and/or field investigations are needed to confirm the source of lead at the property.

Discussion:

The LCR compliance sampling includes properties built from 1983 to 1987 in Tier 1 sampling to capture the impact of lead solder. However, all homes in the Denver Water service area built from 1952 to 1987 potentially have lead solder, unless updates were made to plumbing inside the home. An understanding of the typical release of lead from the 1983 to 1987 homes compared with all homes that potentially have lead solder (1952 to 1987) was evaluated. The results from this analysis was used as part of the equivalency test of the Lead Reduction Program compared with orthophosphate addition to drinking water for corrosion control.

The build date of all homes included in the Denver Water service area was reviewed based on decade of construction (see Table 3). The number of service connections built between 1983 and 1987 is relatively low, representing less than 5% of all connections in the Denver Water service area.

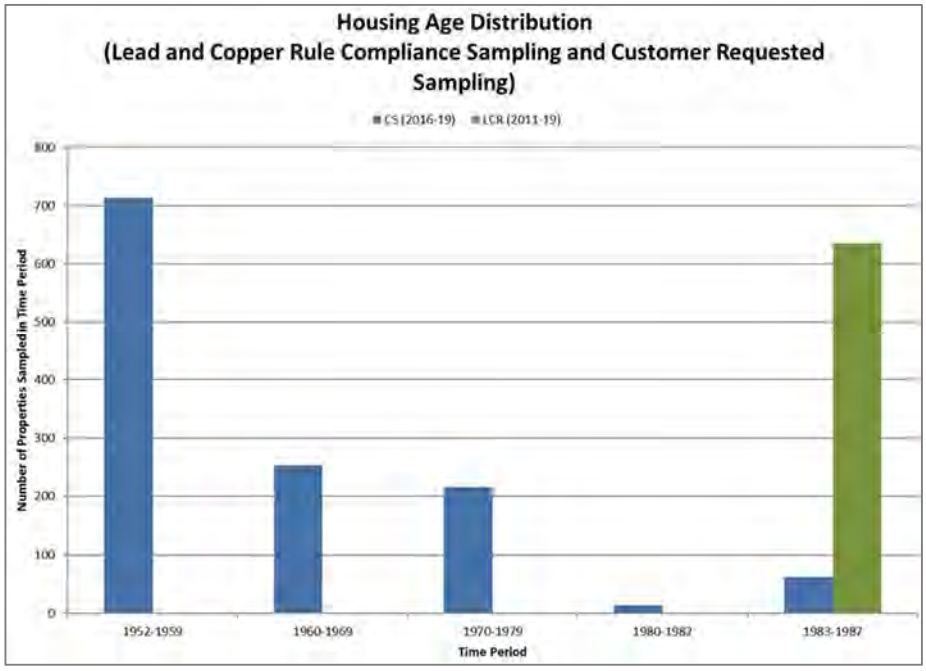
Table 3: Estimated Number of Service Lines by Housing Age, by Decade

Service Line Material Type	Estimated Build Date	Estimated Number of Service Lines
Lead Service Lines	≤ 1951	63,955
Copper Piping with Lead Solder	1952 - 1959	46,429
	1960 - 1969	37,699
	1970 - 1979	49,427
	1980 - 1982	11,961
	1983 - 1987	14,089
	Total 1952 - 1987	159,605
Non-Lead Service Line	≥ 1988	96,140

*Source: See Appendix III.B.2 and Tables 6, 8 and 9 in the Lead Reduction Program Plan.

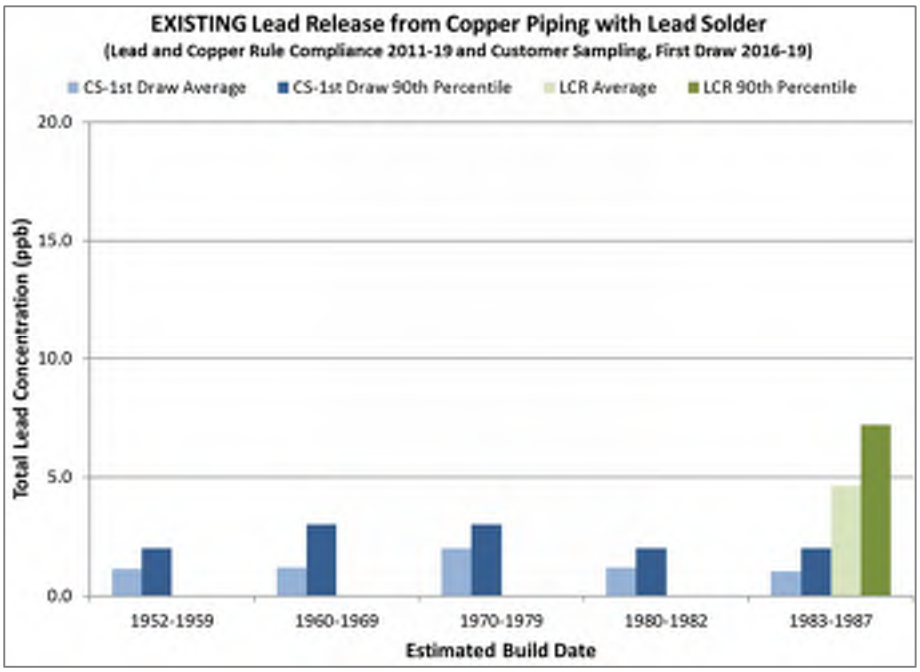
Water quality data from all properties identified as having copper with lead solder that are included in the LCR compliance dataset (collected 2011 to 2019) and customer requested sampling (2016 to 2019) dataset were reviewed as a function of the build date of the property. A summary of the number of properties included in this analysis by decade is shown in Figure 6, with a build date of 1983 to 1987 assumed for samples included in LCR compliance sampling.

Figure 6: Distribution of Available Water Quality Samples, by Decade



The analysis by decade of lead concentrations measured at homes with copper piping with lead solder are presented in Figure 7. Most results for lead concentration are relatively low and typically below 5 ppb, although higher lead release (8.0 ppb) is observed from homes constructed between 1983 and 1987. Although this group contributes less than 5% to the total housing stock in the Denver Water service area, the elevated lead that has been reported for the 1983 to 1987 properties warrants the further investigation of outliers to better understand the source of lead. If a property currently included in the 1983 to 1987 LCR compliance sampling set is found to have a lead service line it should be added to the list for replacement and a request to remove the property from the LCR compliance sampling set should be made to CDPHE.

Figure 7: Analysis of Lead Release from Copper Piping with Lead Solder with Existing Corrosion Treatment, by Decade



Recommendations:

There are several reasons why elevated lead is measured higher than would be expected at a property classified as having copper piping with lead solder, such as:

- Faucet material
- Incorrect sampling location and/or sample collection protocol by customer
- Contamination of sample in the field
- ICP-MS Matrix effects during analyses
- Inappropriate classification of property due to inconsistencies with build date and tap date

Additional water quality sampling and field investigations are recommended to better understand the source of lead and the service line material used, to allow the appropriate remediation strategy to be employed to reduce lead as measured at the tap. The choice of follow-up method for additional sampling (3-bottle test or sequential profile testing) and/or field investigations (visual, potholing, excavation) will depend on the availability of results from water quality sampling completed to date as well as historical information to characterize the property. Development of a standard operating procedure to capture potential follow-up steps is recommended.

APPENDIX III.A - OVERALL COMMUNICATIONS, OUTREACH AND EDUCATION PLAN

September 2019

DENVER WATER

APPENDIX III.A.1

OVERALL COMMUNICATIONS, OUTREACH & EDUCATION PLAN

Version 3.0: August 19, 2019

Presented by: Denver Water External Affairs

TABLE OF CONTENTS

EXECUTIVE SUMMARY

There is no lead in the water Denver Water sends to customers. But lead can get into water as it moves through lead-containing household plumbing and service lines. When it comes to lead in drinking water, no levels are considered safe. Therefore, the intent of the Lead Reduction Program is to ultimately replace customer lead service lines outside the home, while controlling/reducing lead exposure until the lead lines can be replaced and reducing lead release associated with lead solder inside a home's premise plumbing.

In 2012, Denver Water's routine testing of homes with known lead services lines and plumbing to comply with the federal Lead and Copper Rule had results that exceeded the action level for lead, prompting the utility to implement its largest public health education campaign and initiate follow-up action. Since 2012, Denver Water's ongoing lead campaign has involved sharing information with customers, stakeholders and community leaders about lead service lines, solder and fittings, proactive lead identification and replacement programs, offering free water quality testing and informing customers about what they can do to minimize their lead exposure.

In addition to those actions, Denver Water conducted detailed studies and analyses to evaluate corrosion control treatment methods to reduce lead exposure for customers with lead service lines or plumbing. In 2018, CDPHE designated orthophosphate as the Optimal Corrosion Control Treatment, or OCCT, for reducing lead exposure in homes with lead service lines or plumbing as required per the Safe Drinking Water Act. Denver Water requested an Environmental Protection Agency variance from this decision in order to implement a multipart Lead Reduction Program designed to maximize public health for customers while minimizing impacts to the environment. Both options will benefit public health by improving water quality and protection from lead. Also, in 2018, Denver Water and several parties (including Denver Water and CDPHE) entered into a collaborative agreement to address lead via an ongoing technical and stakeholder (public) workgroup process. Specifically, this group is working toward long-range regional solutions that protect public health and the environment per the Safe Drinking Water Act and the Clean Water Act, while additionally minimizing impacts to water supplies, wastewater treatment plants and watersheds.

Communications, outreach and education is a critical foundation for successful implementation of the LRP. Denver Water will continue to communicate proactively and transparently to help define relevant information for customers and provide a foundation for a well-informed public dialogue.

CURRENT AND ONGOING ACTIVITIES

Delivering safe water to 1.4 million people in the metro area is Denver Water's most important responsibility, and the utility long ago adopted a proactive approach that includes adapting its ongoing communications, operations and monitoring efforts as science and regulations have evolved. When it comes to lead in drinking water, no levels are considered safe.

The utility has tested water from inside customer homes with known lead service lines or lead solder once a year since 1992, per the EPA's Lead and Copper Rule. Information about lead is included as part of the sample collection process. In 2012, Denver Water's routine testing turned up results that exceeded the Action Level for lead, prompting the utility to implement its largest public health education campaign and initiate follow-up action, which included testing two times a year.

Since 2012, Denver Water's ongoing lead campaign has involved sharing information with customers, stakeholders and community leaders about lead service lines, solder and fittings, proactive lead identification and replacement programs, and what customers can do to minimize their lead exposure. The utility has used a variety of strategies and tactics, including direct mailings to customers, bill inserts, sharing information at community gatherings, meeting annually with elected officials and using traditional and social media for mass communications and engagement on the issue.

Denver Water communications, outreach and educations efforts include free water quality testing for customers who want to know if the water from their taps contains lead. Information about the testing program, as well as general issues surrounding lead, is included on Denver Water's website, in bill inserts, on social media, in presentations to groups touring Denver Water's facilities, and is the focus for discussions at Denver Water's water trailer, which supports numerous neighborhood events throughout the metro area. Denver Water also has a youth education program that reaches thousands of local families and Denver-area youth by directly engaging with schools in Denver Water's service area every year.

Denver Water has tested more than 15,000 samples of water from schools within its service area for lead and are working with the school districts on their remediation efforts. Starting in 2016, Denver Water partnered with Denver Public Schools and conducted multiple rounds of sampling and testing, developed strategies to remediate different sources of lead (plumbing, faucets, water fountains), and replaced the only two lead service lines remaining at their schools. Results from testing were posted on the Denver Public Schools website, along with the description and timeline of the school district's remediation efforts.

Additional coordination efforts with Denver Public Schools included developing sampling procedures adapted from EPA's 3Ts (Training, Testing, and Taking Action) tool kit, as well as communications and signage, which were then offered to other utilities in the country. Denver Water performed a single round of testing for Littleton Public Schools and helped with the communications and signage to parents and teachers. Douglas County Schools, Clayton Early Learning, and Children's Colorado KidStreet were three additional partnerships that included sample testing, communications and other efforts on a much smaller scale. The procedures, signage examples, and other protocols were provided to CDPHE and other utilities and schools both in Colorado (Loveland, Byers, Thompson School District and Colorado Springs) and elsewhere in the United States (Maryland and New York).

Denver Water has adapted its information campaign as technology has evolved. As the use of social media has increased in the community, Denver Water has augmented its ongoing

communications efforts to include new platforms and strategies, including using its own Facebook and Twitter accounts to share information and call customers to action.

For example, in fall 2018, Denver Water's community relations staff posted an informational message about lead on Nextdoor, the neighborhood social media platform. The message included links to additional information on Denver Water's website and TAP news site. Since then, that Nextdoor post has garnered more than 15,000 views and continues to gather comments, indicating customers are reading and reacting to the information. Denver Water also highlighted the issue of lead in plumbing in a Facebook live interview in November 2018 via a partnership with 9Health, a highly respected local nonprofit group. The segment to date has received more than 7,300 views.

Moving forward, Denver Water will deploy tactics the utility has used successfully for years, and adapt as new strategies emerge, to communicate with people, families, neighborhoods and communities in Denver Water's service area. Tools and tactics include direct mail notification letters and postcards, website postings, video instructions, traditional and social media outreach and engagement, news sites stories, videos and infographics and advertisements. Outreach and engagement will include ongoing dialogue with diverse community groups, community members, as well as local and state government officials through a wide variety of variety of stakeholder engagement activities, such as town hall meetings, neighborhood meetings, community events and presentations, small group and one on one meetings, etc.

GOALS, OBJECTIVES, STRATEGIES AND TACTICS

Phase I: Pre-Variance (June 2019–October 2019)

Detailed communications, outreach and education plans for the pre-variance phase laid the foundation for the development of future communications, outreach and education plans. EPA, CDPHE and Denver Water agreed on goals and objectives for this phase. The group has also finalized key messages and a commonly asked questions document to serve as the foundation for communication materials.

Goal(s)

Denver Water, CDPHE and EPA agree on the benefits of carrying out education and outreach prior to the OCCT variance decision. More specifically, the agencies will:

- Educate, engage and seek input/feedback from residents, customers, local public health agencies, local government stakeholders and other targeted audiences about ways Denver Water could address reducing lead exposure (OCCT designation and variance alternative).
- Develop a framework that will create a shared understanding of lead education and reduction efforts to help ensure consistent information is being shared and distributed among stakeholders and the broader community.

Objectives

- Develop outreach strategies and tactics to educate, engage and seek feedback from target audiences. Educate residents on the following:
    - A historical overview leading up to the 2012 exceedance.
    - The Lead and Copper Rule, 2012 exceedance and Denver Water programs currently in place.
    - CDPHE's March 2018 decision regarding OCCT and subsequent Denver Water activities.
    - Clear communication on the impacts of lead exposure and what can be done to lower risk in the short-term.
    - Denver Water's Lead Reduction Program proposal, study plan and impacts to residents.
    - Milestones timeline for addressing the problem.
    - Use of filters through the Filter Pilot.
- Engage and seek input and feedback on the following one of two paths forward to address lead — state decision re: OCCT and variance.
    - Designation: Orthophosphate treatment spoken in layman's terms.
    - Alternative: Denver Water's Lead Reduction Program (accelerated lead service line replacement, filter program).
- Gather input and feedback to be used in the following ways:
    - Inform CDPHE and EPA of public sentiment regarding the alternative path forward.
    - Inform Denver Water on methods to increase engagement and implementation of the Lead Reduction Program. In particular the Filter Pilot will begin to educate customers on and encourage filter use, gathering input and lessons learned to apply to the full-scale filter program.

Strategies

- Develop communications and outreach plan.
    - Target audience analysis which includes those listed in the table.
    - Key messaging points developed in tandem with CDPHE and EPA for any agency that comes into contact with the public.

    - Refine strategies as needed and identify tactics for communications and outreach.
    - Identify multicultural outreach services needed (documents, meetings, etc.).[1]
- Communications and education outreach for internal staff.
    - Determine audience(s).
    - Organizational communication.
    - Training for Denver Water Call Center, Customer Service Field, Water Quality, and Safety and Security staff.
    - Support documents and communication materials.
- Implement external communications, outreach and education.
    - Implement filter and potholing pilot programs.
    - Industry Day for contractors interested in bidding on project to proactively answer questions and ensure these individuals know where to direct inquiries they may receive.
        - Coordinate with various City and County of Denver departments, Council Members and Mayor's office to prepare their offices for inquiries.
- Initiate public outreach and input opportunities.
    - Detailed outreach plan incorporated into separate document.
    - Provide pilot study participants with feedback opportunities for participants to share their thoughts on the process and filter preferences.

Phase II: Post-Variance Stakeholder Outreach (October 2019–January 2034)

Goals

The overarching goals for communications will be to scale up education and outreach efforts to achieve the following:

[1] Denver Water is using multiple sources of information to identify language and cultural needs for communications and translation services. Those include the federal interagency Limited English Proficiency webpage, CDPHE Community Health Equity Online Map and Denver Public Schools language information by neighborhood and zip code as well as information from peer cities. All documents include translation into Spanish and are available upon request into additional languages. Denver Water's call center and communications team have Spanish speakers.

- Inform customers and stakeholders of EPA's final decision.
- Raise awareness among all customers of the change and its impacts.
- Emphasize the outcome of implementation of the LRP, namely improved water quality and reduced risk of exposure to lead in drinking water for those with lead service lines and plumbing.
- Provide clear and consistent messaging and branding.

Objectives

Denver Water will further aim to:

- Build a platform for communitywide education and engagement regarding the Lead Reduction Program that includes communications and outreach, and gathers feedback to improve the program as it moves forward.
- Facilitate training for contractors, employees and vendors to educate these groups on where to direct customer inquiries and to support consistent communications on the program.
- Provide clear, accurate and timely information and messaging about the Lead Reduction Program to target audiences.

- Educate and engage with customers, residents, families and communities in order to create a common understanding of and instill confidence in the Lead Reduction Program.
- Support a specific communications, outreach and education program targeted at expectant and existing families with formula-fed infants/children up to age 2 living in homes with copper piping with lead solder built 1983-1987.
- Educate customers to encourage consistent, proper and ongoing filter usage.
    - Develop materials that easily demonstrate how to use the filters.
- Encourage customers to consider in-home plumbing updates and to flush the tap before drinking, cooking or preparing infant formula after prolonged periods during which water is not used, such as first thing in the morning or when returning home from work or school.

- Seek feedback from customers and others about the Lead Reduction Program to learn best practices and effective ways to implement program activities.
- Incorporate the Learning by Doing approach to improve outcomes during the life of the Lead Reduction Program.

Strategies

- Develop communications, outreach and education plans.
    - Target audience analysis including those listed in the table.
    - Key messaging points developed in tandem with CDPHE and EPA.
    - Identify translation services needed (e.g., documents, meetings).

    - Develop customized tools and techniques.[2]
- Communications, outreach and education for distributors.
    - Share customizable outreach materials to support distributors' customer communications.
- Communications, outreach and education for internal Denver Water staff.
    - Determine stakeholders.
    - Organizational communication.
    - Intranet.
    - Training for Call Center, Water Sales, Customer Service Field, Water Quality and Water Distribution staff.
    - Support and standard procedure documents.[3]
- Communications, outreach and education for contractors.
    - Training.[4]
    - Support documents and communication materials.
- Implement external communications, outreach and education.
    - Notification to all customers.
    - Targeted notifications to impacted customers (e.g., with known or suspected LSLs).
    - Target outreach campaign to impacted customers.

LEAD REDUCTION PROGRAM COMPONENTS

Each component requires clear goals, strategies, objectives and tactics specific to the component. For example, the strategies and tactics will differ for the Accelerated Lead Service Line Replacement and the Filter Program.

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[2] Tools and Techniques will be customized by target audiences to include direct mail notification letters and postcards, website postings, video instructions, traditional and social media outreach and engagement, news site stories, videos and infographics, advertisements, public engagement activities, such as town hall meetings and neighborhood meetings, as well as collaborative efforts with community organizers, Spanish-speaking community groups and government officials.

[3] Documents include FAQs about the program, fact sheets, brochures, website information, maps, customer surveys for filter program, newsletters, news site stories, videos and infographics and bill inserts.

[4] Denver Water will offer seminars for contractors for education on best practices for replacement, following our standards and post-replacement flushing protocol.

There are several phases for all program components phases, including development, initial launch and implementation and sustained program management that incorporates course corrections along the way (i.e., learning by doing). Components vary in the timing of when each phase begins or ends which has implications for overall messaging and engagement.

Lead Service Line Inventory (In progress)

Goal

Continuously update and publish the inventory of lead service lines throughout the service area to improve estimate of number of lines that require replacement.

Objectives

- Inform and educate customers about their service lines — ownership, material types and plumbing.
- Engage suburban distributors to assess lead service lines within Denver Water's integrated system.
- Work with municipalities to develop better records regarding service line material.

Strategies

- Develop communications plan.
    - Target audiences (e.g., customers in homes with known or suspected lead service lines, local governments, elected officials, public health agencies). As lead inventory is updated, follow up and messaging differs by group.
    - Key messaging points.
    - Translate documents.
    - Tools and techniques.
- Communications, outreach and education for distributors.
    - Share customizable outreach materials to support distributors' customer communications.
- Communications, outreach and education for internal Denver Water staff.
    - Determine stakeholders.
    - Organizational communication.
    - Training for Call Center, Water Sales, Customer Service Field, Water Quality and Water Distribution.
    - Support and standard procedure documents.
- Communications, outreach and education for contractors collecting inventory data.

    - Training on service line inspection and identification including photo documentation.
    - Support documents and communication materials.
- Implement external communications, outreach and education.
    - Direct mail marketing and outreach.
    - Utilize existing internal resources to engage with distributors.
    - Mapping tool to show:
        - Unknown, suspected and known lead service line locations.
        - Known copper service line locations.
    - Links to water quality test requests and filter program.
    - Website information about service line verification techniques.
    - Training resources for plumbers.
- Review, revise and reinforce components of communications, outreach and education.

Filter Program (October 2019)

Goal

Provide customers with known or suspected lead service lines with a filter and educational materials to encourage consistent, ongoing and proper use of filters.

Objectives

- Inform and educate customers about the Filter Program.
- Engage with customers with known or suspected lead service lines to ensure they receive a filter.
- Work with property owners, local housing authorities and tenants to share information and encourage filter use with residents in rental and multi-family properties.
- Encourage filter use for drinking, cooking and when preparing infant formula.
- Encourage changing the filter cartridge according to the manufacturer's instructions.
- Educate customers about flushing and provide flushing instructions to encourage flushing the tap before drinking, cooking or preparing infant formula after prolonged

periods during which water is not used, such as first thing in the morning or when returning home from work or school.

Strategies

- Develop communications plan.
    - Target audiences, including those listed in the table.
    - Key messaging points.
    - Translate documents.
    - Tools and techniques.
- Develop a specific communications, outreach and education program targeted at expectant and existing families with formula-fed infants/children up to age 2 living in homes with copper piping with lead solder built 1983-1987. The program will:
    - Work with area healthcare providers to deliver educational material.
    - Encourage people to run the cold water tap before drinking, cooking or preparing infant formula after long periods of stagnation (per recommendation from profiling studies).
    - Encourage households to get their water tested.
    - Provide free filters and replacement cartridges for households with formula-fed infant/children up to age 2, where lead level results exceed 3 ppb, per CDPHE guidance.
- Communications, outreach and education for distributors.
    - Share customizable outreach materials to support distributors' customer communications.
- Communications, outreach and education for internal staff.
    - Determine stakeholders.
    - Organizational communication.
    - Training for Call Center, Water Sales, Customer Service Field, Water Quality and Water Distribution.
    - Support and standard procedure documents.
- Communications, outreach and education for contractors performing filter distribution work to ensure they can direct customers to appropriate resources and channels to get questions answered.
    - Training on flushing, filter types, installation methods and replacement protocols.

    - Support documents and communication materials.
- Implement external communications, outreach and education.
    - Notify impacted residents.
    - Complete distribution (mail and door-to-door delivery).
    - Ensure implementation of registration, tracking (i.e., QR code).
    - Utilize local opportunities to engage with residents.
    - Implement feedback surveys on filter adoption.
    - Initiate replacement filter process including how-to videos and use verification.
    - Implement voucher program, if used, for replacement cartridges.
- Review, revise and reinforce components of communications, outreach and education plan.

Accelerated Lead Service Line Replacement Program (December 2019)

Goal

Replace customer-owned lead service lines and provide information on post-replacement flushing procedures.

Objectives

- Inform and educate customers about their service lines — ownership, material types and plumbing.
- Inform and educate customers about their premise plumbing – sources of lead, known potential health risks, and options or strategies to reduce the risk of lead exposure from premise plumbing.
- Obtain property-owner consent to replace their lead service line and share information with the owner and residents of the property on what to expect from service line replacement.
- Provide support and information on post-replacement filter use and flushing.
- Provide customers with appropriate education and resources on water quality testing and the results of testing following lead service line replacement.
- Offer Denver Water staff and contractors strategies to obtain the consent of property owners who have refused to have their lead service line replaced.

Strategies

Communications efforts for this part of the program will build on work done during the inventory and filter programs. As part of the replacement segment of the program, customers will be supplied educational materials on how to eliminate additional sources of lead from premise plumbing, will be provided with lead filter cartridges for an additional six months and be offered a water quality test following replacement of the LSL. This will include the best practices found for post-replacement flushing to minimize lead particles.

- Develop communications plan.
    - Target audiences, including those listed in the table.
    - Key messaging points.
    - Translation.
    - Tools and Techniques.
- Communications, outreach and education for distributors.
    - Share customizable outreach materials to support distributors' customer communications.
- Communications, outreach and education for internal staff.
    - Determine stakeholders.
    - Organizational communication.
    - Training for Call Center, Water Sales, Customer Service Field, Water Quality and Water Distribution.
    - Support and standard procedure documents.
- Communications, outreach and education for contractors.
    - Training on replacement standards and flushing guidelines.
    - Training to provide talking points and business cards to direct customer inquiries.
    - Support documents and communication materials.
- Implement external communications, outreach and education.
    - Develop messaging around lead service line identification and inventory process.
    - Before LSL replacement.
        - Website information, direct mail and educational materials.

        - Notify impacted property owners via letter in advance of construction.
        - Carry out appointments with property owners to discuss construction and gain property-owner consent for LSL replacement.
        - Notify within 24 hours of service shut-off for construction activities.
- During and post LSL replacement.
    - Encourage continued filter use through the first six months following LSL replacement.
    - Educate customers on flushing protocol.
    - Offer water quality testing for follow-up.
        - If water quality results remain above the action level, walk through educational materials with the customer on how to reduce lead in their premise plumbing and refer them to community organizations and funding programs that can assist with investigating and removing lead from their home.
- If LSL replacement is declined, provide customers with educational information and follow appropriate protocols for documentation, notification and escalation if needed.
- Review, revise and reinforce components of communications, outreach and education plan.

Corrosion Control Treatment (CCT)

Goal

Educate and inform customers about how Denver Water treats water to help minimize the release of lead into water from lead service lines and household plumbing and fixtures that contain lead.

Objectives

- Provide information on the Lead and Copper Rule and metal corrosion for general audiences.
- Inform and educate residential and commercial customers about the sources of lead in plumbing.
- Raise awareness among customers of the upcoming water treatment change and how it will or will not impact water quality, including little-to-no noticeable impacts to Denver Water customers, their plumbing and appliances; no anticipated changes to taste and odor; and specific considerations for chemistry dependent uses.

- Emphasize the outcome of increasing the pH — improved water quality and reduced risk of lead exposure in drinking water for customers with lead service lines and lead plumbing.
- Educate customers about flushing and provide flushing instructions to encourage flushing the tap before drinking, cooking or preparing infant formula after prolonged periods during which water is not used, such as first thing in the morning or when returning home from work or school.
- Provide clear and consistent messaging and branding.

Strategies

- Develop communications plan.
    - Target audiences, including those listed in the table.
    - Key messaging points.
    - Translation.
    - Tools and Techniques.
- Communications, outreach and education for distributors.
    - Share customizable outreach materials to support distributors' customer communications.
- Communications, outreach and education for internal staff.
    - Determine stakeholders.
    - Organizational communication.
    - Training for Call Center, Water Sales, Customer Service Field, Water Quality and Water Distribution.
    - Support and standard procedure documents.
- Communications, outreach and education for contractors.
    - Training on replacement standards and flushing guidelines.
    - Support documents and communication materials.

- Implement external communications, outreach and education.
    - Outreach to industrial commercial customers whose processes may be impacted by water chemistry changes.
    - Educate customers about flushing and provide flushing instructions for best water quality practices.

- Review, revise and reinforce components of communications, outreach and education plan.

APPENDICES

Appendix A: Pre-Variance Stakeholder Outreach

Goal

Denver Water, CDPHE and EPA agree on the benefits of carrying out education and outreach prior to the optimal corrosion control treatment variance decision. More specifically:

- The agencies will educate, engage and seek input/feedback from residents, customers, local public health agencies and providers, local government stakeholders, distributors and other targeted audiences about ways Denver Water could address reducing lead exposure (OCCT and variance paths).

Objectives

- Develop outreach strategies and tactics to educate, engage and seek feedback from target audiences. Educate audiences on the following:
    - The scope and history of the problem
        - The Lead and Copper Rule, 2012 exceedance and Denver Water programs currently in place.
        - CDPHE's March 2018 decision regarding OCCT and subsequent Denver Water activities.
    - Risk communication on the impacts of lead exposure and what can be done to lower risk in the short-term.
    - Denver Water's Lead Reduction Program proposal, study plan and impacts to residents.
    - Timeline for addressing the problem.
- Engage and seek input and feedback on the alternative path forward to address lead — state decision re: approval of the variance.
    - OCCT designation: Orthophosphate treatment spoken in layman's terms.
    - Alternative path (variance): Denver Water's Lead Reduction Program (accelerated lead service line removal, Filter Program).
- Gather input and feedback to be used in the following ways:
    - Inform CDPHE and EPA of public sentiment regarding the alternative path forward

- Inform Denver Water on methods to increase engagement and implementation of the Lead Reduction Program (e.g., filter program).

Introduction

EPA, CDPHE and Denver Water agree that seeking stakeholder feedback regarding the alternative path to reduce lead is critically important to the success of the communication, education and outreach efforts related to the full Lead Reduction Program.

This document outlines various components required to educate and gather feedback about the OCCT designation and alternative path to reduce lead exposure before a variance decision (October 2019) including:

- Timeline — provided below (updates happening frequently).
- Outreach framework including audiences — complete.
- Key messages — in a separate document.

Outreach Framework (Target audiences and timeline)

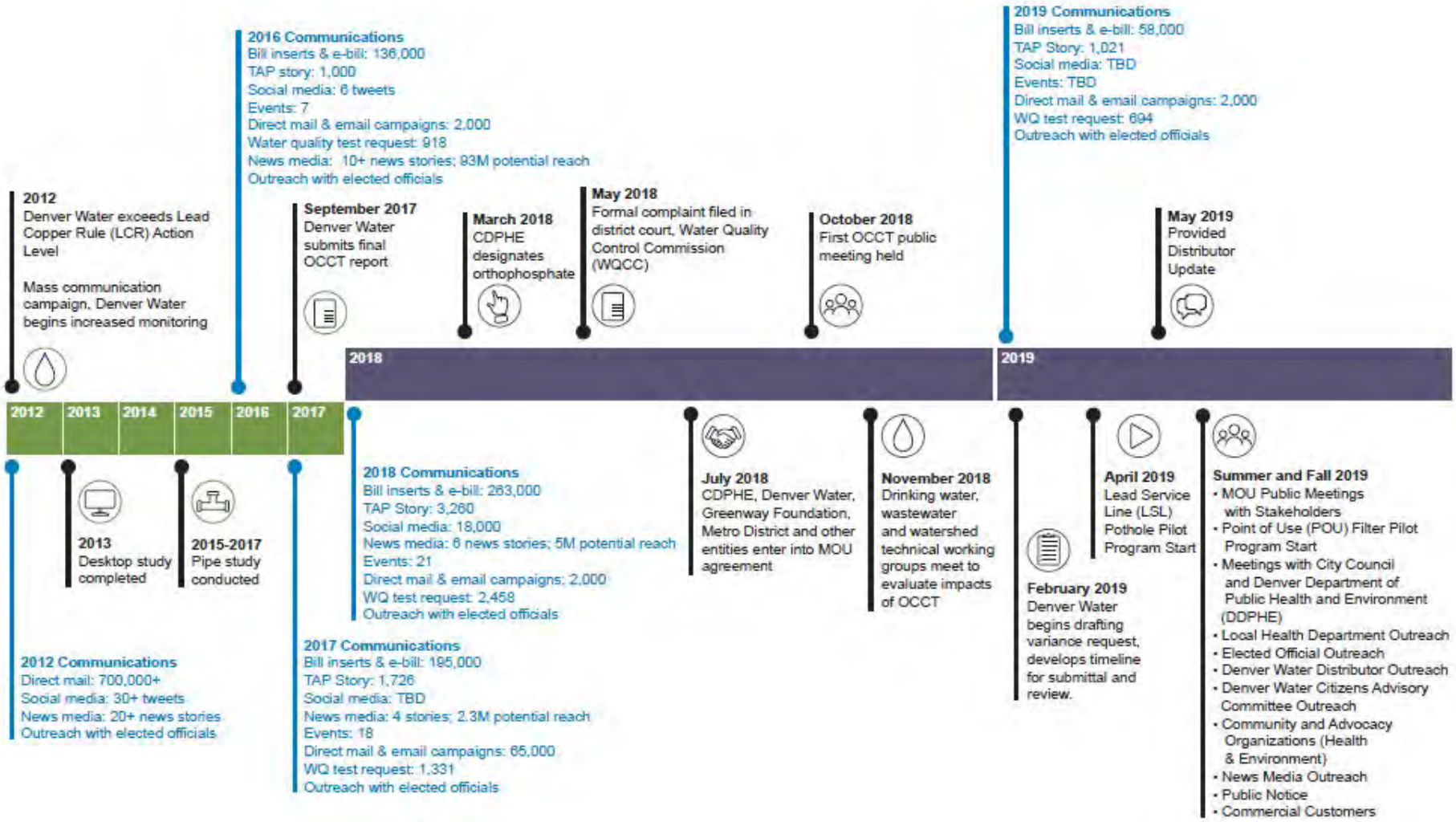
Communication strategies relate to program audiences, which have been placed in categories based on associated influences and communication goals. Timeline column denotes when the activity was or will be completed.

Timeline	Target Audience	Agency lead	Objectives	Method of Communication
Beginning 2/2019 and ongoing.	**Denver Water customers (Pre-1951 homes)**	Denver Water	Create awareness about LSLs. Provide information to learn more (e.g., water quality testing, loans for service line replacement).	Direct mail, and others as identified through communications plans.
Quarterly	**Denver Mayor's Office**	Denver Water	Provide information to elected officials and staff about the reason for implementing OCCT. Provide assistance for handling citizen calls. Obtain input and guidance on approach to council districts.	Meetings. Informational materials.
Beginning 6/2019 and ongoing.	**Denver City Council**	Denver Water	Provide information to elected officials and staff about the reason for implementing OCCT. Provide assistance for handling any citizen calls. Obtain input and guidance on approach to council districts.	Meetings. Informational materials. Presentations as requested.
Beginning 7/2019 and ongoing.	**City and County of Denver departments** (includes Planning, Public Works, Engineering, Office of Environmental Justice and Health Equity, etc.)	Denver Water	Create awareness about CCT variance request. Determine areas requiring coordination for construction and community affairs.	Meetings. Informational materials. Presentations as requested.

Timeline	Target Audience	Agency lead	Objectives	Method of Communication
Beginning 5/2019 and ongoing.	**Public health agencies and public health providers**	Denver Water	Enlist support for water quality improvements for the benefit of public health. Inform about the benefits of CCT. Inform about the impacts of any change in water quality. Gain support from the health department as a communications partner with special, targeted audiences, including general public, physicians, etc.	Meetings. Informational materials. Presentations as requested. Others as identified through communications plans.
6/2019 7/10/2019 7/16/2019 8/2/2019 8/5/2019 others pending.	**Denver Water Distributors (wholesale/retail large account holders)**	Denver Water	Create awareness. Obtain input.	Meetings. Informational materials. Presentations as requested. Others as identified through communications plans.
6/2019 6/20/19 7/18/2019 others pending.	**Denver Water - Citizens Advisory Council**	Denver Water	Create awareness. Obtain input.	Meetings. Informational materials.
7/2019 – 8/2019	**Customers/participants in filter pilot**	Denver Water	Educate and engage to gauge viability of a filter distribution program and adoption rates by Denver Water customers that have known or suspected lead service lines.	Letters, informational materials, phone calls, door-to-door outreach.
Beginning 6/2019 and ongoing.	**Advocacy organizations: public health, children's health advocacy, environmental groups**	CDPHE & Denver Water for public health and children's health; EPA & Denver Water for enviro groups.	Create awareness. Build interest. Obtain input.	Meetings. Informational materials. Presentations as requested. Others as identified through communications plans.

Timeline	Target Audience	Agency lead	Objectives	Method of Communication
Monthly	**MOU stakeholder group**	CDPHE	Present overview of variance option and input requested.	Meetings.
Beginning 7/2019 and ongoing.	**Customers and residents**	Denver Water	Implement a comprehensive, strategic, integrated public communication and outreach program. Create awareness about program approach. Obtain input.	Various, including those listed above and others identified through communications plans.
Beginning 7/2019 and ongoing.	**Commercial customers**	Denver Water	Create awareness about program approach. Obtain input.	Various, including those listed above and others identified through communications plans.
Beginning 7/2019 and ongoing.	**Impacted customers (with known or suspected LSLs)**	Denver Water	Educate and engage with customers about LSLs, coordinate LSL removal.	Various, including those listed above and others identified through communications plans.

Outreach Timeline


2012
Denver Water exceeds Lead Copper Rule (LCR) Action Level
Mass communication campaign, Denver Water begins increased monitoring
2016 Communications
Bill inserts & e-bill: 136,000
TAP story: 1,000
Social media: 6 tweets
Events: 7
Direct mail & email campaigns: 2,000
Water quality test request: 918
News media: 10+ news stories; 93M potential reach
Outreach with elected officials
September 2017
Denver Water submits final OCCT report
March 2018
CDPHE designates orthophosphate
May 2018
Formal complaint filed in district court, Water Quality Control Commission (WQCC)
October 2018
First OCCT public meeting held
2019 Communications
Bill inserts & e-bill: 58,000
TAP Story: 1,021
Social media: TBD
Events: TBD
Direct mail & email campaigns: 2,000
WQ test request: 694
Outreach with elected officials
May 2019
Provided Distributor Update
2018
2019
2012
2013
2014
2015
2016
2017
2013
Desktop study completed
2015-2017
Pipe study conducted
2012 Communications
Direct mail: 700,000+
Social media: 30+ tweets
News media: 20+ news stories
Outreach with elected officials
2018 Communications
Bill inserts & e-bill: 263,000
TAP Story: 3,260
Social media: 18,000
News media: 6 news stories; 5M potential reach
Events: 21
Direct mail & email campaigns: 2,000
WQ test request: 2,458
Outreach with elected officials
2017 Communications
Bill inserts & e-bill: 195,000
TAP Story: 1,726
Social media: TBD
News media: 4 stories; 2.3M potential reach
Events: 18
Direct mail & email campaigns: 65,000
WQ test request: 1,331
Outreach with elected officials
July 2018
CDPHE, Denver Water, Greenway Foundation, Metro District and other entities enter into MOU agreement
November 2018
Drinking water, wastewater and watershed technical working groups meet to evaluate impacts of OCCT
February 2019
Denver Water begins drafting variance request, develops timeline for submittal and review.
April 2019
Lead Service Line (LSL) Pothole Pilot Program Start
Summer and Fall 2019
• MOU Public Meetings with Stakeholders
• Point of Use (POU) Filter Pilot Program Start
• Meetings with City Council and Denver Department of Public Health and Environment (DDPHE)
• Local Health Department Outreach
• Elected Official Outreach
• Denver Water Distributor Outreach
• Denver Water Citizens Advisory Committee Outreach
• Community and Advocacy Organizations (Health & Environment)
• News Media Outreach
• Public Notice
• Commercial Customers

APPENDIX III.B.1 - INTEGRATED AND CONSECUTIVE SYSTEMS

September 2019

DENVER WATER

Appendix III.B.1: Integrated and consecutive systems

DENVER WATER DISTRIBUTORS

Denver Water provides water to two types of systems: integrated and consecutive. Consecutive systems are entities that receive some of their water supply from Denver Water and blend it with other sources, examples include Broomfield, Inverness and East Cherry Creek Valley. Consecutive Systems are not included in the lead service line inventory because they do not conform to Integrated System requirements defined by Denver Water.

Integrated System Agreements include three distinct types of districts: Master Meter, Read and Bill and Total Service. These districts have a total of over 160,000 service lines with approximately 6,000 pre-1951 taps, which have been included in the lead service line inventory. Additional factors, as spelled out in lead service line inventory section and Appendix III.B.2, may result in more homes being included in the final count of known or suspected lead service lines.

The districts are being included in the identification and verification efforts for the lead service line inventory. These efforts include records review, site surveys, potholing, and water quality sampling. Prior to the execution of Phase II of the Lead Reduction Program Plan, an agreement will be reached with the Integrated Service Agreement districts to comply with the program elements and schedule as outlined in the plan.

READ AND BILL

Read and Bill districts are also integrated systems where the distributor owns and is responsible for construction, operation, maintenance, and replacement of its water system into which Denver Water delivers water. Denver Water reads the meter of each individual customer and bills each individual customer at the established "Read and Bill" rate.

Read & Bill District	***Total***	***< 1951***	***> 1950***
North Lincoln	***248***	40	205
Phillips Petroleum	***4***	0	4
Country Homes Metro	***39***	0	37
South Sheridan	***1111***	0	1109
Alameda	***503***	0	501
Southgate	***11943***	22	11778
Southwest Metro	***14355***	6	14112
Bear Creek	***3201***	0	3161
Platte Canyon	***6095***	11	6031
Suncor	***3***	0	3
Lockheed Martin	***1***	0	1
Colorado DNR	***9***	0	8
Willows	***1131***	0	1127
Totals	***38643***	79	38077
Percentage		***0.20%***	***98.50%***

Based upon available tap date data

TOTAL SERVICE

In Total Service areas, Denver Water owns the water system and is responsible for its operation, maintenance and replacement. Denver Water reads each individual customer's meter and bills each individual customer at the established "Total Service" rate. In Total Service areas, the water service provided to the customers is identical to that provided to customers inside the City and County of Denver.

Total Service District	*Total*	*< 1951*	*> 1950*
Southeast Englewood	***12200***	5	12039
Holly Hills	***803***	1	802
HI-LIN	***259***	4	254
Bennett Bear Creek Farm	***220***	1	213
Fehlmann	***19***	0	19
Sheridan	***1606***	115	1470
Cherry Hills North	***146***	0	146
Mansfield Heights	***181***	1	175
Littleton	***11387***	49	11199
Lloyd King	***10***	0	10
Loretto Heights	***83***	23	58
Columbine	***748***	0	733
Lochmoor	***58***	0	58
Cherry Hills Heights	***52***	4	48
Southwest Plaza Metro	***37***	1	32
Havana	***2442***	0	2394
Southwest Suburban	***2234***	0	2232
Grant	***776***	0	775
Hillcrest	***262***	0	262
Devonshire	***68***	3	65
Panarama Park	***71***	0	61
Galleria Metro	***55***	0	55
Greenwood Village	***269***	14	254
South University Place	***36***	12	24
Cherry Hills Village	***1287***	19	1230
Arapahoe Estates	***282***	0	282
Holly Mutual	***48***	0	47
Colorado Academy	***39***	0	39
Berkeley	***1361***	361	986
Castlewood	***2957***	3	2902
East Cherry Hills Village	***58***	0	57
Totals	***40054***	616	38921
Percentage		***1.50%***	***97.20%***

Based upon available tap date data

MASTER METER

Master Meter districts are integrated systems that are solely supplied by our water through one or several meters, but they set their own rates and maintain their own infrastructure. These systems can reside in municipalities that have several water sources.

Master Meter District	***Total***	***< 1951***	***> 1950***
Con Mutual	***16,249***	213	15902
Wheat Ridge	***6,160***	2065	4053
Edgewater	***1,522***	42	1467
Bow-Mar	***290***	68	222
Alameda	***352***	2	346
Bonvue	***172***	0	172
Cherry Creek Valley	***2,422***	13	2333
Northgate	***11***	6	5
High View	***975***	2	950
Valley	***1,896***	39	1825
South Adams County	***183***	2	179
Lakehurst	***5,756***	4	5713
North Washington	***3,787***	5	3750
Cherry Creek Village	***472***	9	458
Meadowbrook	***1,365***	1	1356
Willowbrook	***3,875***	0	3825
North Pecos	***708***	3	676
Ken-Caryl Ranch	***4,388***	3	4326
Bancroft-Clover	***9,380***	57	9296
Lakewood	***835***	364	459
Green Mountain	***10,375***	17	10319
Crestview	***5,156***	2420	2706
Glendale	***285***	6	271
Willows	***4,746***	0	4746
Totals	***81,360***	5341	75355
Percentage		***6.60%***	***92.60%***

Based upon available tap date data

APPENDIX III.B.2 - PRELIMINARY IDENTIFICATION OF LEAD SERVICE LINES

September 2019

DENVER WATER

MOTT MACDONALD

Technical Memorandum

To Denver Water
From Mott MacDonald
Cc Denver Water, Corona Environmental, and AECOM
Date August 8, 2019
Project No. 507100139
Page Page 1 of 15
Subject Denver Water Lead Reduction Program
Appendix III.B.2 – Refinement of the Lead Service Line Inventory

I. EXECUTIVE SUMMARY

Based upon additional information and further analysis of the data presented in the Preliminary Identification of Lead Service Lines and other data, a refinement to the service line inventory for the Denver Water service area was completed. The refinement resulted in service lines being removed from inventory and adjustments to the probability of a service line being lead pipe. Results of the refinement to the inventory are:

- 319,700 service lines used for drinking water in the Denver Water service area
- 84,546 service lines identified as known, suspected and possible lead service lines – these premises are candidates for the filter program
    - 63,955 service lines are estimated to be lead services lines – this is the lead service line inventory and the basis for the annual 7.0% ALSLR
    - 20,591 service lines are estimated to be non-lead services lines – these will be investigated and confirmed non-lead

This technical memorandum documents the background, analysis and results of the refinement to the inventory.

II. BACKGROUND

As Denver Water does not own its customers' service lines, an inventory of lead service lines was compiled based upon available data. It should be noted that compiling and analyzing available data sets to develop a service line inventory is an extensive and challenging process. For Denver Water this is compounded by the fact that service line materials were not historically recorded until this past decade and the analysis of available data (dates service lines were tapped to the water main, building dates, parcel dates, water main installation dates, and other data) collected in multiple databases over the past century results in numerous scenarios to determine the probability of lead. Incomplete or missing data and changes to service line replacement policies and procedures over time further complicate these efforts.

The starting point for our analysis is the *Preliminary Identification of Lead Service Lines* prepared by Corona Environmental Consulting dated August 7, 2019 (included as

ATTACHMENT 1). The *Preliminary Identification of Lead Service Lines* includes details on lead service line background, data sources, data preparation and clean-up, results, and next steps. An earlier version of this initial inventory technical memorandum was included in the July 11, 2019 draft submittal. The estimated inventory of service lines in the Denver Water service area developed in the *Preliminary Identification of Lead Service Lines* is shown in Table 1.

Table 1. Preliminary Inventory

	Preliminary Identification of Lead Service Lines	
Service Type	July 11, 2019	August 7, 2019
Known LSL	1,118	926
Suspected LSL	63,597	62,816
Possible LSL	36,533	36,388
Unlikely LSL	83,543	83,312
Not LSL	150,666	152,015
Total Services	335,457	335,457
Lead Service Lines	75,036	72,158

III. METHODOLOGY

Additional detailed records analysis of the *Preliminary Identification of Lead Service Lines* inventory was completed, which resulted in an update to the estimated lead service line inventory. The purpose of this Technical Memorandum is to document the analysis and refinements to the inventory. The framework for the analysis is as follows:

Category A: Service Lines Removed from Inventory

- Re-evaluation of source information
- Resolution of data discrepancies from different record systems

Category B: Adjustment to the Probability of Lead

- Adjustment based on evaluation of baseline data and new data
- Modification of rules due geographic applicability of the logic
- Resolution due to data discrepancies

Category C: Service Lines Excluded from Filter Program

- Inactive accounts
- Vacancies
- Service lines not associated with a parcel
- Water use types

This update documented is through defined accounting procedures and replaces the numbers estimated in the lead service line inventory dated July 11, 2019.

IV. VERSION CONTROL

The starting point for our analysis is the results from the Technical Memorandum titled *Preliminary Identification of Lead Service Lines* prepared by Corona Environmental Consulting dated August 7, 2019 (included as ATTACHMENT 1).

The new analytics applied to the lead service line inventory allotted the necessity to manage tracking of changes for version control and tracking for changes in the inventory. In order to manage changes between version, new rules were added as follows:

Rules for Removing or Updating Records

Two additional fields were added to the lead service line inventory to prevent double-counting of a service line which may be included in multiple categories. The two additional fields include:

1. **lsli_remove_20190802** is a flag if a record is removed (Category A)
   - 1 if removed, 0 if not
2. **lsli_update_20190802** is a flag if a record is updated (Category B)
   - 1 if updated, 0 if not

Updates to the inventory were applied using the two flags in the order as presented herein. The two flags were applied to ensure that a record is only counted for removal or update the first time it is encountered during the sequence of data processing.

V. CATEGORY A: ANALYSIS AND FINDINGS

A review of the source data to develop the lead service line inventory compared to the output identified locations that needed further refinement based on the outcome of the probabilities of lead.

A.1 – Distributor Contracts

In May 2019, a list of Distributor Contracts was annotated by Denver Water (MS Excel file ISA_LSL_Clarification_Final20190507.xlsx) to identify service lines that should be

included in the inventory. Denver Water provided data for the initial inventory that included Distributor Contracts noted as "Include in LSL Inventory".

A further analysis was completed to confirm service lines associated with Distribution Contract are captured in the inventory, which is highlighted below.

- *A.1.1 – Raw Water (4,489 removed)*

  A geographic review of the inventory with Denver Water staff identified the inclusion of service lines from North Table Mountain Water and Sanitation District (NTMWSD). Although NTMWSD contract (M169) was listed as "Include in LSL Inventory", it was determined that the NTMWSD contract (M169) is for Raw Water only.

  Denver Water provides the Raw Water distributors with untreated raw water only and Denver Water is not responsible for distribution water quality. The distributor is responsible for treating and delivering the water. Service lines associated with "Raw Water" distributors are not included in the lead service line inventory.

  As such, 4,489 service lines associated with NTMWSD contract (M169) were removed from the inventory.

- *A.1.2 – Emergency Connections (3 removed)*

  A search of records that have Distributor Contracts listed as "Include in LSL Inventory" was completed. The initial inventory included three (3) service lines identified with E000 - Emergency Interconnect.

  In some cases, water is provided to distributors or neighboring cities during emergency scenarios (main break, major fire, etc.) through an emergency connection. Under normal operations, the distributor is responsible for treating and delivering the water. Service lines associated with "Emergency Connection" distributors are not be included in the inventory.

  Three service lines (X34069(6"), 335073 (16"), X25117B (6")) with Distributor Contract E000 were removed from the inventory.

Based upon the above, Denver Water reviewed and confirmed the updated Distributor Contracts noted as "Include in LSL Inventory" (ISA_LSL_Clarification_Update20190723.xlsx).

A.2 – Service Point Types, Irrigation (3,166 removed)

Denver Water uses the service point type field to identify the use of water associated with a customer's service line. In some cases, water use defined by service point type is not for drinking. In May 2019, Denver Water identified service point types that should be included in the inventory, which are listed in Table 2.

Table 2. Service Point Types as Selected by Denver Water May 2019

Service Point (SP) Type	SP Type Description	Selected for LSLI
TAP-BHMM	TAP Behind Master Meter	X
TAP-BBYF	TAP Behind Master Meter Bypass Meter Fire Line	
TAP-BCOM	TAP Behind Master Meter Commercial	X
TAP-BFIR	TAP Behind Master Meter Fire Line (non-metered)	
TAP-BIRR	TAP Behind Master Meter Irrigation	X
TAP-BMFM	TAP Behind Master Meter Multi-Family	X
TAP-BRES	TAP Behind Master Meter Residential	X
TAP-BYFL	TAP Bypass Meter Fire Line	
TAP-COM	TAP Commercial	X
TAP-EMCY	TAP Emergency Interconnect	X
TAP-FIRE	TAP Fire Line (non-metered)	
TAP-IRR	TAP Irrigation	X
TAP-MAST	TAP Master Meter	X
TAP-MFM	TAP Multi-Family	X
TAP-RAW	TAP Non-Potable/Raw Water	
TAP-PLAN	TAP Planning	
TAP-QUAL	TAP Quality Control	
TAP-RECY	TAP Recycled Water	
TAP-RES	TAP Residential	X
TAP-TEMP	TAP Temporary	

Further evaluation of service point type records was completed. Multiple service point types may be associated with a single service line.

It was concluded by Denver Water that irrigation services should be excluded from the inventory, as follows:

- service point type = “TAP-IRR” and no other service point types listed; or
- service point type = “TAP-IRR” and all other service point types are also excluded from the inventory, as noted in Table 2.

Irrigation services do not fall into the guidelines of the LRP – their service point type is not for drinking and they should be removed from the inventory.

Denver Water will implement a policy that prevents the reclassification of existing “TAP-IRR” services to a service point type for drinking unless there is confirmation of non-lead service or replacement of the lead service. In addition, COE efforts will be completed to educate on why not to use irrigation for water consumption.

The results of this analysis identified 3,444 service lines as "TAP-IRR". However, 278 had another service point type that fit the criteria in Table 2 and these service lines should remain in the inventory. The remaining 3,166 service lines were removed from the inventory.

A.3 – Data Reconciliation (8,099 removed)

Denver Water provided data for the initial inventory from multiple sources. The initial inventory did not include data from Denver Water's internal tap lifecycle status fields. Denver Water uses tap lifecycle status fields to record information on service line tap work completed. However, other departments such as Water Sales routinely use other internal fields, such as additional address fields to add notes about lifecycle status. Based upon a review by Denver Water of these additional tap lifecycle status fields, it was concluded that services lines with a tap lifecycle status indicating "Cancelled Stub-in"; "Cancelled Tap"; "Customer Cancelled"; "Tap Cut"; and "License Change – See New Tap" indicate cut, cancelled, replaced, or non-drinking use water service lines which should be removed from the inventory. Some of these services may have been active once but per Denver Water these service lines currently are not in service. These premises will be flagged by Denver Water to not become active service lines in the future until the service line is confirmed non-lead or a new service is installed. Since tap lifecycle status fields are from different sources, Denver Water developed a list of suspect service lines, falling into the following four broad data fields from the records:

1. *A.3.1 – Resident ID (3,463 removed)* - The field indicated cut, cancelled, or replaced service line.
2. *A.3.2 – Address Line 4 (41 removed)* - The field indicated service line cut, abolished, or fire line.
3. *A.3.3 – Tap Remarks (3,610 removed)* - The field indicated service line cancelled or cut.
4. *A.3.4 – Data Source Combination (3,015 removed)* - The tap lifecycle status and other fields indicated abolished or disconnected.

The Water Sales group within Denver Water will continue to investigate these service lines. This is a manual desktop review of various data sets and it is expected for this to be completed by October 2019. An initial review by Denver Water indicates that approximately 80-90% of the manual reviews confirmed that the service line should be removed from the inventory. At most 10-20% of the service lines identified for removal could be re-added to the inventory. Accordingly, a 20% contingency was applied to account for this possibility, resulting in the inclusion of 2,030 service lines as item A.3.5. However, the best information available at present indicates these service lines should be removed from the inventory.

- *A.3.5 – 20% Readjustment (2,030 added)* – Contingency for re-added service lines.

VI. CATEGORY B: ANALYSIS AND FINDINGS

B.1 – Service Line Replacements (189 adjusted)

Denver Water confirmed that service line replacement work completed after July 2016 was a full replacement (water main to house). As such, service lines with a "Replaced Date" after July 2016 were changed to have a p-value of "0".

B.2 – Manifolds (1,191 adjusted)

A geographic review of the initial inventory identified some recently developed areas having a high probability of lead. Based upon further review of the data in those areas, a "." entry for the "Tap Date" was identified. Denver Water confirmed that service lines with a "." entry for the "Tap Date" indicates that the service line is tracked as part of a manifold. Denver Water provided a list of parent and child service lines. The parent manifold tap date is provided as the "Tap Date" for the child and the p-value has been updated using the logic rules 31-37 as noted in the *Preliminary Identification of Lead Service Lines*.

- *B.2.1 – Manifolds with Tap Date (1,143 adjusted)*
  1,144 service line p-values were updated due to having a "." entry for the "Tap Date".
- *B.2.2 – Manifolds without Tap Date (48 adjusted)*
  48 service lines were updated based on the parcel date alone.

B.3 – Geographic Considerations (Littleton) (3,846 adjusted)

A geographic review of the initial inventory identified some recently developed areas with results having a high probability of lead. Upon further review, the initial inventory of service lines in the Littleton service area were identified as having the same "Tap Date" of 1971. Denver Water's evaluation of this record determined that 1971 was the year Littleton entered into a service agreement with Denver Water and is not reflective of the actual "Tap Year". For this reason, the processing performed for the initial inventory removed this tap year. In lieu of using "Tap Year", the "Parcel Year Built" will be used for Littleton as an indicator of the likelihood of a lead service line using the logic rules 31-37 as noted in the *Preliminary Identification of Lead Service Lines*. In addition, to ensure that re-developed properties that were originally built prior to 1952 were not included in the adjustment, only those service lines with a "GIS Main Install Year" and "GIS Abandoned Main Year" greater than 1951 (if present) were adjusted. Based upon the above, resulting analysis included 3,846 adjustments to p-values.

B.4 – Scrape-Offs (783 adjusted)

A geographic review of the initial inventory identified services in areas under development with high probability of lead, which are known as scrape-offs. Recent aerial photography was utilized to confirm development. Denver Water maintains a database tracking "scrape-offs" in the City and County of Denver as far back as 2013. Starting in July 2016, Denver Water required full-service line replacement (water main to house) for all scrape-offs.

- *B.4.1 – Completed Scrape-Offs (779 adjusted)*
  Service lines located at a post July 2016 scrape-off are considered "non-lead" (p value = 0), resulting in 783 p-value adjustments (779 are completed, 4 are pending). The inclusion in the post-July 2016 scrape-off list takes precedence over the tap date to assign the p-value.
- *B.4.2 – Pending Scrape-Offs (4 adjusted)*
  Pending scrape-offs were only included if there was a one-to-one relationship between the premise ID and the tap number, since the provided list of pending scrape-offs included only a premise ID and not the tap number.

B.5 – Tap and Parcel Year Mismatched (5,045 adjusted)

The initial inventory applied a conservative set of logic rules to analyze the lead service line inventory for conflicting date ranges for "Parcel Built Year" and the "Tap Year". When both the "Parcel Built Year" and the "Tap Year" are after 1951 but one or the other is before 1958, a year mismatch resulted and a p-value of 0.5 was applied according to rule 38 in the *Preliminary Identification of Lead Service Lines*. However, if both the tap year and parcel year are after 1951, the likelihood of lead is very low and should have a similar probability of lead as those service lines subject to rule 34 (where both the parcel year and tap year are between 1952 and 1958) in the *Preliminary Identification of Lead Service Lines*. Like the B.3 adjustment, p-value adjustments were only made to service lines where the "GIS Main Install Year" and "GIS Abandoned Main Year" were both after 1951 to ensure that older redeveloped properties that could have a lead service line are not included in the adjustment. Accordingly, the p-values for the 5,045 service lines with a mismatched tap and parcel year have been updated to "0.03" to reflect the low likelihood of a lead service line.

B.6 – Geographic Considerations (District 11) (59 adjusted)

A geographic review of the initial inventory identified some recently developed areas having a high probability of lead. Development in Denver Council District 11 primarily occurred after 1971, with the construction of Denver International Airport and the redevelopment of the Stapleton area. Based upon further review of the data, several service lines in District 11 were missing a tap year and were therefore categorized with p-value showing possibility of lead. Evaluation of the records with a missing tap year indicates lead is highly unlikely. Due to the inconsistency of this record (tap year) in

District 11, the "Parcel Year Built" field was the primary field used to evaluate the probability of lead resulting in an update to the p-value using the logic rules 31-37 as noted in the *Preliminary Identification of Lead Service Lines*. This analysis caused 59 service lines to have their p-values adjusted (after the previous adjustments). A remaining eight service lines with no parcel year or tap year remain in the dataset due to insufficient records to determine their likelihood of lead. Further record review and investigation will be needed to identify their status in the lead service line inventory.

B.7 – Systems Data Exchange Integration (Default: 01/01/1901 Tap Date) (225 adjusted)

Data processing between systems may have resulted in a date conversion error based on the manner that different systems interpreted field types and null values. During data migration, the date field defaulted to populate cells with no data with 01/01/1901. In conjunction with a Denver Water geographic review of areas that should not have a high probability of lead, fields with 01/01/1901 taps dates were reviewed to verify this date. It was established that the 01/01/1901 date is an error in data transfer. It was concluded that service lines with a "Tap Date" of 01/01/1901 will prioritize the "Parcel Year Built" and "GIS Main Install Year" as the primary fields to determine the probability of lead (p-value) instead of the "Tap Date" field. Based on the evaluation of these records, adjustments to the inventory are as follows:

- *B.7.1 – Parcel and GIS Main After 1972 (62 adjusted)*
- *B.7.2 – Parcel and GIS Main After 1952 (163 adjusted)*

B.8 Distributor Evidence (207 adjusted)

Additional information from the City of Edgewater indicated that some service line replacements were in fact only partial replacements. Information from the provided Excel file "edgewater_Lead_Line_Replacements_2014.xlsx" was used to assign a p-value of "1" to service lines known to have lead material between the meter and the premise while others were assigned p-value "0.5" indicating uncertainty with further investigation required. This analysis resulted in adjustments of the p-value to 207 service lines.

B.9 Potholing Data (20 adjusted)

In 2019, Denver Water began performing field investigations by "potholing" service lines to determine the service material type. The standardization of potholing efforts is evolving, and past work completed may not identify when a service line transitions from one material to another. As a result, pothole information was used to confirm lead and assign a p-value of "1" to 20 service lines. However, determination of a different material resulted in no change to the p-value. In other words, potholing information can confirm a lead service line but is not applied to confirm a non-lead service line. Future investigation

will use other available information such as water quality results to better estimate locations with a non-lead service line.

B.10 Water Quality (37 adjusted)

Denver Water has two primary sources of water quality data showing lead levels in the customer's plumbing / service line: Lead and Copper Rule (LCR) compliance testing, and Customer Service (CS) requested testing. The LCR tests involves first draw single liter test results, while CS tests involve a series of three one-liter tests to determine lead levels through the customer's plumbing and service line. Review of the available LCR data from 1997 to the present proved inconclusive as elevated lead levels in the first liter can indicate an issue with customer plumbing (e.g. brass fixtures or lead solder) independent of the presence of a lead service line. Alternatively, the CS data were well-suited to estimating the presence of a lead service line. Using the most recent test at each testing site, a p-value of "0.8" was assigned to all tests where the second or third bottle had a result of 5 µg/L or higher. P-values were only adjusted when the pre-existing p-value was less than 0.8. Like B.9 potholing data, water quality information is not currently being applied to confirm a non-lead service line. This analysis resulted in p-value changes to 37 service lines. Further investigation will be performed to incorporate LCR water quality data, including investigation to determine if water quality testing can be used to identify premises with copper with lead solder.

B.11 Universal Metering (none adjusted)

A universal metering project was completed in 1989-90 and the meter installation worksheets included observations of service line material type. A database from the scanned meter installation worksheets from the universal metering project was completed by Denver Water. Review of these records indicated the following:

- Eight (8) service lines identified as lead, however these lines were already listed in the inventory with a p-value ≥ 0.8.
- 1,127 lines identified as galvanized
    - 183 services have a current p-value <0.5.
- 783 service lines were identified as copper
    - 458 have a p-value >= 0.5.

Since many records have information contradicting other information sources, data from the universal metering program was not used to confirm a non-lead service line at this time. No adjustments were made.

VII. CATEGORY C: ANALYSIS AND FINDINGS

This category consists of identifying service lines that do not directly affect activities related to the Filter Program and/or are a low priority for Accelerated Lead Service Line Replacement (ALSLR). These service lines include those associated with inactive customer accounts, vacant properties, and others that are not used for drinking water.

Service lines identified in Category C will be fully developed by October 2019, prior to the implementation of the Filter Program. These service lines will remain a part of the lead service line inventory and Denver Water will track for future administrative action when the status changes.

C.1 – Inactive Customer Accounts

If there is no water use at a property for an extended period, the service is shut-off at the meter / curb stop and the customer account is considered inactive. A review of the Denver Water customer account status (active/inactive) shows that 3,918 service lines in the lead service line inventory are inactive. On August 7, 2019, the number of inactive service lines is 2,718. Identifying and tracking active/inactive customer service accounts will be integrated into the program. Filters will not be distributed to inactive customer accounts and they will not be prioritized for ALSLR.

C.2 – Vacant Property

Vacant properties were considered for removal when determining the lead service line inventory, as their service lines are not in use. Because service lines may not remain vacant, they are preserved in the lead service line inventory, though filter distribution is not required at vacant properties. Identifying and tracking vacant properties will be integrated into the program. Filters will not be distributed to vacant properties and they will not be prioritized for ALSLR.

C.3 – Service Lines Not Associated with a Parcel

Geographic inspection of some service lines indicates that some service lines do not seem to be associated with a parcel. Denver Water has begun a review of geolocation results and may recommend action based on the results of this analysis. However, no action is taken at present. Reconciling these service lines is expected to be completed by October 2019. Filter distribution may not be required for these service lines if there is no identifiable entity to receive a filter.

C.4 – Fire Lines and Hydrants

Service lines associated with fire lines and hydrants have been flagged for further review. Service lines identified in these categories have not been removed as the evaluation of these service lines has not ruled out splices to properties services or association with other

service types on the same service line that are to be included in the inventory. These service lines will be reviewed on a case by case basis for inclusion in the lead service line inventory.

VIII. RESULTS

The *Preliminary Identification of Lead Service Lines* inventory included 335,457 service lines and an estimated 72,158 lead service lines. As part of this analysis,

- Removals documented in category A resulted in an inventory reduction of 15,757 service lines, resulting in a service line total of 319,700.
- The adjustments in category B resulted in revised p-values for 11,602 service lines.
- Based upon the above, the inventory estimate of lead service lines is 63,955.

Table 3 below highlights the service line inventory breakdown from July 11, 2019 to date.

Table 3. Refinement to Inventory - Summary

	Preliminary Identification of Lead Service Lines		Refinement of Inventory
Service Type	July 11, 2019	August 7, 2019	August 8, 2019
Known LSL	1,118	926	1,066
Suspected LSL	63,597	62,816	61,374
Possible LSL	36,533	36,388	22,106
Unlikely LSL	83,543	83,312	89,388
Not LSL	150,666	152,015	145,766
Total Services	335,457	335,457	319,700
Lead Service Lines	75,036	72,158	63,955

Tables 4, 5, 6 & 7 on the following pages provides a detailed breakdown of removals and adjustments to the lead service line inventory.

Service lines identified in Category C will be fully developed by October 2019, prior to the implementation of the Filter Program. These service lines will remain a part of the lead service line inventory and Denver Water will track for future administrative action when the status changes.

Table 4. Refinement to Inventory – Service Lines Removed

	Refinement to Inventory	
Update Description	Service Lines Removed	Change in LSLI
A.1) Distributor Contracts - Removed Raw Water / Emergency Connections	-4,492	-391
A.2) Removed Irrigation Only Services	-3,166	-199
A.3) Removed Service Lines with Tap Lifecycle Status = Service Line Cut, Cancelled, Abolished, Replaced, etc.	-8,099	-2,024
	-15,757	-2,614

Table 5. Refinement to Inventory – p-value Adjustments

	Refinement to Inventory	
Update Description	p-value Adjustments	Change in LSLI
B.1) Recent Service Line Replacements	189	-106
B.2) Newer Service Lines Have Manifolds: Use Parent Tap Year or Parcel Year Built	1,191	-595
B.3) Littleton Tap Year was 1971: Use Parcel Year Built & Main Install Date	3,846	-1,923
B.4) Scrape-offs	783	-500
B.5) Tap Year and Parcel Year > 1951 Adjusted to p-value <0.5	5,045	-2,523
B.6) District 11 (newer development)	59	-29
B.7) Data Exchange Had 01/01/1901 Tap Date: Use Parcel Year Built & Main Install Date	225	-112
B.8) New Data - City of Edgewater	207	180
B.9) Potholing Data	20	4
B.10) Water Quality Data	37	15
		-5,589

Table 6. Refinement to Inventory – Details Removals and p-value Adjustments

Key
A: removed from LSI, Filters and ALSLR
B: p-value adjustment - remain in LSI, Filters and ALSLR

			p-value											
			1	0.9	0.8	0.7	0.5	0.05	0.04	0.03	0.02	0.01	0	
			Known	Suspected			Possible	Unlikely					Not lead	Total
		July 31, 2019 Inventory	926	28,417	33,837	562	36,388	766	637	31,383	46,869	3,657	152,015	335,457
				62,816				83,312						
Distributor Contracts	A.1.1	Raw Water	-	-	-	(1)	(782)	(1)	(83)	(190)	(753)	-	(2,679)	(4,489)
				(1)				(1,027)						
	A.1.2	Emergency Connections	-	-	-	-	-	-	-	-	-	-	(3)	(3)
				-				-						
Service Point Types	A.2	Irrigation	-	(17)	(25)	(8)	(319)	(55)	(15)	(452)	(35)	(1,391)	(849)	(3,166)
				(50)				(1,948)						
Data Reconciliation	A.3.1	Resident ID	(4)	(137)	(114)	(70)	(1,132)	(54)	(88)	(394)	(134)	(79)	(1,257)	(3,463)
				(321)				(749)						
	A.3.2	Address Line 4	-	(1)	(7)	-	(6)	-	-	-	(1)	(4)	(22)	(41)
				(8)				(5)						
	A.3.3	Tap Remarks	(4)	(65)	(86)	(46)	(1,419)	(23)	(22)	(108)	(160)	(46)	(1,631)	(3,610)
				(197)				(359)						
	A.3.4	Data Source Combination	(7)	(252)	(279)	(21)	(691)	(22)	(8)	(98)	(91)	(110)	(1,436)	(3,015)
				(552)				(329)						
	A.3.5	20% Readjustment	3	91	98	28	650	20	24	120	78	48	870	2,030
				217				290						
Service Line Replacements	B.1	Service Line Replacements	(18)	(51)	(44)	(1)	(14)	(3)	-	(24)	(33)	(1)	189	-
				(96)				(61)						
Manifolds	B.2.1	Manifolds with Tap Date	-	-	-	-	(1,143)	-	-	635	508	-	-	-
				-				1,143						
	B.2.2	Manifolds w/o Tap Date	-	-	-	-	(48)	3	-	45	-	-	-	-
				-				48						
Geographic Considerations	B.3	Littleton	-	-	-	-	(3,846)	1,568	2,131	147	-	-	-	-
				-				3,846						
Scrape-Offs	B.4.1	Completed Scrape-Offs	(2)	(226)	(218)	(11)	(224)	(9)	(2)	(36)	(43)	(8)	779	-
				(455)				(98)						
	B.4.2	Pending Scrape-Offs	-	-	-	-	(2)	-	-	(1)	(1)	-	4	-
				-				(2)						
Tap and Parcel Year	B.5	Tap and Parcel Year Mismatched	-	-	-	-	(5,045)	-	-	5,045	-	-	-	-
				-				5,045						
Geographic Considerations	B.6	District 11	-	-	-	-	(59)	-	-	-	59	-	-	-
				-				59						
Systems Data Exchange Integration	B.7.1	Parcel and GIS Main >= 1972	-	-	-	-	(62)	-	-	-	-	62	-	-
				-				62						
	B.7.2	Parcel and GIS Main >= 1952	-	-	-	-	(163)	-	-	163	-	-	-	-
				-				163						
Distributor Evidence	B.8	Distributor Evidence	152	-	-	-	55	-	-	-	-	-	(207)	-
				-				-						
Potholing Data	B.9	Potholing Data	20	(5)	(10)	-	(5)	-	-	-	-	-	-	-
				(15)				-						
Water Quality	B.10	Water Quality	-	-	37	(1)	(27)	-	-	(1)	(1)	-	(7)	-
				36				(2)						
Universal Metering	B.11	Universal Metering Records	-	-	-	-	-	-	-	-	-	-	-	-
				-				-						

Table 7. Refinement to Inventory – Lead Service Line Inventory Details

	p-value											Total
	1	0.9	0.8	0.7	0.5	0.05	0.04	0.03	0.02	0.01	0	
Total Service Line Inventory	1,066	27,754	33,189	431	22,106	2,190	2,574	36,234	46,262	2,128	145,766	319,700
	Known	Suspected			Possible	Unlikely					Not lead	Total
	1,066	61,374			22,106	89,388					145,766	319,700
Change from Preliminary Inventory	140	(663)	(648)	(131)	(14,282)	1,424	1,937	4,851	(607)	(1,529)	(6,249)	(15,757)
Updated LSLI*	1,066	24,979	26,553	303	11,054						-	63,955
	Known	Suspected			Possible						Not lead	Total
	1,066	51,835			11,054						-	63,955

* = Total Service Line Inventory X p-value when p-value >= 0.5

ATTACHMENT 1 TO APPENDIX III.B.2:

Preliminary Identification of Lead Service Lines

Date:	Revised August 16, 2019 March 21, 2019
To:	Denver Water
From:	Corona Environmental Consulting, LLC

Background

The purpose of this Technical Memorandum is to present how the estimate of lead service lines (LSLs) was generated. An inventory of LSLs is needed to determine how many and where to deploy point-of-use filters as well as determine how many LSLs must be replaced each year. The inventory is also used in the Lead Exposure Model to compare the effectiveness of the variance versus OCCT of orthophosphate for public health protection.

This estimate of LSLs in Denver Water's integrated system is based on data available from several sources available at each tap. No fieldwork has been performed to verify this effort to date. While the logic has been substantiated, and the mapping results appear to match our expectations, the estimate is only as good as the underlying data. No warranty is expressed or implied that these data are correct. These data represent the best available information.

Data Sources

Data used in this effort were aggregated from multiple sources. Data used are summarized in the following table:

Data	Use	Source
OM Current	Data from the field recorded in CCB, reported to O&M. Includes >=2018. Current service line material	CCB
OM Previous	Data from the field recorded in CCB, reported to O&M. Includes >=2018. Previous service line material	CCB
PBCU SERVICE	Service line material from LCR Sample Sites materials survey	Water Quality
ARG Full/Partial	ARG historical data. Goes up to 2018. Records of full and partial service line replacements.	ARG
Year Built	The year the parcel was developed.	Counties
Year Tapped	Year the tap was made to the main.	CCB
Main Install Date	Year the main was constructed.	ARG
Tap Size	Tap size.	CCB
Service Line Size	Service line size. Lead was rarely used for large diameters.	CCB
Distributor Name	Distributor name.	CCB
Service Area	Service area.	CCB
WQ Count	Number of lead samples at the tap.	Water Quality
WQ Max	Highest concentration of lead at the tap.	Water Quality
WQ Avg	Average concentration of lead at the tap.	Water Quality
Tap Cut Date	Full date of the tap cut.	CCB
Aban Install Date	Date the first time a water main was available to tap.	ARG

Data Preparation and Clean-up

1. File contains 335,457 records of taps that are for active, treated water. Provided by Denver Water GIS on 6/17/2019.
   Read in additional file of service line replacement dates, provided by Denver Water on 7/12/2019. Keep only Tap.Number and Date.Replaced and remove duplicates.
   Files merged into one dataframe by Tap.Number.
2. Created three new fields:
   - "p-value" the probability that the service has some lead materials. For example, a p-value of 0 indicates that tap does not contain lead, and a p-value of 1 indicates that a tap does contain lead. A for the p-values of 0.5, half of them would be expected to contain lead. The p-value will be used to produce a numeric estimate of the total number of LSLs in the Denver Water service area.
   - "Category" the categorical classification of the likelihood of an LSL. This should be used for communicating the results.

- "Basis" which reports what data was used in the p-value and categorical determination. This is used to supplement our knowledge of the estimate.

3. Populate new "CCB.Service.Line.Type" column with "OM_Current" information. Service line material reflected in this field did not always reflect the material from the main to the house, depending on the main install year and service line replacement date.
    a. Populate column with abbreviated service line material. For example: "Copper meter to main, Lead meter to house" becomes "COPPLEAD"
    b. For records with Main Install Date before 2010, change to UNKUNK unless they are lead or galvanized. Complete service line replacement during main installs and replacements was not standard practice at this time.
    c. For records from 2010 to 2016, change to COPPUNK unless they are lead or galvanized. Lines were typically replaced only to the property line during this time period.
    d. For records 2016 and later, change any COPPUNK, UNKUNK, and UNKCOPP to COPPCOPP. Service lines were replaced entirely beginning in 2016.
    e. Repeat steps b-d using Date Replaced. This overrides all previous assignments; the replacement date is considered more accurate.
4. Prioritize distributor provided tap dates when possible. These records are presumed to be more accurate than Denver Water records.
    a. Rename "TappedYear" column "DW_TappedYear"
    b. Create new "TappedYear" column that populates first with "D_ISA_Tapped_Date" then with "DW_TappedYear"
5. Clean up City of Littleton data. 1971 was the year Littleton became part of the integrated system and some data reflects that rather than the actual tap or main install dates. The dates being removed were selected based on large peaks in the number of records on a specific date close to 1971.
    a. Filtered by "DistributorName" for "City of Littleton". Deleted all "TappedYear" and "TappedDate" with "TappedDate" = 01-01-1971. 4,727 records.
    b. Filtered by "DistributorName" for "City of Littleton". Deleted all "GISMainInstallYear" and "GISMainInstallDate" with "GISMainInstallDate" = 05-12-1970. 1,821 records.
    c. Filtered by "DistributorName" for "City of Littleton". Deleted all "GISAbanMainInstallYear" and "GISAbanMainInstallDate" with "GISAbanMainInstallDate" = 05-12-1970. 48 records.

Estimation Procedure

The estimation procedure can be outlined as follows:

- Identify service lines where there is a record of observation (direct evidence) of the service line material
- Service lines installed before 1950 were required to be lead. However, a portion of those LSLs will have been replaced with non-lead materials.
- In 1971, lead was prohibited as a service line material. Services after this date are considered to not contain any lead.
- Services installed between 1950 and 1971 will have a low rate of lead occurrence. Lead had already fallen out of favor for service lines by the time Denver Water allowed use of other materials in mid-1949.
- Denver Water has some records on full and partial replacements that they have made.

- The model is further refined with data from retail areas in the integrated system and other evidence that is available (e.g. water quality tests).

The detailed procedure follows.

Use CCB OM records first because these records are considered the most accurate by Denver Water. These are completed by field workers on leak repairs and line replacements.

1. Filtered by "CCB.Service.Line.Type" for "COPPLEAD", "LEADLEAD", "LEADCOPP", or "LEADUNK".

p-value	Category	Basis	No. Records
1	Known LSL	Direct Evidence	29

   These records were not considered further in the analysis based on other data. This data field is considered to be known when complete and contains the most reliable records.

2. Filtered by "CCB.Service.Line.Type" for "COPPGALV" and "OM_Previous" to "Lead meter to main, galvanized meter to house". These are considered to behave as LSL.

p-value	Category	Basis	No. Records
1	Known LSL	Direct Evidence	5

   These records were not considered further in the analysis based on other data. This data field is considered to be known when complete.

3. Filtered by "CCB.Service.Line.Type" for "COPPCOPP".

p-value	Category	Basis	No. Records
0	Not lead	Direct Evidence	10,189

   These records were not considered further in the analysis based on other data. This data field is considered to be known when complete.

Incorporate the pool of LCR monitoring sites which have had a materials survey.

4. Filtered by "PBCU_SERVICE" for "PB".

p-value	Category	Basis	No. Records
1	Known LSL	Direct Evidence	142

   These records were not considered further in the analysis based on other data. This data field is considered to be known when complete.

5. Filtered by "PBCU_SERVICE" for "CU".

p-value	Category	Basis	No. Records
0	Not Lead	Direct Evidence	117

   These records were not considered further in the analysis based on other data. This data field is considered to be known when complete.

Use ARG records next because they are direct evidence, but tend to be not as accurate as CCB records because the recordkeeping shifted from ARG to CCB a few years ago and may be dated.

6. Filtered by “ARG_FullPartial” for “Partial”.

p-value	Category	Basis	No. Records
1	Known LSL	Direct Evidence	146

These records were not considered further in the analysis based on other data. This data field is considered to be known when complete, but “CCB.Service.Line.Type” takes precedence. “Full” was not used because the definition of a “full replacement” has changed over time. At times in the past, “full replacement” may have referred to meter to main only.

Incorporate records from retail customers.

7. Filtered by “D_Confirmed_Copper” for “Y”. This column was added to the database to reflect results of the ISA survey conducted by Denver Water. Records were assigned “Y” when distributors verified the line was copper based on visual inspection, detailed records, or distributor policies.

p-value	Category	Basis	No. Records
0	Not Lead	Distributor Evidence	447

8. Filtered by “DistributorContractDesc” for North Washington, City of Edgewater, and Crestview. These distributors have verified that there are no LSLs in their service areas. North Washington and Crestview first installed water service lines in 1954; the lines were required to be copper. In addition, both areas have completed extensive main replacements recently and did not discover lead services. Edgewater completed potholing of all lines and replaced lead lines in 2014.

p-value	Category	Basis	No. Records
0	Not Lead	Distributor Evidence	9,898

9. Filtered by “DistributorContractDesc” for City of Glendale and “TappedYear”>1952. Glendale was incorporated in 1952 and has never allowed LSLs.

p-value	Category	Basis	No. Records
0	Not Lead	Distributor Evidence	260

10. Filtered by “DistributorContractDesc” for Cherry Creek Valley and “TappedYear”>1961. Cherry Creek Valley was formed in 1961 and has never allowed LSLs.

p-value	Category	Basis	No. Records
0	Not Lead	Distributor Evidence	2,486

11. Filtered by “DistributorContractDesc” for North Pecos and “TappedYear”>=1967. North Pecos was formed in the mid-1960s and has used only copper lines.

p-value	Category	Basis	No. Records
0	Not Lead	Distributor Evidence	463

12. Filtered by “DistributorContractDesc” for Valley Water District and “TappedYear”>1957. The District was connected in 1957 and has no known lead.

p-value	Category	Basis	No. Records
0	Not Lead	Distributor Evidence	1,842

13. Filtered by “DistributorContractDesc” for Southgate Water District and “TappedYear”>1961. Southgate formed in 1961 and all records indicate that lines are copper or poly.

p-value	Category	Basis	No. Records
0	Not Lead	Distributor Evidence	11,356

14. Filtered by “DistributorContractDesc” for Meadowbrook and Willowbrook and “TappedYear”>=1964. Neither district allowed lead from 1964 forward. DW tap dates on older homes in the area were checked against tap permit records by the Districts and found to be matching.

p-value	Category	Basis	No. Records
0	Not Lead	Distributor Evidence	5,242

Identify service lines first installed after lead was prohibited. Records in this category with a water quality sample result indicative of an LSL is considered to be a positive identification.

15. Filtered by “ParcelYearBuilt” for years 1972 to present and “TappedYear” for years 1972 to present.

p-value	Category	Basis	No. Records
0	Not Lead	Post No Lead	108,676

16. Filtered by “ParcelYearBuilt” & “TappedYear” for years 1951 and earlier. Filtered by for those with 3 or more lead samples. Considered an average lead concentration >=5 ppb conclusive evidence of an LSL.

p-value	Category	Basis	No. Records
1	Known LSL	pre 1952, WQ results	604

To this point, the information used is considered as an inventory. 151,902of the 335,457 services under consideration have been assigned (45%). 926 LSLs, 150,976non-LSLs.

The following steps have two recorded dates <=1951 and 1/2” or 5/8” service line sizes. Services lines in these sizes during this time period are indicative of lead; however, evidence shows that size records are less likely to be updated when lines are replaced.

17. Sort for records with “ParcelYearBuilt” and “TappedYear” <=1951 and “ServiceLineSize” of 1/2 or 5/8.

p-value	Category	Basis	No. Records
0.9	Suspected Lead	5/8 or 1/2 Service, pre 1952	28,329

18. Sort for records with no “ParcelYearBuilt” and “TappedYear” <=1951, “GISAbanMainInstallYear”<=1951 and “ServiceLineSize” of 1/2 or 5/8.

p-value	Category	Basis	No. Records
0.9	Suspected Lead	5/8 or 1/2 Service, pre 1952	13

19. Sort for records with no “ParcelYearBuilt” and “TappedYear” <=1951 , “GISMainInstallYear”<=1951, no “GISAbanMainInstallYear” and “ServiceLineSize” of 1/2 or 5/8.

p-value	Category	Basis	No. Records

0.9	Suspected Lead	5/8 or 1/2 Service, pre 1952	163

20. Sort for records with no “TappedYear” and “ParcelYearBuilt” <=1951 , “GISAbanMainInstallYear”<=1951 and “ServiceLineSize” of 1/2 or 5/8.

p-value	Category	Basis	No. Records
0.9	Suspected Lead	5/8 or 1/2 Service, pre 1952	0

21. Sort for records with no “TappedYear” and “ParcelYearBuilt”<=1951 , “GISMainInstallYear” <=1951, no “GISAbanMainInstallYear” and “ServiceLineSize” of 1/2 or 5/8.

p-value	Category	Basis	No. Records
0.9	Suspected Lead	5/8 or 1/2 Service, pre 1952	4

The following steps have two recorded dates <=1951. Denver Water required lead service lines until 1951 but does not have records of all service line replacements.

22. Filtered by “ParcelYearBuilt” for <=1951, and “TappedYear” for <=1951.

p-value	Category	Basis	No. Records
0.8	Suspected Lead	Build & Tap Date	33,750

23. Filtered by no “ParcelYearBuilt”, “TappedYear” for <=1951, and “GISAbanMainInstallYear” <=1951. The abandoned main install likely reflects the year the service line was installed, given that it is the date of the original main install.

p-value	Category	Basis	No. Records
0.8	Suspected Lead	Build & Tap Date	12

24. Filtered by no “ParcelYearBuilt”, “TappedYear” for <=1951, “GISMainInstallYear” <=1951, and no “GISAbanMainInstallYear”. For records that do not have an abandoned main install date, the main install year is the original install date.

p-value	Category	Basis	No. Records
0.8	Suspected Lead	Build & Tap Date	137

25. Filtered by no “TappedYear”, “ParcelYearBuilt” for <=1951, and “GISAbanMainInstallYear” <=1951.

p-value	Category	Basis	No. Records
0.8	Suspected Lead	Build & Tap Date	4

26. Filtered by no “TappedYear”, “ParcelYearBuilt” for <=1951, “GISMainInstallYear”<=1951, and no “GISAbanMainInstallYear”.

p-value	Category	Basis	No. Records
0.8	Suspected Lead	Build & Tap Date	22

The following steps have two recorded dates >=1972. Unlike the subset included in the inventory, the following records are missing either “ParcelYearBuilt” or “TappedYear” data and are therefore considered to be less certain.

27. Sort for records with no “ParcelYearBuilt” and “TappedYear” >=1972 and “GISAbanMainInstallYear” >= 1972

p-value	Category	Basis	No. Records
0.01	Unlikely Lead	Tap & Main Install Date	72

28. Sort for records with no “ParcelYearBuilt” and “TappedYear” >=1972 and “GISMainInstallYear”>= 1972 with no “GISAbanMainInstallYear”

p-value	Category	Basis	No. Records
0.01	Unlikely Lead	Tap & Main Install Date	3,317

29. Sort for records with no “TappedYear” and “ParcelYearBuilt”>=1972 and “GISAbanMainInstallYear” >= 1972

p-value	Category	Basis	No. Records
0.01	Unlikely Lead	Build & Main Install Date	20

30. Sort for records with no “TappedYear” and “ParcelYearBuilt”>=1972 and “GISMainInstallYear”>= 1972 with no “GISAbanMainInstallYear”

p-value	Category	Basis	No. Records
0.01	Unlikely Lead	Build & Main Install Date	434

The following steps have either “TappedYear” or “ParcelYearBuilt” information. Since fewer data are available, less certainty is applied than in previous steps.

31. Filtered by “TappedYear”<=1951 and no other dates. Later dates in other date categories indicate uncertainty as to when the current service line was installed.

p-value	Category	Basis	No. Records
0.7	Suspected Lead	Tap Date	277

32. Sort for records with “TappedYear”>=1972 and no “ParcelYearBuilt”. An early parcel build date could indicate that a new tap was installed without completely replacing the service line material.

p-value	Category	Basis	No. Records
0.03	Unlikely Lead	Date and Distributor	2,734

33. Filtered by ParcelYearBuilt<=1951 and no other dates. Later dates in other date categories indicate uncertainty as to when the current service line was installed.

p-value	Category	Basis	No. Records
0.7	Suspected Lead	Date and Distributor	323

The following steps work with the records that are between the last required lead year, 1951, and the first no lead year, 1972. During this time, lead was not commonly used. For this analysis, it is divided into two bins, surrounding the year 1958. 1958 was chosen based on the latest build date associated with a known LSL of 1956.

34. Filtered by “ParcelYearBuilt” for >1951 and <=1958, and “TappedYear” for >1951 and <=1958.

p-value	Category	Basis	No. Records
0.03	Unlikely Lead	Build & Tap Date	28,872

35. Filtered by “ParcelYearBuilt” for >1958, and “TappedYear” for >1958.

p-value	Category	Basis	No. Records
0.02	Unlikely Lead	Build & Tap Date	47,286

36. Filtered by “TappedYear” >1951 and <=1958 and no other dates

p-value	Category	Basis	No. Records
0.05	Unlikely Lead	Date and Distributor	237

37. Filtered by “TappedYear” >1958 and no other dates

p-value	Category	Basis	No. Records
0.04	Unlikely Lead	Date and Distributor	680

38. Unassigned records at this point consist of conflicting date ranges between threshold dates.

p-value	Category	Basis	No. Records
0.5	Possible Lead	Build & Tap Date	36,869

Adjust assigned values by removing the large diameters and main replacements.

39. Filter for “ServiceLineSize” & “TapSize” = 3 or 4 inches with an existing p-value > 0.05. Large diameters are rarely lead; however, LSLs up to 4 inches have been found.

p-value	Category	Basis	No. Records
0.05	Unlikely Lead	Build & Tap Date + Size	419

40. Filter for “ServiceLineSize” & “TapSize” >= 3 inches excluding records above.

p-value	Category	Basis	No. Records
0	Not Lead	Size	1,039

41. Filter for “GISMainInstallYear” after 1/1/2016 with p-value >0.5. Denver Water policy requires any LSL found during a main replacement after 1/1/2016 should be replaced to the first fitting in the building. However, Denver Water records and interviews indicate that the policy was not fully employed.
https://www.denverwater.org/project-updates/pipe-replacement

p-value	Category	Basis	No. Records
0.05	Unlikely Lead	Presumed replacement at scrape	133

Results

The results have been mapped by Denver Water GIS and the results are consistent with our expectations based on areas where LSLs are known to occur. The following table summarizes the number of taps in each category:

Service Type	Services
Known LSL	926
Suspected LSL	62,816
Possible LSL	36,388
Unlikely LSL	83,312
Not LSL	152,015

An estimate of the total number of lead service lines can be made by summing of the p-values greater than 0.5. This would indicate 72,158 LSLs in the Denver Water service area. However, it should be noted that the p-values assigned were based on consensus and judgment and not actual data. As the data becomes available, this estimate may be refined.

	Basis	LSLs	Non-LSLs	Total
Census	Direct Evidence	322	10,306	10,628
	Distributor Evidence	0	31,994	31,994
	Post No Lead	0	108,676	108,676
	Pre 1952 + WQ	604	0	604
Estimate	Build & Tap Dates	71,232	110,732	181,964
	Service Size	0	1,458	1,458
	Presumed Replacement	0	133	133
	Totals	**72,158**	**263,299**	**335,457**

Most of the probable LSLs are located in the core Denver Water service area. The Table below summarizes the occurrence of LSLs by service area.

Service Area	LSLs	Total	% LSL
Inside City	61,596	172,499	36%
Littleton	2,413	10,622	23%
SE Englewood	378	11,797	3%
Berkeley	369	1,336	28%
Sheridan	235	1,566	15%
Wheat Ridge	2,409	6,310	38%
South Sheridan	76	1,084	7%
Southgate	26	11,644	0.2%
Holly Hills	51	853	0.6%

Next Steps

Denver Water is currently undertaking a field verification effort of potholing as many service lines as possible. These will be used to verify the logic used in the development. This will also supplement existing data to be able to base p-values on actual occurrence data. The estimate will continue to improve as data begins to come in when the ALSLR program begins. Denver Water also continues to refine methods in being able to identify service lines from water quality sampling.

The full-scale lead service line replacement program will include an identification component consisting of a combination of replacement, water quality testing, potholing, and potentially other technologies. Also, customers will be asked to help in identifying lead services lines by providing proof of replacement, pictures of the first fitting in the house, and requesting a lead sample kit.

APPENDIX III.B.3 - PREDICTIVE MODEL AND PRIORITIZATION

September 2019

DENVER WATER

Memo

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To: Denver Water

Project ref: Denver Water Lead Reduction Plan

From: AECOM

CC:

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Appendix III.B.3 Predictive Model and Prioritization

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Acronyms

p-value	Predictive Model Probability of Lead Score
ACR	American Census Record
ALSLR	Accelerated Lead Service Line Replacement
CDPHE	Colorado Department of Public Health and Environment
COE Program	Communications, Outreach, and Education Program
EPA	Environmental Protection Agency
LRP	Lead Reduction Plan
LRP Plan	Lead Reduction Program Plan
O&M	Operation and Maintenance
PPB	Parts Per Billion
RF	Random Forest
WM	Water main

References

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Background and Purpose

The Lead Reduction Program Plan (LRP Plan) is supported by an Accelerated Lead Service Line Replacement (ALSLR) Program (see Appendix III.D). Properties with known and suspected lead service lines are enrolled in the ALSLR Program and Denver Water will replace the service lines within its service area (including distributor areas) within 15 years of the approved variance.

The ALSLR Plan details the process and resource estimates to replace the estimated 63,955 lead service lines at a minimum cumulative program year average replacement rate of 7.0%. Of interest is the number of total lead services estimated in the Denver Water service area: not only will this serve as the basis for the target for annual replacements, but it also serves as the basis for developing the ALSLR Plan. To efficiently identify the number of lead services that exist in the Denver Water service area, a predictive model will be used with the lead service line inventory to strategically perform explorations.

This technical memorandum (TM) describes the development of the predictive model. The predictive model will be used to generalize the results of explorations completed to date and to guide subsequent explorations in the future, without having to undertake an excavation at every property. Once developed, the predictive model will be applied to the Denver Water Lead Service Line Inventory to prioritize enrollment in the Filter Program and prioritize the replacement of lead service lines. The TM defines data sources used to populate the predictive model and its application toward prioritization regarding those efforts.

Predictive Model Implementation

Introduction

Denver Water's lead service line Inventory was developed to identify lead service line within Denver Water's service area and surrounding communities (see Appendix III.B.2, Preliminary Identification of Lead Service Lines). A set of logic rules was applied to the data to sort service lines into groups based on the estimated probability that a lead service line is present. The probability represents the uncertainty in our knowledge of the service line material and is captured as a "p-value" that is assigned based on known construction practices, historical records, expert judgement, and data interpretation. The inventory assigns a p-value score to each property to guide Filter Program enrollment, service line material exploration, and lead service line replacement. The p-value score ranges from 0 to 1, with 0 being a known non-lead service and 1 being a known lead service line in the service line. The service connections are grouped into classes of likelihood based on p-value. Table 1 (Estimate of Service Materials Based on Probabilities of Lead) shows the estimated number of services in each class. The inventory currently contains a preliminary estimate of approximately 319,700 records and will be updated to incorporate additional information periodically.

Table III.B.3-1. Estimate of Services Based on Probabilities of Lead

Probability of Finding a Lead Service	p-Value	Estimated Number of Services
Known lead service line	p = 1	1,066
Suspected lead service line	0.8 ≤ p < 1	61,374
Possible lead service line	0.5 ≤ p < 0.8	22,106
Unlikely lead service line	0.01 ≤ p ≤ 0.05	89,388
Non-lead service line	p = 0	145,766
Numbers in the table are provisional, subject **to change will be updated by the August submission**		

The existing inventory (see Appendix III.B.2, Preliminary Identification of Lead Service Lines) was constructed based on data available from several sources. It includes apartments, schools and businesses. To date, some fieldwork has been performed to gain a better understanding of the estimated number of lead service lines. As additional data become available for a property, the p-value score for properties with similar characteristics will be adjusted accordingly to reflect the inventory updates. Enhancements to the inventory and predictive model are underway to support enrollment in the Filter Program and implementation of the ALSLR.

Using the Lead Service Inventory to Build the Predictive Model

A predictive model will be used throughout the ALSLR Program to take advantage of results from field investigation of service line type or service line material and service line replacements to better estimate the materials expected. This data-driven approach will permit the estimation of the possible presence of an lead service line based on observed property and other common characteristics. The recommended approach involves the use of a machine learning model known as a random forest (RF) (Breiman, 2001).

The RF can be set to include existing rules and has the capacity to generate new rules based on the discovery of relationships between input and output variables. In addition, this approach offers the means to audit and explain the decision-making process. Finally, the model can be used to address data inconsistencies, handling data measurements on a variety of scales, and categorical data.

The model will be used to build on the current lead service line inventory based on learning from the results of completed work. The model will make use of the results of field lead service line data collection indicating service line composition found, as well as potholing data collected to verify presence/absence of lead service lines in areas not participating in the ALSLRP. This data driven approach will permit the estimation of “p-value” scores based on observed direct evidence findings and other common characteristics incorporated into the model. These will include tap data as derived for the initial lead service line inventory (year installed, etc.) as well as possible additional variables (sewer age, median income levels, etc.). The model calibration and investigation of service line type or service line material process will identify variables that contribute significantly to the accurate identification of lead service line.

The RF model uses an ensemble of individual decision trees to assign a decision and a probability to observations. A simple decision tree is shown in **Figure III**.B.1 **Decision Tree Example**.

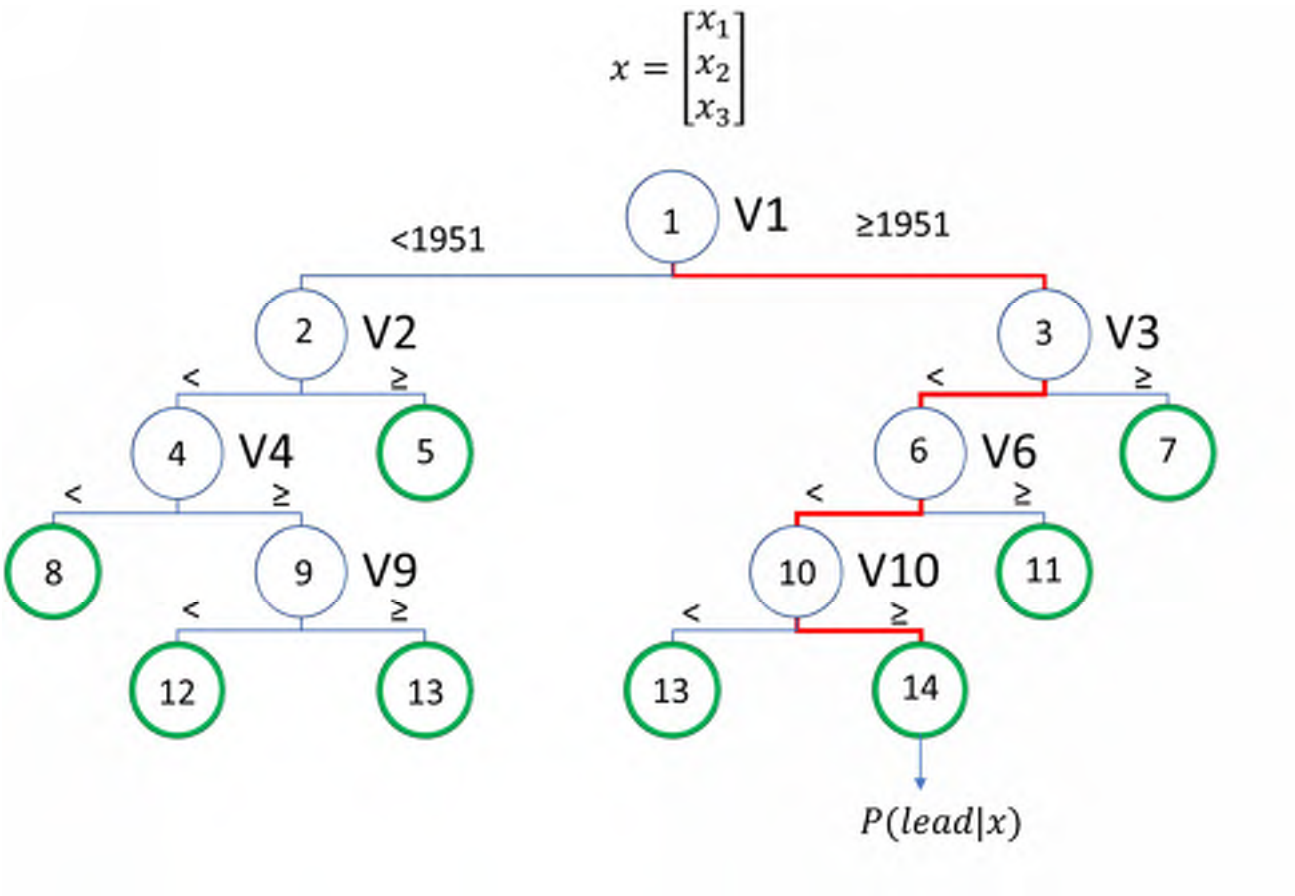


Figure III.B.1 Decision Tree Example

Figure III.B.1 **Decision Tree Example** has four layers of decision processing. The branching node labeled as 1 is where all properties enter the tree and are split according to a characteristic variable (V1). This variable could represent the tap year with the threshold of 1951 representing the year prior to which service lines are most likely lead (the algorithm uses statistical methods to decide on the variables and thresholds to be used). In this example, properties will be split to node 2 or 3 based on the year and a probability of lead being present assigned based on this variable alone. If this split perfectly distinguished lead services from non-lead services in the data, we could stop there, but this will not be the case. The next layer of decisions at nodes 2 and 3 will use two additional variables (V2 and V3) to further split the property services, such as tap size, and assign probabilities for the presence of lead at the child nodes. This process continues using different thresholds of different variables until the algorithm decides to terminate the branching process. These terminal nodes (known as leaf nodes, in green) contain all the property services. Each leaf node classifies the services that fall into it based on the suite of variables expressed in the rules necessary to reach it. A prediction for a property service based on this tree simply considers all relevant variables starting at node 1 and splits through each node until it lands in a leaf node.

The RF algorithm uses many individual trees (as described above) that are randomized both in terms of the data sampled for training (known as “Bagging” (Breiman 1996) and the variables used at each split in the decision tree. Each tree provides a prediction that are on average close to the true mean (low bias), but inherently noisy and sensitive to changes in the data (high variance). When the “forest” of many low bias and high variance trees are averaged for the final model, each tree contributes a vote, thereby reducing the variance and retaining a low bias (Hastie et al. 2009:588). Figure III.B.2 shows a schematic representation of how the ensemble method works. This example shows individual trees (1

through b), which can number as computer resources allow, although there is a point of dimensioning returns.

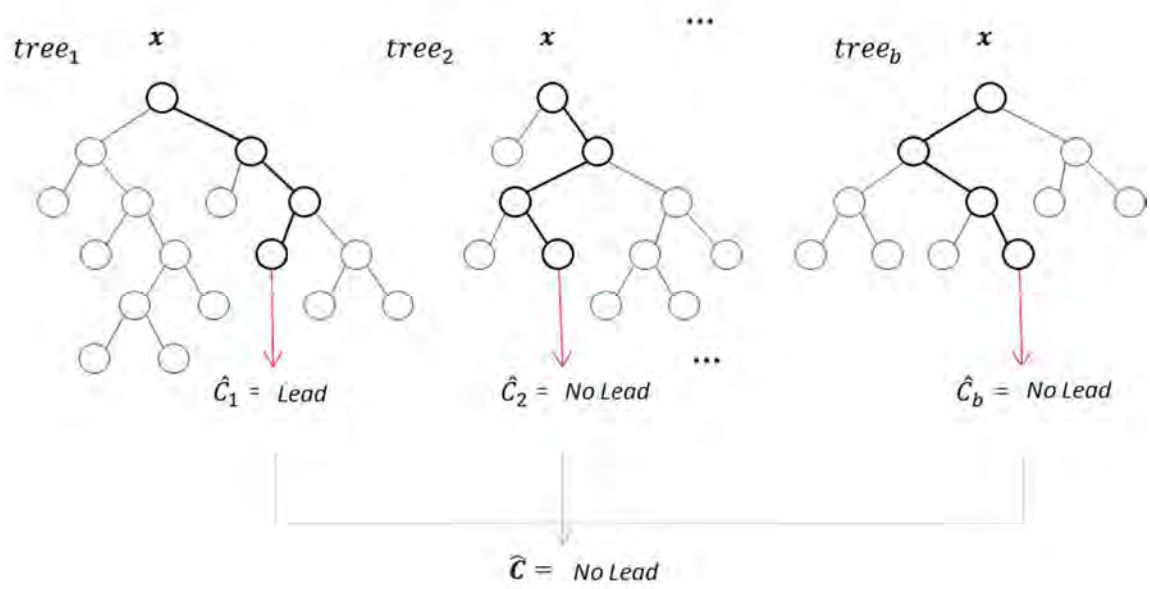


Figure III.B.2 Schematic of Prediction Based on a Decision Tree Ensemble

As a new property observation (x) is sent though each tree, it is split at each node according to the splitting criterion established when the tree was fit to field inspection data that is essential for project delivery. This follows the track of the bolded branches and nodes depicted in **Figure III**.B.2 **Schematic of Prediction Based on a Decision Tree Ensemble**. Even though the property data x are the same, each tree sends it along a different path because each tree was built with a randomized sample and randomly selected variables at each node. For each tree, the property is split until it reaches a leaf node and its service is then assigned a classification and probability. This can be represented as $\hat{C}_b(x)$ where C-hat is the predicted class of x for the bth tree.

The final prediction, represented as $\hat{C}_{rf}^{B}(x)$, is simply the class that the majority of trees agree on, in this case two out of three trees predicted that x is not lead. The algorithm also provides a final probability that property x service line is lead, expressed as $P\left(\hat{C}_{rf}^{B} \mid x\right)$.

An algorithm incorporating the RF model based on decision trees was selected because it is a natural extension of the decision logic developed for the initial lead service line inventory. Further, there is a precedent for incorporating RF as part of lead service line models as discussed by Abernethy et al. (2018), Chojnacki et al. (2017), and Goovaerts (2019) for Flint, Michigan; Gurewitsch (2019) for Pittsburgh, Pennsylvania; and Ardila et al. (2016) for Chicago, Illinois. The approach has the capacity to give priority to existing classification rules, to generate new rules based on the discovery of relationships between input and output variables, and weight specific observations. Furthermore, this approach offers the means to audit and explain the decision-making process through machine learning explanation tools (Biecek and Burzykowski 2019). Finally, is robust to data on different scales of measurements as well as categorical data.

The RF algorithm is a non-parametric tree-based estimator focused on reducing prediction variance through the use of randomization (bagging) and the majority-votes principle of an ensemble (Breiman 1996).; as discussed in the text above. The assumptions of this approach are like other parametric and

non-parametric classification models. Namely that the input data consist of a set of observed outcomes in specific classes and a series of variables that lend to the discrimination of the observed classes. It is assumed that the observed classes are *exchangeable*, meaning that the reordering of each observation does not change the outcome (i.e. the data do not represent a time series or possess some other inherent ordering). It is also assumed the explanatory variables are not highly correlated, however RF is less affected by this property compared to other models. Finally, for the purposes of model diagnostics and scoring, it is assumed that the model residuals are normally distributed (violations of this assumptions can be verified, and appropriate action taken to control for this). It is acknowledged that spatial correlation will lead to bias in the assumptions of exchangeability and residual distribution. For these reasons' additional steps for spatially valid cross-validation and neighborhood random effects are being explored.

Model Updates

The model enhancements will change the approach from inventory to prediction, based on field validated results. The predictive model will support decisions regarding the location of future construction activities, will provide support for long-term strategies to maintain the 7.0% target for lead service line replacements, and will be referenced by the Communications, Outreach, and Education Program (COE Program). This will be completed by transforming estimates of the presence of lead service lines into actionable items and developing a better understanding of the likelihood (or not) of finding a lead service line.

The predictive model will support Denver Water's annual ALSLR Plan by allowing Denver Water to focus efforts on the areas with a higher likelihood of lead. It will also be used by Denver Water to determine where additional investigation of service line type or service line material activities are needed, particularly at properties enrolled in the Filter Program (i.e., possible lead service). It is anticipated that this model will be updated when field results are available from the previous year's activities. Both the model data inputs, the model itself, and the output property lead service line probabilities will be assessed after each update to support the development and prioritization of construction work areas. It is currently projected that the model will be run twice a year to include probability and consequence updates to support enrollment in the Filter Program and construction sequencing of the ALSLR Program.

Model Performance Analysis

Model performance assessment involves several approaches and metrics. The area under the receiver operator characteristic (ROC) curve is computed. The area under the curve (AUC) is a measure of the probability that the model will assign a higher probability to a randomly selected lead tap versus a randomly selected non-lead tap. A value of 50% means the model is no better than random guessing. Residuals (errors between predictions and outcomes) also can be examined for patterns. Additionally, several metrics capturing different aspects of classification accuracy can be computed for different threshold p-values. These include: sensitivity (true positive rate, i.e. the fraction of lead taps correctly identified); specificity (fraction of non-lead taps correctly identified); accuracy (fraction of positives and negatives together correctly identified over all taps); precision (the fraction of predicted positive taps that turn out to be positive); F1 score (the harmonic mean between precision and sensitivity); and the false negative rate (fraction of lead taps predicted to be non-lead) among others.

In addition to model performance metric, structural aspects of the model and data will be considered. Independent variables will be examined for the strength of their contribution to the p-value. This can include an assessment of the loss in predictive capability when a variable of interest is resampled randomly (i.e. its value is selected randomly from existing values), and plots of p-values as a function of the value of a particular variable (all others held constant). These methods allow one to simplify the model or otherwise take into account information in the data. For example, identification of correlations between independent variables can be useful to model development.

Prioritization

Properties with a known, suspected or possible lead service will be prioritized for i) Filter Program enrollment and ii) ALSLR implementation. The results of the prioritization analysis will be used to identify areas having the greater potential to benefit from the ALSLR Plan while considering logistical needs.

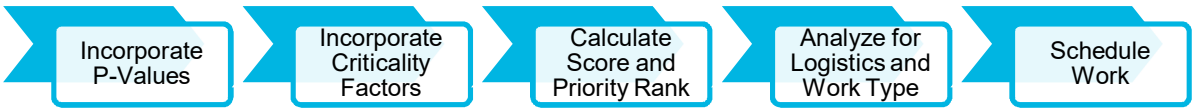
Prioritization involves developing a risk-based approach for long-term construction activity planning that accounts for impacts to public health, equity and environmental justice as well as logistical issues related to other planned capital improvements. The prioritization evaluation will be completed by integrating the p-value from the lead service line Inventory with a measure of consequence.

There are three primary factors that are used to develop a prioritization. These include i) a probability of having a lead service, ii) considerations that affect the consequence of lead exposure, and iii) logistical constraints that need evaluation to turn planning into work activities. Each of these individual components are incorporated into an analytical process for evaluation.

The analytical process consists of gathering the datasets from the respective sources and compiling them into a Geographic Information Systems (GIS) centric environment. Once all the datasets are obtained, they are combined with the lead service line inventory data to create one source of information. The information is then used to calculate the resulting likelihood and criticality scores which are computed from each individual service line location represented in the lead service line inventory. Upon completion of the individual risk calculations, the scores are totalized to the census tract area for normalization analysis

the results of this analysis are incorporated into a multistep process that incorporates logistical constraints and then be administered for construction activities as shown in Figure III.B.3-3 (Prioritization Process).

Figure III.B.3-3. Prioritization Process



Prioritization and Confirming a Lead Service

Under the current Lead Service Line Inventory, properties with known, suspected or possible Lead Service Lines will be included in the Filter Program and be placed in the ALSLR Program. In order to implement the ALSLR Program prioritized sets of actionable properties must be extracted from the Lead Service Line Inventory based on risk and placed into contracting groups (see below and in Appendix III.D.1). Actions taken on properties within these groups will be based on the group type and their lead service lines status. These are presented in Table III.B.3-2 (Lead Service Line Status Cohorts and Actions).

Table III.B.3-2 Service Line Category and Actions

Group	Service Line Category	ACTION AND RESPONSES		
		Filter Program	Lead Inventory	ALSLR Program
A	Known lead service line	Provide Filter	Add to lead inventory as confirmed lead	1. Add to list for replacement 2. Remove from inventory / Filter Program through replacement
B**	Suspected and possible lead service line	Provide Filter	Confirm materials (per Table III.D-6)	1. Add to list for replacement 2. Remove from inventory / Filter Program through replacement
C	Unlikely lead service line	Desk-top review / COE as necessary. Review predictive model output regularly for change in service line material assumption		
D	Confirmed to be lead-free	COE Program		
E***	Other (fire lines, recycled water taps, consecutive system)	No Action / COE Program		

*Table was developed using information in Appendix III.B.2 (Preliminary Identification of Lead Service Lines).

**Water Quality sampling will be limited to clusters or groups of properties in Group B.

*** Inclusion in Group E is based on application process, not likelihood of lead. Service lines will be maintained in the inventory, should the application change in the future. Provide COE that indicates the water supply is not a suitable source of drinking water.

The preliminary set of service line category and actions shown in Table III.B.3-2 (Service Line Category and Actions) are based on the current lead service line inventory predictions. This approach is conservative in the sense that properties with a possible lead service line status are included in the Filter Program. The predictive model that is under development will reduce this uncertainty and refine the inventory lead service line status and allow for refinement of the target properties over time.

Revisions to the inventory lead service line status based on future updates and learning by doing will allow action levels to be refined as needed to assess the estimated number of lead services and how this is reported.

Properties classed as having a known or suspected lead service will be visited and subject to an investigation with the lead service replacement performed as necessary. Properties identified as possible lead service lines will be investigated by either water quality sampling, and/or potholing as necessary (in that order) to confirm service line material. Those properties found to have a lead service will have it replaced. Properties confirmed to have no lead will be taken off the Filter Program. Properties unlikely to have a lead service will be given a record review, customer outreach and or visual inspections,

water quality as necessary (in that order) to confirm service line material. The results of these investigations will provide data to verify the results of the model and improve its predictive power.

Probability Factors

The probability of the presence of a lead service is determined primarily through the lead service line inventory p-values (see Appendix III.B.2, Preliminary Identification of Lead Service Lines), and through the predictive model p-values in future updates. Subsequent actions can be taken to revise these numbers. These include:

- Digging or potholing
- Water quality sampling
- Visual inspections (by field crews)
- Customer outreach
- Additional and/or more detailed records review

Digging and potholing is considered definitive confirmation of service line material. The validity of the remaining methods in assigning service line status will be evaluated as part of the ALSLR, and where appropriate such information integrated into the predictive model.

Criticality Factors

The criticality factors are used to describe the potential impact of lead exposure, based on features unique to a property such as water quality sampling results or the demographics of the occupants. These factors are selected to consider the health consequences of lead exposure in the larger context of health equity and environmental justice (HE&EJ).

The consequence of lead exposure provides a priority categorization separate from the likelihood of lead. It provides additional justification for selecting work locations on a yearly basis. Each property of the Lead Service Line Inventory will be evaluated based on health impacts of lead exposure, equity and environmental justice. Criticality factors associated with each property will be identified and weighted. The criticality factors and weights can be defined by analysis tools and/or stakeholder consensus agreement. The process to develop the criticality score is presented in Figure III.B.3- 4 (Criticality Weighting Process).

Figure III.B.3-4 Criticality Weighting Process

Table III.B.3-3 A list of proposed criticality factors and their weights developed in consultation with EPA and CDPHE presented in Table III.B.3-3 (Proposed Criticality Factors and Weighting). Each factor's

values are expressed as a score on a scale of zero (0) to one (1) and a weighted combination computed as shown below. Values for factors will be determined based on the best available data. In some cases, estimates will need to be substituted for missing values (e.g. using an average age for a missing age attribute).

Table III.B.3-3 Proposed Criticality Factors and Weightings

Criticality Factor* (Cf)	Description	Criticality Co-efficient*	Criticality Weight*(%) (Cw)
Public Health Consideration	Odds Ratio (OR) Contours from the Spatial Confounder-Adjusted Spatial Risk Model (Berg, et al, 2017)	Spatial risk odds ratio for elevated childhood blood lead level	0.2
Filter Adoption Rate**	Areas where filter adoption is low.	Non-successful filter adoption X 1) / total number of customers per area	0
Critical Customers	Day care centers child care providers, schools, dialysis centers, formula fed infants	Count of critical customers	0.3
Age (Census Data)	Children	Population estimates of children under 5 years of age	0.4
	Expecting Families	Population estimates of existing families within XX-XX years of age***	
Socio-Economic Factors	Probability of being below the Federal Poverty Level	Population estimates of Residences that fall under the defined federal poverty level	0.1
	Median Income Level	Weighted Income Distribution	
		Criticality Weight Total:	1

* List of criticality weightings currently in use changes shall be based on learn by doing or coordination with CDPHE and EPA.

** To be incorporated in future model iterations

*** Based on available data from the 2010, 2013-2017 ACS data that encompasses medically derived age bearing years. Considerations from CDPHE and EPA are recommended.

The Odds Ratio from the Spatial Confounder data was converted to a score of zero (0) to one (1), with a ratio of 1 set to 0.5 (see Equation 1, where OR is the odds ratio). In addition, a default value of 0.5 was set for locations that were within the extent of the odds ratio data.

Equation 1 Odds Ratio Score Rescaling

$$\begin{cases} OR < 1 & \sqrt{\frac{OR}{\max(OR)}} + mult1 * \left(\frac{\sqrt{\frac{OR}{\max(OR)}}}{\sqrt{\frac{1}{\max(OR)}}} \right) \\ OR \geq 1 & \sqrt{\frac{OR}{\max(OR)}} + \frac{mult1}{mult2} * \left(1 - \sqrt{\frac{OR}{\max(OR)}} \right) \end{cases}$$

$$mult1 = 0.5 - \sqrt{\frac{1}{\max(OR)}}, \qquad mult2 = 1 - \sqrt{\frac{1}{\max(OR)}}$$

Other factors' values were split into five (5) groups using Jenks natural breaks, and a score assigned to each group (0, 0.2, 0.5, 0.8 and 1). With all criticality factors scored on a scale of zero (0) to one (1), the weighted criticality score (between 0 and 1) is calculated as follows:

Equation 2 Consequence of Lead

$$F_{LSL_C} = Tap\ Prioritization\ Ranking\ Value$$

$$F_{LSL_C} = (Cw1 * Cf1) + (Cw2 * Cf2) + (Cw3 * Cf3) \ldots$$

The list of criticality factors has gone through an analysis to evaluate the data usage and their alignment with HE&EJ and program goals. Each one of the criticality factors was given different weights and run through the prioritization model to better understand the sensitivity of the criticality factor as it relates to output and the performance to meet the objectives of the LRP Program. This sensitivity analysis showed how adjustments to weights affected the outcome to guide the factors considered and their preferred weightings. For example, the dataset that included an older population category was removed to focus on customers more vulnerable to lead exposure. In coordination with CDPHE, review of the criticality model indicated that additional information, such as data from women, infant, and children (WIC), is most beneficial for inclusion as critical customers. The current weights as shown in Table III.B.3-3 (Proposed Criticality Factors and Weighting) were chosen to ensure the risk score is in alignment with HE&EJ and program goals and will continue to evolve in coordination with CDPHE and EPA.

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Risk Factors

Once the individual likelihood (probability of lead, p-value) and criticality scores are generated for each property, a risk score is then calculated for the property to establish the individual risk score (Equation 3 Individual Risk Score).

Equation 3 Individual Risk Score

$$Risk = Probability\ of\ lead\ x\ Criticality\ of\ lead$$

Individual risk scores are totalized to a common spatial boundary (i.e., the 2010, 2013-2017 Census Neighborhood Blocks / American Census Survey records (ACS)) to establish an overall risk score. The result of this is the aggregate risk over an area that is normalized to take into account density by summing over parcels with taps and dividing by the area of parcels with taps in each census area. (Equation 4 Normalized Risk Score).

Equation 4 Normalized Risk Score

$$Normalized\ Risk = \frac{\sum(Probability\ of\ lead\ x\ Criticality\ of\ lead)\ for\ parcels\ with\ tap}{\sum Area\ of\ Parcels\ with\ Tap}$$

This process allows for the control of differences in area/size between spatial units (larger areas tend to have more taps, while at the same time some areas have significant open spaces with no taps). The result of this analysis is that individual and accumulated risk scores can be assigned to a spatial feature based on occupied area rather than total area. Additional issues can then be considered in the prioritization process, including logistics and ALSLR contracting work development.

Using Risk Scores to Prioritize Construction and Filter Distribution

The process used for establishing priority ranked activities is based on the results of the probability and consequence evaluations. The goal is to take the risk scores from all the (census) areas and look at replacing lead services in a way that addresses both the (high) risk of lead exposure at a property and the efficiency of working through an area of properties to consider the risk to a broader portion of the community. This is considered a geographical construction area. Additionally, locations that are high risk that are not incorporated in a census area for production are also evaluated for sequence of constructions as part of individual construction activities. As a result, lead service replacements may be completed on an individual basis or as part of a larger grouping of properties.

Both the prioritization risk scores that are established for individual locations and grouped together in the Census survey areas are used to produce lists where both the greatest probability and the greatest consequence is considered. An example of how the individual and combined scores (from Equations 2 and 3) will be applied is described in Table III.B.3-4 (Applying Risk Scores for Prioritization).

Table III.B.3-4 Applying Risk Scores for Prioritization

Risk Score Types	Description
Individual	Individual scores are considered for properties defined as high consequence but are geographically isolated.
Geographic Area	Combined scores are considered for properties where the categories of known and possible lead scores define an area.

Evaluation of the two types of risk scores is the basis to prioritize i) enrollment in the Filter Program, ii) sequencing the ALSLR Program contracting needs, and iii) communication efforts. Additionally, the output from this analysis shows where additional investigative efforts are needed to drive the LRP and

sustain the year-over-year annual targets for the number of lead service line replacements. As described above, all properties in a high-risk contractor group derived using census areas will be investigated.

The Predictive Model and Coordination with Other Capital Programs

The results from the predictive model in terms of prioritizing lead service line replacements will be evaluated with other activities within the Denver Water service area for scheduling and coordination of construction. Other considerations (mobilization, street repair, scheduled water main replacement, etc.) are necessary scheduling components to minimize repeat visits to the same street or block and to efficiently complete the necessary lead service line replacements. The logistical considerations (see Table III.B.3-5, Predictive Model and Coordination with Other Capital Programs) will influence the development of construction activities. Additionally, information related to current customers will be identified to ensure that work is performed at connected services.

Table III.B.3-5 Predictive Model and Coordination with Other Capital Programs

Coordination Item*	Description
Previously Completed Partial Replacements (where some portion of the service line is still lead)	Public to curb box previously completed; follow-up work outside of the full replacements
Water Main Replacement Program Schedule	ALSLR based on scheduled water main replacements
Long-term Roadway Full Depth Resurfacing Plan	Full depth or resurfacing roadway projects in areas susceptible to lead services
Leak Repairs and Operation and Maintenance Activities	ALSLR based on a response to reported leaks or necessary maintenance
Redevelopment Properties	City of Denver Development in areas susceptible to lead services
Archeological / Cultural / Historic Areas / Locations	Identification of areas requiring more sensitive construction coordination and approval
Property Type (Single Family Commercial / Industrial / Multi-dwelling units)	Building inventory of data regarding residential, commercial, and industrial units
Active Water Account	Identifies taps that have service agreements
Property Status	Identification of property status (occupied, abandoned, etc.)

Implementing the Predictive Model Outcomes

Upon completion of the analysis phase, information for i) individual and grouped risk scores and ii) logistical considerations that exist within the Denver Water service area will be available to support the annual planning cycle for the LRP. The next step is to apply the results to the Filter Program and ALSLR Program.

Filter Distribution Prioritization

Filter distribution will target the properties with a known, suspected, or possible lead service line under the current lead service line inventory. The predictive model will be used to identify the risk category for each census area to allow a sequence of distribution of the Filter Program based on starting at the highest risk areas and working down in priority.

ALSLR Prioritization

The process used to develop the ALSLR Program construction sequence is presented in Figure III.B.3-5 (The Role of the Prioritization Analysis for Annual Updates to the ALSLR Plan). This is based on taking the results from the predictive model and prioritization analysis to establish the annual ALSLR work activities.

Figure III.B.3-5 The Role of the Prioritization Analysis for Annual Updates to the ALSLR Plan

The predicative model and consequence data will be used to identify candidate properties for the different ALSLR contracting groups presented in Appendix III.D.1 (see Table III.D.8 Contracting Groups Summary). The contracting groups include:

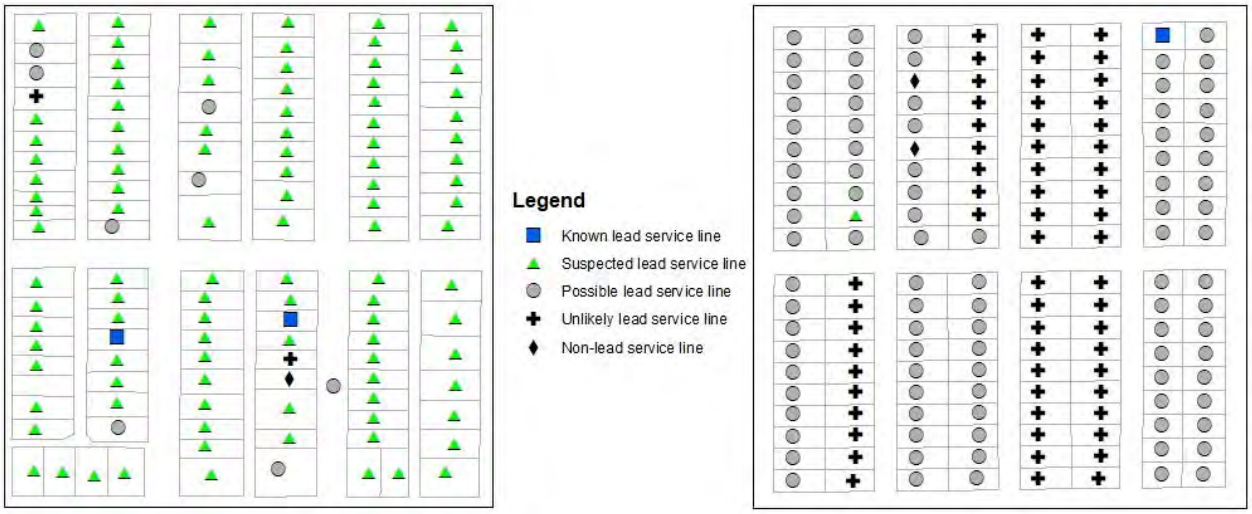
- Group A – Geographic Area ALSLR Type
- Group A – Individual ALSLR Type
- Group B – Investigation

The risk scores developed from the prioritization analysis will be used to further define the groups and sub-group categories that will comprise the yearly work plan.

Group A - Geographic Area ALSLR Work Type

The list of properties with a known lead service included in Group A – Geographic Area ALSLR will be generated from the output of the prioritization risk analysis. Grouped risk score areas will be reviewed to identify the highest priority areas for inclusion in the annual ALSR Program's scope of work. The properties associated with the identified areas will be collectively issued to contractors for replacement of lead service lines on blocks or streets as needed. Figure III.B.3- 4 (Geographic and Individual Area Visual Representation) shows an example of an area selected for the ALSLR Program. In this example, the results of normalized risk (Equation 3) were used to identify the work area. This geographical area shown below would hypothetically receive a high priority ranking and would incorporate all the properties within the boundary for the contract in accordance with the yearly construction goals. As described above, all properties in this group will be investigated using progressively more invasive methods based on p-values.

Figure III.B.3- 4 Geographic Area (left) and Individual Map (right) Visual Representation



Group A – Individual ALSLR Work Type

The properties with a known lead service included in Group A – Individual ALSLR are properties that were individually prioritized as “high” but are not in close enough proximity (geographically) for inclusion in the geographic lead service line replacement areas. This ASLR contracting strategy takes into consideration where critical properties would not typically rise to the top of the list from a grouped risk-based analysis. Figure III.B.3- 4 Geographic and Individual Area Visual Representation defines an area where the density of properties is low, but a select group of properties were defined to be critical for prioritized construction activities. In this situation the individual risk score (equation 3) was evaluated and the top ranked properties were identified in accordance with the yearly construction goals.

Group B – Investigation Work Type

The goal of investigation work areas is to gather more information where necessary to produce better predictive model results in areas where available information is limited and to provide a more representative sampling of data. Investigation type activities include detailed records review, non-intrusive inspections, water quality sampling and potholing to support the ALSLR construction and planning. In areas where there are groupings of similar properties with similar p-values, then a sample of the total group population will be investigated to evaluate the composition of taps at these properties.

Another example for where investigation is needed occurs at properties for which risk is high due to a high consequence of having a lead service, but the likelihood of lead is relatively low. In this case, investigations as described above will be performed to determine service line material and support better model prediction outcomes as new iterations of the predictive model are run.

APPENDIX III.C.1 - FILTER ADOPTION

September 2019

DENVER WATER

Appendix III.C.1

Lead Filter Program Sample Size Required for Determining Rate

Date:	Revised August 16, 2019 March 14, 2019
To:	Denver Water
From:	Corona Environmental Consulting, LLC

Executive Summary

The objective of this memorandum is to develop a statistical method to estimate the number of Denver Water customers that adopt a lead filter and therefore reduce their exposure to lead in their drinking water. To meet this objective, the memorandum answers the following question: "How many Denver Water customers must respond to the lead filter program survey to sufficiently estimate filter adoption rate for all customers provided a lead filter?" Survey responses from 1,059 or more randomly selected Denver Water customers that received lead filters are needed to estimate the filter adoption rate (p) with at least 95% confidence and no more than 5% error, based on an adoption rate greater than 60%. Distributing the survey to a group of 1,250 Denver Water customers that received a lead filter is recommended to achieve the requisite survey response from 1,059 random surveyed customers while limiting the self-selection bias.

Introduction

Corona prepared a statistical approach to support Denver Water's efforts in understanding the required number of customers to be surveyed to sufficiently estimate point of use filter device adoption rates. Denver Water is investigating a program to provide filter devices to customers to protect them from lead exposure. When used properly, filter devices are effective at removing dissolved and particulate lead from drinking water. Therefore, the effectiveness of the filter devices in protecting Denver Water customers from lead exposure relies on customers' adoption of the devices. Filter device adoption assumes customers are installing, using and maintaining the device properly, as well as replacing the filters at the appropriate time. Customers not using the filter device but relying on bottled water for drinking and cooking will also be considered an adoption. Corona's statistical approach described in this memorandum details the number of customers that received a filter device that need to be surveyed based on the acceptable confidence level and the error in the estimated filter device adoption rate.

Statistical Analysis

The objective of the statistical analysis is to estimate the number of Denver Water customers that adopt their lead filter and therefore reduce their exposure to lead in their drinking water. The total number of Denver Water customers that adopt their lead filter can be estimated using the total number of Denver Water customers that receive a lead filter and the filter adoption rate for this entire population. To avoid having to survey the entire population of customers receiving a lead filter, a statistical analysis can be used to estimate the filter adoption rate utilizing a subset of the population. To determine the

subset sample size required, the adoption rate distribution, confidence level, and acceptable error must be considered.

Lead filter adoption takes on a binomial distribution of "adoption" or "lack of adoption" (e.g. 1 or 0), which gives a discrete probability distribution of Bernoulli trials. A Bernoulli trial is an event that has two possible outcomes, such as flipping a coin. Each filter adoption, or lack of adoption, can be described as a Bernoulli trial because there are only two possible outcomes: adoption ("success") or no adoption ("failure"). We assume each customer's lead filter adoption, or lack of adoption, is independent of other customers' filter device adoption, and therefore, each "trial" constitutes a random, independent experiment. This assumption that each customer's filter adoption is not dependent on any other's customer's filter adoption emphasizes the need for Denver Water to ensure that surveyed customers are randomly selected. More information on the recommended survey procedure to prevent sampling bias is provided in the following section. We also assume that the probability, p, of a success in each trial remains constant. This means that we assume the probability that each customer will adopt the lead filter is constant and equal to some value p. Because actual adoption may not be constant, we recommend Denver Water repeat the survey annually.

The binomial distribution has a mean np and variance $np(1-p)$ where n is number of Bernoulli trials. In the context of this memorandum, n is equal to the number of surveyed Denver Water customers offered lead filters. The number of surveyed customers who have adopted their filter are defined as X, where $X \leq n$. The quantity X/n is the point estimator ($\hat{P}$) of the filter adoption rate (p) for all customers receiving a lead filter. The binomial distribution is described in further detail in the Appendix. The descriptions were developed utilizing Montgomery & Runger (2007)[1].

The size of the confidence interval, which can also be defined as the difference between the true proportion of all Denver Water customers' filter adoption rate, p, and the proportion of surveyed customers' lead filter adoption rate, $\hat{p}$, is dependent on both α, which defines the confidence level, and n, the sample size of surveyed customers[2]. By defining the error $E = \left|p - \hat{P}\right|$ and selecting an acceptable error (i.e. 0.05) and an acceptable statistical power (i.e. 95%) that *E* is less than our acceptable error, we can determine the required sample size utilizing the statistical computing software R package Binomial Confidence Intervals For Several Parameterizations ("binom")[3]. The power of a statistical test is the probability of rejecting the null hypothesis H_0 when the alternative hypothesis is true, which can be interpreted as the probability of correctly rejecting the false null hypothesis. In this application, the alternative hypothesis is true if the true proportion of all Denver Water customers' adoption rate p is greater than the proportion of surveyed customers' adoption rate $\hat{p}$ minus the error E.

$$H_0: p = \hat{p} - E$$

$$H_0: p > \hat{p} - E$$

Figure 1 illustrates the relationship between the survey sample size of Denver Water customers needed to estimate the filter acceptance rate and the acceptable error and confidence level. Table 1 summarizes

[1] Montgomery, D.C. & Runger, G.C. 2007. Applied Statistics and Probability for Engineers: Fourth Edition. John Wiley & Sons, Inc. USA.

[2] Note that $\hat{P}$is a random variable point estimator for the filter device adoption rate (p) and $\hat{p}$ is the filter device adoption rate for surveyed Denver Water customers.

[3] Dorai-Raj, S. 2015. Package 'binom'. "Binomial Confidence Intervals For Several Parameterizations. Accessed 5/8/2019. https://cran.r-project.org/web/packages/binom/binom.pdf

the required sample sizes for acceptable errors of 10%, 5%, and 1% and for filter adoption rates of 50%, 60%, 70%, 80%, 90%, and 95% assuming 95% statistical power. To ensure, with 95% statistical power, that the sample size filter device acceptance rate, of at least 60%, is within 5% of the entire customer population filter acceptance rate, responses would be required from 1,059 random surveyed customers. If the adoption rate falls to 60% with the sample size of 1,059 random surveyed customers, the error of the estimate increases by less than 1%. Therefore, we recommend a sample size of random surveyed customers of 1,059 to be both achievable and representative.

Figure 1 Survey sample size based on acceptable error and filter adoption rate using a binomial distribution assumption with 95% statistical power

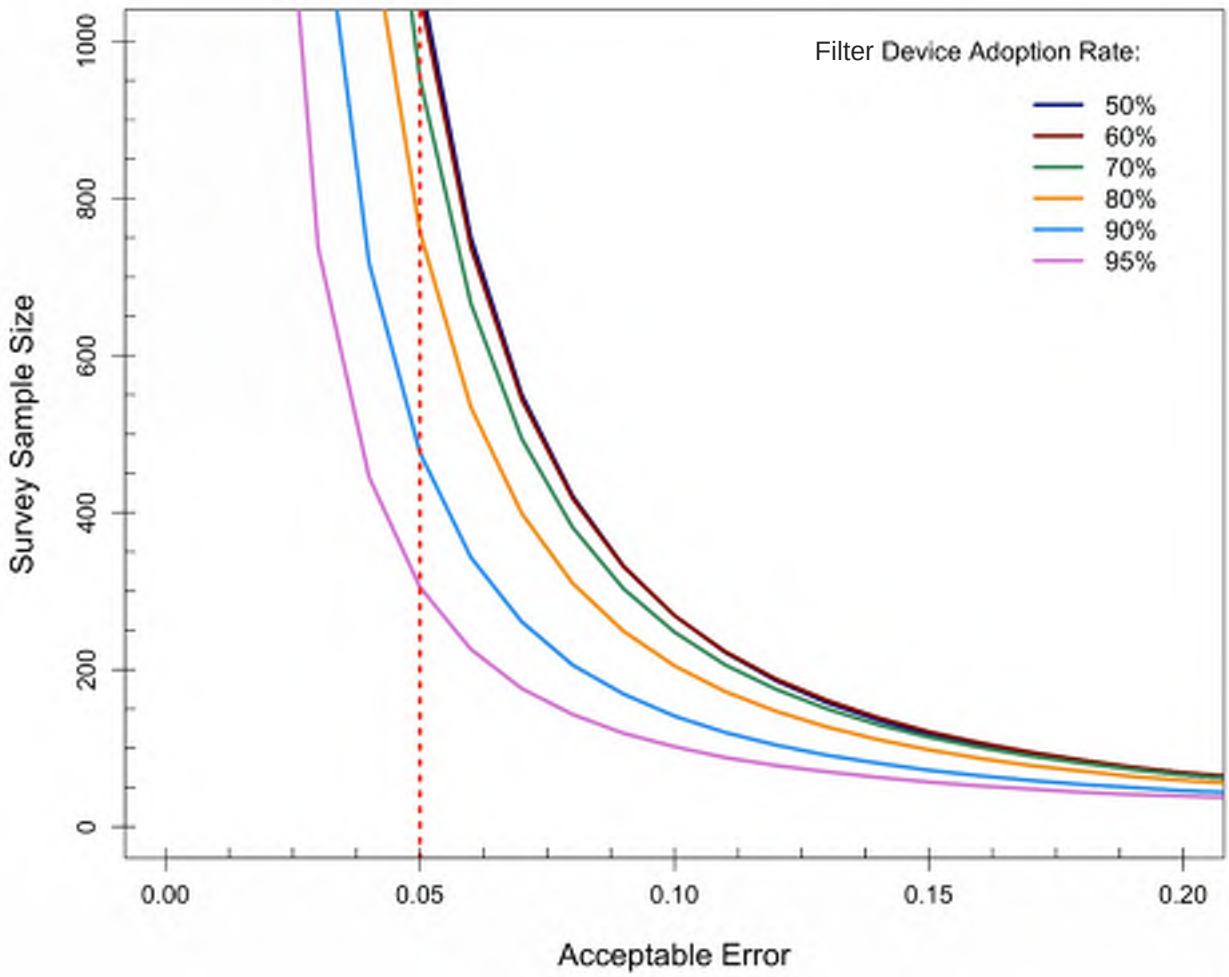


Table 1 Required sample size of surveyed customers based on acceptable error and filter adoption rate and 95% statistical power

Acceptable Error	50% Adoption	60% Adoption	70% Adoption	80% Adoption	90% Adoption	95% Adoption
10%	n=269	n=269	n=248	n=205	n =141	n=102
5%	n=1,081	n=1,059	n=951	n=757	n=476	n=305
1%	n=27,054	n=26,080	n=22,942	n=17,640	n=10,173	n=5,630

Alternatively, a normal approximation can be assumed for the point estimator $\hat{P}$ of the filter adoption rate (p) for all customers receiving a lead filter if the sample size (n) is sufficiently large and p is not too close to 0 or 1. To apply this approximation, we require that np and $n(1-p)$ are greater than or equal to 5. The normal distribution, standard normal distribution and the normal approximation and confidence interval for the probability p that each customer will adopt the filter are described in detail in the Appendix.

Using the normal approximation, the size of the confidence interval, which can also be defined as the difference between the true proportion of all Denver Water customers' filter adoption rate, p, and the proportion of surveyed customers' filter adoption rate, $\hat{p}$, is dependent on both α, which defines the confidence level, and n, the sample size of surveyed customers[4]. If we define the error $E = \left|p - \hat{P}\right|$, and we select an acceptable error (i.e. 0.05) and an acceptable confidence (95%) that *E* is less than our acceptable error, we can determine the required sample size as:

$$n = \left(\frac{z_{\alpha/2}}{E}\right)^2 p(1-p) \qquad \textit{Equation 1}$$

Using the exact binomial distribution results in a more conservative sample size requirement as compared with the normal approximation assumption. Therefore, if the surveyed customers' filter adoption rate is greater than 60% a sample size of 1,059 for survey responses from Denver Water customers is a sufficiently conservative requirement to determine that the filter adoption rate for all Denver Water customers receiving a lead filter is within 5% of the surveyed customers' filter adoption rate.

Sample Selection and Verification

A random selection of 1,250 customers from the group of all of the customers provided a filter should be performed each year. The customers selected and the corresponding surveys received should be randomized based on geography and demographics. Efforts to achieve the requisite response rates (e.g. at least 1,059 of 1,250) must be undertaken to prevent self-selection bias in the reporting group. These efforts may include mailings, phone calls, and site visits to the randomly selected customers. Community groups present an opportunity to leverage independent parties that might obtain higher response rates and a higher level of truthfulness in the responses.

Even though the number of respondents may approach a level of confidence and error that are acceptable, efforts should be continued to complete responses from all the customers selected for

[4] Note that $\hat{P}$is a random variable point estimator for the filter device adoption rate (p) and $\hat{p}$ is the filter adoption rate for surveyed Denver Water customers.

verification. A high response rate from the random selection ensures a full representation of the diversity of Denver Water's customer base.

Recommendation

For the lead filter program to be considered successful, the adoption rate needs to be greater than or equal to 60% for equivalence. However, Denver Water should continue efforts to maximize the adoption rate. Corona recommends obtaining responses from a minimum of 1,059 customers out of a randomly selected group of 1,250. The survey should be repeated on an annual basis to detect changes in adoption rate over time. Responses from 1,059 randomly selected customers would achieve 95% confidence that the true sample adoption is within 5% of the subsample adoption if the subsample adoption is above 60%. If the subsample adoption is greater than 60%, then the confidence is increased and/or the error is decreased. If the subsample adoption is lower, then Denver Water should take measures to increase the adoption rate.

Appendix

Binomial Distribution

A random experiment consists of n Bernoulli trials such that

(1) The trials are independent
(2) Each trial results in only two possible outcomes, labeled as "success" and "failure"
(3) The probability of a success in each trial, denoted as p, remains constant

The random variable X that equals the number of trials that result in a success has a binomial random variable with parameters $0 < p < 1$ and n = 1,2,…. The probability mass function X is:

$$f(x) = \binom{n}{x} p^x (1-p)^{n-x} \qquad \textit{Equation 2}$$

$\binom{n}{x}$ equals the total number of different sequences of trials that contain x successes and $n - x$ failures. The total number of different sequences that contain x successes and $n - x$ failures times the probability of each sequence equals $P(X = x)$.

If X is a binomial random variable with parameters p and n, the mean $\mu = E(X) = np$ and the variance $\sigma^2 = V(X) = np(1-p)$.

Normal and Standard Normal Distributions

A normal random variable X from a normal distribution with mean μ and variance σ^2 can be standardized by the following:

$$Z = \frac{\bar{X} - \mu}{\sigma} \qquad \textit{Equation 3}$$

Z is then a standard normal random variable with a standard normal distribution. A standard normal distribution is a normal distribution with mean μ=0 and variance σ^2=1. The standard normal distribution probability density function is described below by $P(x)$:

$$P(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-\mu)^2)/(2\sigma^2)} = \frac{1}{\sqrt{2\pi}} e^{\left(-x^2/2\right)} \qquad \textit{Equation 4}$$

To determine the probability that the standard normal random variable Z is less than or equal to some value z, written as $P(Z \leq z)$, we can use the cumulative distribution function of a standard normal random variable, denoted as $\Phi(z)$, which is found by integrating the probability density function:

$$\Phi(z) = P(Z \leq z) = \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} e^{\left(-z^2/2\right)} dz \qquad \textit{Equation 5}$$

To determine the probability that Z is greater than some value z, $P(Z > z)$, we can utilize the fact that the integral of the probability density function taken from -∞ to ∞ is equal to 1:

$$P(Z > z) = 1 - P(Z \leq z) \qquad \textit{Equation 6}$$

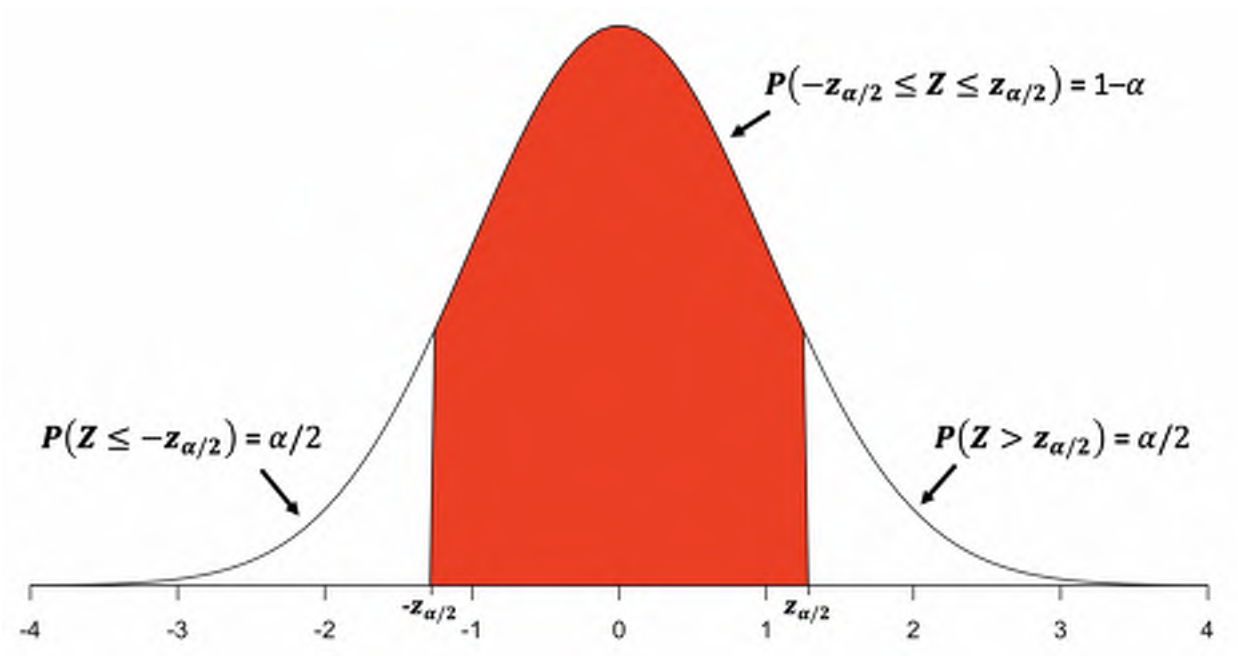
For a standard normal distribution, we can define the probability that Z is within a defined confidence interval with a confidence level of 100(1-α)% by:

$$P\left(-z_{\alpha/2} \leq Z \leq z_{\alpha/2}\right) \cong 1 - \alpha \qquad \textit{Equation 7}$$

where $z_{\alpha/2}$ is defined as the z value that corresponds with the upper $\alpha/2$ percentage point of the standard normal distribution (see Figure 2). Alternatively, we can say with 100(1-α)% confidence that:

$$-z_{\alpha/2} \leq Z \leq z_{\alpha/2} \qquad \textit{Equation 8}$$

Figure 2 Standard normal distribution showing confidence intervals for Z



Large Sample Confidence Intervals for the Mean of a Normal Distribution

In the case of sampling from a normally distributed population with an unknown mean and a known standard deviation σ with the objective to estimate the population mean, a large sample confidence interval for the mean μ can be determined if the sample size is sufficiently large. Given the assumption that the sample size is large, the central limit theorem can be applied such that the sample mean $\bar{X}$ has an approximate normal distribution with mean μ and variance ${\sigma^2}/{n}$. Therefore, for a normal distribution with a large sample size:

$$Z = \frac{\bar{X} - \mu}{S/\sqrt{n}} \qquad \textit{Equation 9}$$

where: $\bar{X}$ is the sample mean,

μ is the distribution mean,

S is the sample standard deviation, and

n is the sample size.

The large sample confidence interval for μ for a confidence level of approximately 100(1-α)% can then be described as:

$$\bar{x} - z_{\alpha/2}\frac{s}{\sqrt{n}} \leq x \leq \bar{x} + z_{\alpha/2}\frac{s}{\sqrt{n}} \qquad \textit{Equation 10}$$

Normal Approximation to the Binomial Proportion

Using the normal approximation, the sampling distribution of $\hat{P}$ is approximately normal with mean *p* and variance *p*(1-*p*)/n. If Denver Water uses a sufficiently large sample size n and *p* is not too close to 0 or 1, the normal approximation for *p*, the probability that each Denver Water customer who receives a lead filter will adopt the filter, is equal to the following:

$$Z = \frac{\hat{P} - p}{\sqrt{\frac{p(1-p)}{n}}} \qquad \textit{Equation 11}$$

where Z has an approximate standard normal distribution. Using the normal approximation of the binomial proportion, we can use the standard normal confidence intervals to determine the following approximate confidence interval for our binomial proportion, p:

$$\hat{p} - z_{\alpha/2}\sqrt{\frac{\hat{p}(1-\hat{p})}{n}} \leq p \leq \hat{p} + z_{\alpha/2}\sqrt{\frac{\hat{p}(1-\hat{p})}{n}} \qquad \textit{Equation 12}$$

The error E between the true filter adoption rate among all Denver Water filter recipients p and the filter adoption rate among all surveyed Denver Water customers $\hat{p}$ can be defined as $E = \left|p - \hat{P}\right|$ where $\hat{P}$ is a random variable from a binomial distribution with mean *p* and variance *p*(1-*p*)/n. Thus, there is 100(1-α)% confidence that $E < z_{\alpha/2}\sqrt{p(1-p)/n}$. If we set $E = z_{\alpha/2}\sqrt{p(1-p)/n}$, we can solve for the sample size n.

LEAD REDUCTION PROGRAM PLAN

APPENDICES

VOLUME 2 OF 2

DENVER WATER

APPENDIX III.C.2 - FILTER PILOT

September 2019

DENVER WATER

TECHNICAL MEMORANDUM

To Denver Water
From Mott MacDonald
Date August 13, 2019
Project No. 507100139
Page Page 1 of 19
Subject Denver Water Lead Reduction Program (LRP)
Appendix III.C.2 Filter Pilot Plan

I. PURPOSE

The purpose of this Technical Memorandum (TM) is to summarize the framework for Denver Water's Filter Lead Out of Water (FLOW) Pilot program. The FLOW Pilot targets a subset of premises that will be included in the full-scale FLOW Program. The basis for the FLOW Pilot is twofold:

1. Demonstrate processes and workflows that can be used for the full-scale FLOW Program implementation.
2. Survey customers to obtain feedback on filter use adoption for at least 200 premises.

Presented herein is a summary of the background, processes and workflows, filter distribution methods, customer notifications, filter kit materials, follow-up/survey information, filter use adoption validation basis, schedule, and filter survey summary.

II. BACKGROUND

General

Denver Water serves high-quality drinking water to approximately 1.4 million people and continuously monitors water quality. Drinking water entering the distribution system prior to the connection to the customer's service line is free of lead. However, lead may leach into the drinking water as it stagnates in the customer-owned lead service line and/or premise plumbing.

Denver Water believes there is no safe level of lead in drinking water and is committed to taking steps to optimize its water system for control of lead by implementing a Lead Reduction Program (LRP). One element of Denver Water's LRP is FLOW, which includes the distribution of filters certified to NSF/ANSI Standards 53 to Denver Water households according to Denver Water's service line inventory, as follows:

Denver Water's service line inventory dated August 8, 2019 includes:

- 319,700 service lines used for drinking water in the Denver Water service area.
- 84,546 service lines identified as known, suspected and possible lead service lines – these premises are candidates for FLOW.

Multi-family properties are included in the 84,546 service lines that are part of the filter program. A multi-family property has multiple household units. A household unit is an individual residence that receives a filter. Using available data, it is estimated that Filter

Program participants consist of 119,250 Denver Water household units, with each household unit receiving a filter.

FLOW is used as the interim treatment barrier to remove lead from customers' drinking water until the lead service line is replaced or confirmed as non-lead. Denver Water is considering providing filters through the end of 15 years as Denver Water progresses through the inventory of lead service line properties and replaces lead service lines. Denver Water households using an NSF certified filter to reduce lead will experience a >97% reduction in lead levels.

Upon LRP approval, it is expected that the full-scale implementation of FLOW will commence immediately following the multi-media public information campaign and customer notification model in accordance with the Communication, Outreach and Education (COE) Plan. The success of the COE and FLOW is paramount to provide Denver Water with information and, also to share information with Denver Water households that does as much as possible to encourage filter use and education.

The goal of the FLOW Pilot is to distribute filters and collect follow-up surveys from at least 200 Denver Water households. The schedule for the FLOW Pilot is:

- General LRP press release by Denver Water on July 1, 2019.
- Distribute approximately 300 filters starting July 9, 2019.
- Collect and analyze follow-up surveys on filter usage from at least 200 Denver Water households by early August 2019.

Filter Type

As part of Denver Water's current practice, a pitcher filter is distributed by Denver Water to a Denver Water household:

- after the replacement of their lead service line, with five (5) months of replacement cartridges; or
- after potholing reveals a lead service line, with five (5) months of replacement cartridges.

Denver Water currently distributes a ZeroWater pitcher filter with the following features:

1. 10-cup capacity
2. NSF/ANSI Standards 42 and 53 certified
3. 5-stage filter with ion exchange that removes 99.6% of detectable dissolved solids, including lead and fluoride
4. filter cartridges replaced based upon average use (approximately 30-days for a Denver Water household)

In addition to pitcher filters, other filters certified to remove lead by NSF include: filters attached to the kitchen faucet and refrigerators filters. Denver Water will be able to purchase filters from multiple vendors that are NSF certified to remove lead and do not remove fluoride. A summary of available pitcher filters and available alternative filter

types and replacement cartridges for consideration by Denver Water is included in Appendix A.

Although Denver Water's available inventory of ZeroWater 10-cup pitcher filters remove fluoride, the ZeroWater pitcher filters were distributed for the FLOW Pilot due to the pilot schedule and use of Denver Water's stock of pitcher filters.

Filter Kit

Each participant of the FLOW Pilot received a kit with the pitcher (including a filter), three replacement filter cartridges (four total filter cartridges), and education/outreach material. Details on the pilot filter kit (education / outreach documents, pitcher filter and cartridge manufacturer instructions, packaging, and other contents) are included in Appendix B.

Filter Distribution Method

Filter kits were distributed to Denver Water households using various methods:

- Direct mail by Denver Water with tracking and delivery confirmation through USPS shipping software, Pirate Ship
  - USPS - Priority Mail (1 to 3 day delivery)
- Hand delivery by Denver Water or contractor
  - Door-to-door canvassing
    - In-person transaction
    - Drop-off

For the FLOW Pilot, Denver Water distributed approximately 300 filter kits as outlined in Table III.C.2-1.

Table III.C.2-1 Kit Distribution Breakdown

Distribution Method	Number of Denver Water households
Direct mail USPS	200
Door-to-door	100

Notification Methods

Notification methods that were employed in the FLOW Pilot are intended to be similar to those proposed for the full-scale implementation of the FLOW Program. Methods include:

- Direct mail and door-to-door delivery of filter kits (Appendix B) with a letter to the customer (Appendix C), detailed instructions regarding the FLOW Pilot, water filter cartridge use and replacement, an informational frequently asked questions (FAQ) explainer, a survey/response form (bilingual), a quick response (QR) code

for access to Denver Water's digital registration page (in lieu of mail-in survey/response), a reminder magnet for maintenance of the pitcher, and other related details. For the full-scale FLOW Program, the material will be available on Denver Water's website.

- Door-to-door canvassing of neighborhoods campaigns, neighborhood meetings, and additional strategic community outreach.
- Robo calls to impacted Denver Water households.
- Follow-up communication using mail, email, phone, and door-to-door survey.
- Offer water quality sampling to quantify the magnitude of lead release, if not previously sampled.
- Interview Denver Water households to determine whether or not an alternative means to reduce lead exposure is employed, such as an existing filter system (confirmed NSF certified to remove lead), or if the Denver Water households rely on bottled drinking water for infant formula, drinking, and cooking.
- Make one additional attempt to encourage the customer to use a filter, based on site specific information for materials of construction and the water quality sampling results.

In addition, water quality sampling and community outreach and education materials will continue to be provided to customers not in the FLOW Pilot, as requested.

Survey

The four categories of surveys for gathering information from FLOW Pilot participants about how filters are used for infant formula, drinking, and cooking activities include:

- **Initial Survey:** The intent of this survey is to obtain initial feedback from the Denver Water household. This survey is included in the hand-delivered and mailed filter kits. The questions in the initial survey are included in Appendix D. If the Denver Water household receives a kit and does not complete the initial survey, follow-up emails and phone calls were performed. A $15 Amazon gift card incentive was offered to the Denver Water household, upon completion of this survey, to encourage them to complete the survey. The Initial Survey is located at: denverwater.org/Lead-survey. Further details on follow-up are included in Table III.C.2-2.
- **Use Survey:** The use survey was sent to FLOW Pilot participants a week or two after they have received their filter kit. The primary intent of this survey is to confirm if a Denver Water household is using the pitcher filter for infant formula, drinking, and cooking. The survey includes an option if the Denver Water household prefers an alternative filter other than a pitcher filter, such as filters attached to the kitchen faucet or refrigerator filters. The questions in the survey are included in Appendix D. To remind the Denver Water household to complete the survey, Denver Water sent emails and made follow-up phone calls. A $15 Amazon gift card incentive was offered to the Denver Water household, upon completion

of this survey, to encourage them to complete the survey. The Use Survey is located at: denverwater.org/FLOW-survey.

- **Alternative Survey:** If a Denver Water household has an alternative filter installed, the alternative survey would be sent to confirm if the Denver Water household is using the alternative filter for infant formula, drinking, and cooking. The questions in the survey are included in Appendix D. If the Denver Water household receives an alternative filter and does not complete the survey, Denver Water sent emails and make follow-up phone calls to remind the Denver Water household to complete the survey. A $15 Amazon gift card incentive was offered to the Denver Water household, upon completion of this survey, to encourage them to complete the survey. The Alt Survey is located at: http://bit.do/LSL-AlternativeFilter. Alternative filter cartridge replacement schedules range from 3 to 8 months.
- **Ongoing Surveys:** The intent of this survey is to confirm if the Denver Water household is continuing to use the filter for infant formula, drinking, and cooking. Surveys will be conducted, monthly, in coordination with a reminder for the Denver Water household to change their pitcher filter cartridge. The survey will obtain feedback of the COE and the FLOW Pilot. The questions in the survey are included in Appendix D. Denver Water will send emails and make follow-up phone calls to remind the Denver Water household to complete the survey. A $15 Amazon gift card incentive will be offered to the Denver Water household, upon completion of this survey, to encourage them to complete the survey. The Ongoing Surveys are located at: http://bit.do/LSL-Ongoing. The schedule for the ongoing surveys is as follows:
    - August 26th - Follow-up phone calls/emails to remind participants to complete Use Survey, obtain feedback, and inform customer that pitcher filter cartridge should be replaced per manufacturer's recommendations*.
    - September 23rd - Survey - follow-up phone calls/emails to complete survey and inform customer that pitcher filter cartridge should be replaced per manufacturer's recommendations*.

    ** To evaluate the potential filter adoption rate, a survey of all participants of the FLOW Pilot was undertaken to measure filter use and understand reasons for non-adoption.*

For all surveys, Denver Water provides an online survey option that is mobile friendly (Snap Survey). Surveys included a unique website/Uniform Resource Locator (URL) and a Quick Response (QR) code and may be accessed by mobile phones. Each participant has a unique survey access code assigned, so that responses can be tracked to the Denver Water household.

Denver Water will follow-up to provide education on methods to reduce lead exposure; determine whether or not an alternative lead reduction strategy is used; and ultimately encourage the use of the filter for customers that either do not respond to the survey or communicate that the filter was not used.

Vulnerable Populations

Vulnerable populations, such as expecting families, children, and those of low socioeconomic standing, will be identified, contacted, and tracked using the following methods:

- COE – Outreach to specific groups will be completed using community outreach, meetings, and individual interaction with Denver Water households using the tactics noted in Appendix III.A Communications, Outreach and Education Plan.
- Survey Questions - The survey questions will help identify expecting families and families with infants.

Information will be incorporated into the Lead Service Inventory (LSI) for use with the predictive modelling effort described in Appendix III.B.3 Prediction Model and Prioritization.

Lessons Learned

Other entities have distributed filters to customers for lead and non-lead programs. The lessons learned from distribution of filters for other entities are shown in Table III.C.3-3.

Table III.C.2-2 Lessons Learned in Other Jurisdictions

Item No.	Description
1	Directions for filter use must be clear to ensure proper use of filters.
2	Reach out to Denver Water households through various methods: phone calls, emails, door-to-door, website videos, tables at community events, local TV stations, etc.
3	Impersonators may be an issue. Make sure all staff have ID badges and outreach material spells out what Denver Water households can expect from Denver Water staff.
4	Many man hours are needed for door-to-door delivery of pitchers.
5	Be prepared to field questions of why certain citizens are included in the filter program, and others are not. Make sure the criteria are clear and there is consensus on who is in the filter program and who may be added, as more information is gathered.

General Water Quality - Flushing

To reduce your exposure to lead in drinking water, we recommend flushing following the steps highlighted on www.denverwater.org (https://www.denverwater.org/your-water/water-quality/lead/reduce-your-risk).

When using water for drinking, cooking and making ice, beverages and infant formula:

- *Use cold water. Hot water dissolves lead faster and is likely to contain higher levels of lead.*
- *If water has not been used for a few hours, run the kitchen or any bathroom faucet for a few minutes. You also can run the dishwasher or take a shower.*

III. DENVER WATER HOUSEHOLD IDENTIFICATION/SELECTION OF CANDIDATES

Candidates for the FLOW Pilot are representative of the general Denver Water customer population, including:

- varied income levels, and
- mix of English-speaking and Spanish-speaking.

For the FLOW Pilot, the neighborhoods selected are:

- West Colfax
- Villa Park
- Barnum West
- Barnum
- Westwood
- Valverde, and
- Athmar Park

These neighborhoods are generally considered to have mixed income and include English-speaking and Spanish-speaking Denver Water households.

Candidates for the FLOW Pilot were identified by Denver Water using available GIS data per the following criteria:

- Suspected lead service line
- Premise address is the mailing address
- Owner occupied
- One phone number. Denver Water households with multiple phone numbers on the "Person" table were deleted. Due to the compressed pilot schedule, the use of one phone number will eliminate potential confusion where one tap has many different phone numbers.

Based upon the data query above, Denver Water GIS generated a file of 992 candidates with suspected lead service lines, living in the seven selected neighborhoods. A subset of 300 customers were identified from the 992 candidates. As the 992 customers were not evenly distributed over the seven neighborhoods, customers were proportionally selected based on roughly 3 in 10 customers, while ensuring the proportion of customers in each neighborhood remained close to the original dataset. The records were sorted by

neighborhood, then every third record was selected until the number of selected records was 30% of the original number of records in that neighborhood. Every third record was selected because it was noted that there was some geographic correlation between the natural order of the records which would have otherwise resulted in geographic bias within each neighborhood. The final selection of 300 customers was reviewed by Denver Water staff to ensure they are suitable for inclusion in the FLOW Pilot program (i.e., have a suspected lead service line).

Maps showing the location of the 300 selected premises are provided in Appendix E.

IV. FILTER PILOT - 5100 SERIES

The framework for the FLOW Pilot consists of the following four (4) stages of processes and workflows:

- 5110 – Initial Distribution
- 5120 – Use Survey & Alternative Filters
- 5130 – Filter Adoption
- 5140 – Filter Cartridge Replacements

The FLOW Pilot – 5100 Series: Workflow/Flowchart that illustrates the sequence of the steps for each stage is included in Appendix F. Below are the details of the key steps for each of the stages.

A. Initial Distribution (5110)

Initial Distribution (5110) is the first stage of the FLOW Pilot with the following steps:

- **5111 - Notify Stakeholders:** In addition to the July 1, 2019 press release, Denver Water notified / informed city, community and neighborhood leaders and stakeholders of the FLOW Pilot.
    - Identify key leaders and stakeholders
    - Contact the leaders and stakeholders via telephone call or email
        - Review details in the press release.
        - Notify / inform leaders and stakeholders of the FLOW Pilot.
- **5112 – Training:** Office and field staff supporting the FLOW Pilot were trained.
    - Finalize filter kit education/outreach material, surveys, phone / in-person scripts, FAQs, and other key references, as included in Appendix G.
    - Conduct in-person training.
- **5113 – Kit Assembly:** The filter kit contents (see Appendix B) were procured, assembled into kits, and stored in Denver Water Building H – Warehouse.
    - 200 kits boxed for mailing
    - 100 kits bagged for hand delivery
- **5114 – Mail Kits:** Two-hundred (200) boxed filter kits with letters were mailed to Denver Water households via USPS Priority Mail. The letter is provided in

Appendix C. Denver Water households that are enrolled in the Denver Water email subscription were also emailed the letter highlighting that the filter kit package has been mailed, encourage participation, and request for the Denver Water household to contact Denver Water if the Denver Water household does not receive the kit within 5 days. Further details on the filter kit distribution and follow-up are included in Table III.C.2-2. For the mailed kits, the intent is to split into four groups with varying levels of follow-up. Field staff carried a Denver Water photo identification and were dressed in safety t-shirts, adorned with the approved Denver Water logo, for ease of identification.

- **5115 – Hand-Deliver Kits:** Bagged filter kits with letters were hand delivered to Denver Water households. The letter is provided in Appendix C. Denver Water households that are enrolled in the Denver Water email subscription were also emailed the letter highlighting that the filter kit package will be delivered, and encourage participation. Further details on the filter kit distribution and follow-up are included in Table III.C.2-2. For the hand-delivered kits, the intent is to split into two groups with varying levels of follow-up. Field staff carried a Denver Water photo identification and were dressed in safety t-shirts, adorned with the approved Denver Water logo, for ease of identification.
- **5116 – Initial Survey**

Table III.C.2-3 FLOW Pilot Distribution Plan

Distribution Method	Number of Denver Water households	Details / follow-up
Direct mail USPS (5114)	50	One (1) phone call follow-up reminder to use filter and request Denver Water household to complete the Initial Survey (5116)
	50	Up to three (3) phone call follow-up reminders to use filter and request Denver Water household to complete the Initial Survey (5116)
	50	Up to three (3) phone calls and one (1) follow-up visit / door hanger to remind the Denver Water household to use filter and request Denver Water household to complete the Initial Survey (5116)
	50	Up to three (3) phone calls and up to two (2) follow-up visits / door hangers to remind the Denver Water household to use filter and request Denver Water household to complete the Initial Survey (5116)
Door-to-door canvassing of	50	Visit 1 - in-person transaction (explain the program and encourage use of the filter, hand-deliver a filter kit, and ask Denver Water household to complete Initial Survey

Table III.C.2-3 FLOW Pilot Distribution Plan

Distribution Method	Number of Denver Water households	Details / follow-up
neighborhood (5115)		One (1) phone call follow-up reminder to use filter and request Denver Water household to complete the Initial Survey (5116)
	50	Visit 1 - in-person transaction (same as above) or leave kit on door Up to three (3) phone calls follow-up reminders to use filter and request Denver Water household to complete the Initial Survey (5116)

B. Use Survey & Alternative Filters (5120)

Use Survey & Alternative Filters (5120) is the second stage of the FLOW Pilot with the following steps:

- **5121 - Analysis/Tracking:** Data gathered from the filter kit distribution, door-to-door visits, surveys, and other feedback received were captured in a centralized database. For this step, data was further analyzed related to the participant's pitcher filter use and requests for alternative filters.
- **5122 – Use Survey**
- **5123 – Mail Alt Filter**: If an alternative filter has been requested by the Denver Water household and they have opted for a home-owner-installed alternative filter, the alternative filters will be directly mailed to the Denver Water household. The Alt filter option is predicted to be used for alternative filters that are easily installed.
- **5124 – Install Alt Filter:** If an alternative filter has been requested by the Denver Water household and they have opted for Denver Water to install, an appointment will be made and the alternative filter will be installed. Before installing the filter, Denver Water will conduct a visual inspection of the service line as it enters the house. With the aid of the homeowner, the entry point for the service line will be identified. Field staff will carry a Denver Water photo identification and will be easily identifiable.
- **5125 – Alternative Survey**

C. Filter Adoption (5130)

Starting approximately one week following Initial Distribution (5110), the Filter Adoption (5130) stage commenced with the following steps:

- **5131 - Analysis/Tracking:** Data gathered from the filter kit distribution, door-to-door visits, surveys, and other feedback received were captured in a centralized database. For this step, data was further analyzed related to the Denver Water household's filter use and COE.
- **5132 – Ongoing Surveys**

D. 5140 – Filter Cartridge Replacements

- **5141 – Transition:** When the LRP Variance is approved, the full-scale FLOW Program will be implemented. At this point, the Denver Water household will be transitioned to the Filter Cartridge Replacement: 5200 Series, as part of the full-scale FLOW Program. Filter Cartridge Replacement: 5200 Series will include distribution of replacement cartridges until six (6) months after the replacement of the lead service line. The 5200 Series will continue to have monthly reminders to replace filter cartridges and requests to complete surveys. The tentative transition schedule is as follows:
    - November 8th
        - Distribute next batch of replacement cartridges.
        - Follow-up phone calls/emails to inform customer that pitcher filter cartridges require replacement per the manufacturer's recommendation and the next batch of replacement cartridges was mailed.
        - Finalize transfer of Denver Water household into the Filter Cartridge Replacement: 5200 Series workflow.
- **5142 – Discontinue FLOW Pilot:** If the LRP Variance is not approved, the FLOW Pilot will be discontinued. A letter will be sent to the Denver Water household notifying them.

V. DATA MANAGEMENT

Microsoft SharePoint, Microsoft Excel, and GIS was used to manage data related to the FLOW Pilot. The use of SharePoint and Excel is based primarily on the limited sample size (approximately 300 residences) and the accelerated schedule of the FLOW Pilot, which favors ease of access and customizability compared to more structured data management platforms, like databases, which may have limited access or require advanced knowledge to manipulate. Use of Excel in the SharePoint environment avoids many of the versioning issues resulting from stand-alone Excel files while also taking advantage of distributed access and concurrent editing capabilities. Standards were set for editing information to ensure consistency and facilitate data analysis and reporting, such as applying data validation and locking columns which should not be edited. Quality Assurance/Quality Control (QA/QC) techniques were used to check the accuracy of the data.

Filter recipients were asked to respond to several online surveys related to filter use. The surveys have been administered using the survey tool, Snap Survey, to seamlessly collect data directly from FLOW Pilot participants. The collected survey data was then exported to Microsoft Excel on SharePoint for further analysis/aggregation of results. Excel or PowerBI may be used to produce a dashboard tracking metrics or interest for the FLOW Pilot. The Mott MacDonald Field Inspection Tools (MMFIT) application will not be available during the FLOW Pilot; however, consideration will be given to how data collection efforts may be performed using MMFIT for the full filter program.

VI. FILTER USE ADOPTION SUMMARY

Multiple surveys will continue to be completed by the Denver Water households that are participating in the FLOW Pilot, which include the Initial Survey (5116); Use Survey (5122); Alternative Survey (5125); and Ongoing Surveys (5132). The survey questions and a copy of the surveys are included in Appendix D. Survey results included are supported by a hard copy or an electronic output from the online platform, as shown in Appendix H. Filter use adoption was completed primarily based upon the responses to the following two survey questions:

1. Do you use your filter for drinking water? Yes/No
2. Do you use your filter for water used in cooking? Yes/No

Filter adoption rates and primary sources for drinking water and cooking was tracked during the FLOW Pilot and data collected is included in Appendix H. Filter adoption assumes customers are using the pitcher filter for drinking water and cooking. Denver Water will continue to follow-up with the Denver Water households to complete additional Use Surveys.

A summary of the FLOW Pilot survey responses as of August 13, 2019 is as follows:

1. 247 kits were mailed (187 to original FLOW candidates, 34 to additional FLOW participants who requested kits; 25 re-sent to pilot participants that did not initially receive them; 1 kit sent to resident who requested a second filter for cooking).
2. Kits were mailed on Wednesday, July 10 and hand-delivered on Thursday, July 11, additional kits were mailed July 13, July 23, July 30, and August 2 and hand-delivered on July 27, 30, and 31, 2019.
3. Two kits were refused and mailed back.
4. 93 kits were hand-delivered on Thursday, July 11.
5. 8 kits were hand-delivered during follow-up visits to pilot participants who did not receive their initial kit.
6. 4 kits were hand-delivered during a community resource fair on Saturday, August 10, 2019.
7. All 280 pilot participant houses had at least one follow-up visit.
8. **Initial Survey Responses Received:** 25% - 69 total (out of 280 pilot participants): 52 hard copy surveys and 17 online surveys. Of the 69 surveys received, 5 were completed in Spanish - 7%.

- Use unfiltered tap water for drinking and cooking: 31/69 – 45%
- Use bottled water for drinking: 16/69 – 23%
- Use filtered water for drinking: 22/69 – 32%
- Use filtered or bottled water for cooking: 13/69 – 19%
- Participants who reported that they had a lead service line:
    - Yes: 13/69 – 19%
    - No: 3/69 – 4%
    - Did not know: 53/69 - 77%

9. **Use Survey Responses Received:** 28% – 79 total (out of 280 pilot participants): 54 hard copy surveys and 25 online surveys. Of the 78 surveys received, 10 were completed in Spanish - 13%.
    - Use for drinking water: 72/79 – 91%
    - Use for drinking and cooking: 48/79 – 61%
    - Use for infant formula*:
        - Yes: 19/79 – 24%
        - No: 11/79 – 14%
        - Not Applicable: 49/79 – 62%

    **Survey responses indicated that there may have been confusion regarding the response of "no" or "not applicable" for the infant formula question.*

    - Pilot participants who would prefer an alternative filter:
        - Faucet-mounted filter: 36/79 – 46%
        - Larger pitcher filter: 12/79 – 15%
        - Refrigerator filter: 6/79 – 8%

A summary of the resources required and associated cost to implement the FLOW Pilot as of August 13, 2019 is summarized in Table III.C.2-4.

Table III.C.2-4 Flow Pilot Resource Summary

Task Description	No. of Staff	No. of Hours per Staff	Total Hours / Units	Hourly Rate / Unit Cost	Total Cost	Kits / Customers	Cost per Kit
Labor Costs							
Develop COE Materials and Surveys (Kits)	2	100	200	$175	$35,000	300	$120
Develop Maps and Data Tracking Forms (Kits)	1	40	40	200	$8,000	300	$30
Assemble for Mailing (Kits)	12	12	144	$75	$10,800	200	$50
Assemble for Hand Delivery (Kits)	12	6	72	$75	$5,400	100	$50
Door to Door Hand Delivery (Kits)	12	8	96	$75	$7,200	93	$70
Door to Door Follow-up (Customers)	9	24	216	$75	$16,200	300	$50
Telephone Calls (Customers)	2	15	30	$100	$3,000	300	$10
Logging Data, Survey Results, and Tracking (Kits)	2	40	80	$110	$8,800	300	$30
Gift Card Distribution and Responses (Customers)	2	4	8	$110	$880	142	$7
Oversight (Kits)	1	80	80	$110	$8,800	300	$30
				Total Labor	**$104,080**	300	$450
Direct Costs							
Filter Kits, Replacement Cartridges, Magnets, Bags, Door Hangers, Flyers, Miscellaneous	--	--	300	$50	$13,000	300	$50
Mail Kits (Outside Vendor)	--	--	247	$12	$3,000	247	$12
Gift Cards for Completed Surveys	--	--	142	$15	$2,150	142	$15
				Total Direct Costs	**$18,150**	300	$80
				Total Pilot Cost	**$122,230**	300	$530

VII. PILOT DEMOGRAPHIC SUMMARY

As part of the use survey, it is important to determine the adoption rate amongst the diverse populations in the Denver Water service area. The American Community Survey (ACS) is part of the U.S. Census Bureau's Decennial Census Program and is designed to provide current social, economic, housing, and demographic estimates throughout the decade. Combining American Census Survey (ACS) data with FLOW Pilot data allowed for the estimation of trends between levels of diversity in a neighborhood and filter adoption rates within the FLOW Pilot neighborhoods. ACS information at the Block Group Level will be taken from the 2013 to 2017 American Community Survey estimates. The information was adjusted for the Hispanic representation included as a category to reflect additional available diversity information. The information was linked to the Survey Census Block Groups to develop a geographic component to the data. The survey data was then evaluated by Diversity Categories By Block Group (ACS Data for B02001) as follows:

- Hispanic alone
- White (Non-Hispanic) alone
- Black or African American alone
- American Indian and Alaska Native alone
- Asian alone
- Native Hawaiian and Other Pacific Islander alone
- Some other race alone

The FLOW Pilot survey results were geolocated based on the address, tap number, or other available spatial information. The geolocation allows the data collected from the FLOW Pilot to be associated to a location and a block group for further analysis of the adoption rates and other survey results compared to the available diverse population statistics for each area. The following evaluations were completed for the Filter Pilot premises:

1. The comparison of the adoption rate noted on completed surveys to the diverse population for each surveyed area.
2. The comparison of areas where surveys where sent but not returned or the adoption rate is low.
3. The identification of specific diverse populations where surveys were sent but not returned or the adoption rate is low.
4. The comparison of the survey results between different areas and diverse groups to establish trends by ethnic population.
5. The populations where filters were sent but surveys not returned.
6. The comparison of adoption rate to the baseline approved adoption metric.

The survey results were then compared to the neighborhood demographics. The COE program can be adjusted if there is a lack of survey results or negative feedback from a certain area are identified. If an area is systemically not participating in FLOW, then the areas' criticality (and thus risk) will be ranked as higher priority in the ALSLR Program.

A summary of the FLOW Pilot demographics evaluation, for three of the seven neighborhoods, is shown in Table III.C.2-5.

Table III.C.2-5 Survey Results by Diversity Analysis (sample results)*

Neighborhood	1	2	3
White Hispanic (%)	62	64	61
White Non-Hispanic (%)	29	16	18.6
Black or African American (%)	3	1	0.1
American Indian and Alaska Native (%)	2	1	0
Asian (%)	0	9	19
Native Hawaiian and Other Pacific Islander (%)	0	0	1
Other (%)	4	9	0.3
Number Using Filter for Drinking	8	4	2
Number Using Filter for Cooking	6	4	2
Initial Survey Completed	7	8	0
Filter Use Survey Completed	9	6	2
Using for Drinking (%)	89	67	100
Using for Cooking (%)	67	67	100
Initial Survey Completed (%)	64	73	0
Filter Use Survey Completed (%)	82	55	9

**The demographic data was developed using limited survey data from August 2, 2019 and available census data. The demographic data is provided as an example and will be further developed for the full-scale filter plan.*

The data indicate that at least 67% of the population surveyed use the filter for drinking and cooking in three (3) of the seven neighborhoods where White Hispanics make up the majority of the population. Other considerations may be affecting neighborhood 3, which shows a markedly lower survey response rate. A geographic strategy analysis will be conducted to determine how the COE plan should be adjusted in neighborhood 3 as opposed to modifying the overall COE efforts specified for the White Hispanic population. Neighborhood 3 has a larger Asian pvopulation and this information will be used to provide guidance for increased COE for filter adoption in this neighborhood.

VIII. PILOT LESSONS LEARNED SUMMARY

The intent was to proceed with the FLOW Pilot Distribution Plan described in Table III.C.2-3 but, as a result of the compressed schedule for completion of the pilot, the decision was made to make follow-up home visits to all 280 FLOW Pilot participants. Field staff provided information regarding the program, encouraged program participants to use their filters for infant formula, drinking water, and cooking, and complete the surveys. Door hangers, with educational information, and reminders to use the filters for infant formula, drinking water, and cooking were left on doors of homes with no answer during the door-to-door follow-up field visits. Telephone calls were made to all

participants that were not home during the follow-up field visits. Outreach via telephone calls and the receipt of survey responses continue, on a daily basis, as of August 7, 2019.

Lessons learned from the FLOW Pilot that will be implemented into the full-scale FLOW Program are shown in Table III.C.2-6.

Table III.C.2-6 Lessons Learned From the Filter Pilot Program

Item No.	Description
1	Provide advance targeted communications, outreach and education prior to filter distribution to introduce the program and explain the importance of filter use.
2	Reinforce the importance of using the filter for cooking and infant formula preparation (in addition to drinking water).
3	Inform participants the filters and replacement cartridges are provided at no cost to the customer for the duration of the program.
4	Provide alternative filters such as refrigerator, larger pitchers, and faucet mount.
5	Provide additional Spanish-speaking staff for field crews for initial distribution and follow-up visits.
6	Have one adoption survey after the participants have been contacted, are aware of the program, and have been using the filter for period of time.
7	Send filters addressed to tenants, not owners of the homes, if renters reside in the household.
8	Print individual participant's survey access codes directly on their survey in order to easily track the participant's responses.
9	Make survey questions clear, so that each answer doesn't have more than one meaning.
10	Have more outreach materials educating customers about how the service line is owned by the homeowner and how they can request a lead test kit.
11	Simplify outreach materials.
12	Update phone numbers in the database as project progresses.
13	Provide alternative filters and additional filters as filling the pitcher is cumbersome and slow.
14	Younger generation prefer online survey responses and electronic communications.
15	Not all residents have email addresses and internet access and hard copy surveys should continue to be provided.
16	Follow-up calls should be made from a Denver Water phone number.
17	Outreach staff should fill out and request a water quality sampling kit for concerned residents.
18	Include lead service line replacement information and talking points with filter program.
19	Follow-up visits and door-to-door outreach is not preferred for all participants. Some have requested communication via email only.
20	Simplify survey questions to prevent confusion.

In addition to the FLOW Pilot, Denver Water is distributing and will continue to distribute water pitcher filters to customers:

- post lead service line replacement, with five (5) months of replacement cartridges
- potholing program participants when a lead service line is detected, with five (5) months of replacement cartridges

The non-pilot customers will be surveyed and provided additional education/instruction material that is distributed with the FLOW Pilot.

IX. FLOW PILOT TIMELINE

Date	Activity	Milestone
	5110 – Initial Distribution	
June 2019	Develop FLOW Pilot Plan	Review FLOW Pilot plan
Week of June 3, 2019	Prepare pitcher filter supply	Confirm pitcher filter supplies
June 13, 2019	COE	Launch Denver Water internal COE plan
June 20, 2019	Kick-off meeting with DW, GWD, and MHYC	Contracts completed Project plan implementation begins
June 24, 2019	Order Filter Kit Supplies (door hangers, instructions, bags)	Filter kit supplies ready for kit assembly
Week of July 1, 2019	Go/No Go	Authorization to proceed with FLOW Pilot program
July 8, 2019	Notify Stakeholders	Stakeholders prepared for roll-out of the FLOW Pilot
July 8 & July 9, 2019	Training/Kit Assembly	GWD and MHYC are given training materials and filter kits are ready for distribution
July 10, 2019	Kit Pick-Up	Filter Kits picked up by USPS Priority Mail (1-3 day shipping)
July 10 to July 14, 2019	Hand-Deliver Kits	• Filter Kits hand-delivered • Determination of in-house filter services
July 10 to July 14, 2019	Initial Survey (5116)	Initial Survey (5116) distributed in filter kits (via mail and hand-delivered)
July 11, 2019	Mail & Deliver Kits	Earliest delivery of mailed filter kits to Denver Water households
July 15 to July 17, 2019	External COE	Follow-up phone calls and emails to FLOW Pilot participants

Date	Activity	Milestone
5120 – Use Survey & Alternative Filters		
Starting July 22, 2019	• Analysis/Tracking • Use Survey (5122)	• GWD/MHYC feedback and collection of data • Filter Adoption: Use Survey (5122) • Determine alternative filter type requested
August 19 to September 30, 2019	• Mail Alternative Filters • Install Alternative Filters • Alt Survey (5125)	• Order, delivery, and installation of alternative filter equipment • Filter Adoption: Alt Survey (5125)
August 1 to August 2, 2019	Progress Meeting	• GWD/MHYC feedback and collection of data
5130 – Filter Adoption		
August 1, 2019 to October 31, 2019	• Analysis/Tracking • Ongoing Surveys (5132)	• GWD/MHC feedback and collection of data • Filter Adoption: Ongoing Surveys (5132) • Follow-up phone calls
5140 – Filter Cartridge Replacements		
October 31, 2019	Variance Approved, Yes/No	• Variance Approved - Transition to Cartridge Replacement: 5600 Series • Variance Not Approved - Discontinue FLOW Pilot

APPENDIX A – FILTER TYPES

DENVER WATER

Filter Types

Federal regulations do not exist for residential water treatment filters. Voluntary national standards and National Sanitation Foundation (NSF) / American National Standards Institute (ANSI) protocols have been developed to establish minimum requirements for the safety and performance of residential water treatment filters. NSF/ANSI Standards 42 and 53 are applicable for water quality and lead removal, as described, below.

- **NSF/ANSI 42**

  Filters are certified to reduce aesthetic impurities such as chlorine, taste, and odor. Filters can be point-of-use (POU) (faucet filter, water pitcher, etc.) or point-of-entry (POE) (whole house) treatment systems.

- **NSF/ANSI 53**

  Filters are certified to reduce a contaminant with a health effect, such as lead. The standard establishes health effects as regulated by the U.S. Environmental Protection Agency (EPA). Both standards 42 and 53 include adsorption and filtration treatment.

NSF established laboratories that may test and certify filters that meet the NSF protocols for lead removal. The certified laboratories include: NSF International, CSA International, Water Quality Association (WQA), International Association of Plumbing and Mechanical Officials, Underwriters Laboratory, Truesdail, and Intertek.

A summary of different types of filters, certification laboratory to NSF/ANSI Standards 42 and 53, and associated filter life is shown in Table A1. The general range of filter life for pitcher filters is 1-6 months and the general range of filter life for alternative filters is 1-10 months. Product detail sheets are attached.

DENVER WATER

Table A1: Point-of-Use Filter Types

Filter Type	Brand/Model	Certification Laboratory	Filter Life	Percent Lead Reduction at pH 8.5
Pitcher	Brita Monterey (#OB50) 10-cup pitcher with Longlast filter (#OB06)[1]	WQA	6 months	99.6%
	DuPont 8-cup pitcher (WFPT100) with WFPTC100N filter[2]	WQA	3 months	97.4%
	DuPont WFTP200 10-cup pitcher with WFPTC100N filter[3]	WQA	3 months	97.4%
	ZeroWater 10-cup filter pitcher (ZP-010)[4]	NSF	1 month	99.0%
	Pur Classic 11-cup pitcher (PPT111WV1) with lead reduction filter (PPF951K)[5]	WQA	2 months	97.9%
Water Dispenser	ZeroWater 20-cup water filter jug (ZD-20RP)[6]	NSF	1 month	99.0%
	ZeroWater 30-cup water filter jug (ZD-30RP)[7]	NSF	1 month	99.0%
	ZeroWater 40-cup water filter jug (ZBD-040)[8]	NSF	1 month	99.0%

Table A1: Point-of-Use Filter Types

Filter Type	Brand/Model	Certification Laboratory	Filter Life	Percent Lead Reduction at pH 8.5
Water Dispenser	Brita Ultramax 18-cup Dispenser (#OB24) with Brita Longlast filter (#OB06)[9]	WQA	6 months	99.6%
Faucet-Mount	DuPont WFFM100 Faucet Mount Filter with WFFMC100 or WFFMC300 filter[10]	WQA	5 months	99%
	DuPont WFFM350 with Ultra Protection Filter (WFFMC300)[11]	WQA	10 months	99%
	Brita Faucet Filtration System FF-100 with FR-200 filter[12]	NSF & WQA	5 months	99.3%
	Brita Basic Faucet Filtration System SAFF-100 with FR-200 filter[13]	NSF & WQA	5 months	99.3%
	Pur PFM400H Faucet with MineralClear Filter (RF9999)[14]	WQA	3 months	99.9%

DENVER WATER

Table A1: Point-of-Use Filter Types

Filter Type	Brand/Model	Certification Laboratory	Filter Life	Percent Lead Reduction at pH 8.5
Refrigerator Filters	Frigidaire PureSource 3 (WF3CB)[15]	NSF	6 months	99.1%
	Maytag Refrigerator Water Filter (UKF8001)[16]	NSF	6 months	99.3%

Notes:

1. *https://www.brita.com/water-pitchers/monterey-longlast/?ds_rl=1238837&gclid=Cj0KCQjw9JzoBRDjARIsAGcdIDUi8xyyMENARguLCz_NAqDULgUppLOhn01Pd3XbXRcXZGGWDHWOyLgaAslGEALw_wcB&gclsrc=aw.dshttp://www.protectplus.com/PD-Water-Filtration-82/DuPont-Traditional-Water-Filter-Pitcher-WFPT100-653*
2. *http://www.protectplus.com/PD-Water-Filtration-82/DuPont-Mirage-Water-Filter-Pitcher-WFPT200-652*
3. *http://www.protectplus.com/PD-Water-Filtration-82/DuPont-Mirage-Water-Filter-Pitcher-WFPT200-652*
4. *https://ww.zerowater.com/products-10-Cup-Pitcher?gclid=Cj0KCQjw9JzoBRDjARIsAGcdIDWhrdUxnskz0UuAp4CIuQcDKJ27qwbOVoqxdOPq9XYFa3QJlVwIK2YaAhvzEALw_wcB*
5. *https://www.pur.com/water-filter-pitchers-and-dispensers/pur-ultimate-pitcher-filtration-system-with-lead-reduction*
6. *https://ww.zerowater.com/products-20-Cup-Ready-Pour*
7. *https://ww.zerowater.com/products-30-Cup-Ready-Pour*
8. *https://ww.zerowater.com/products-40-Cup-Ready-Pour*
9. *https://www.brita.com/water-dispensers/ultramax-longlast/*
10. *http://www.protectplus.com/PD-Water-Filtration-82/DuPont-Premier-Faucet-Mount-Drinking-Water-Filter-WFFM100-647*
11. *http://www.protectplus.com/PD-Water-Filtration-82/DuPont-Deluxe-Faucet-Mount-WFFM350-646*
12. *https://www.brita.com/faucet-systems/complete/*
13. *https://www.brita.com/faucet-systems/basic/*
14. *https://www.pur.com/faucet-filtration-systems/pur-advanced-faucet-filtration-system-with-mineralclear-filter*
15. *https://www.frigidaire.com/Filters--Accessories/Filters/water-filters/WF3CB/?gclid=CjwKCAjwuqfoBRAEEiwAZErCsqQkifIHCX2HhuFjxt_hL213qbrqvzOJ96upk87nk6SIa4b2_4hT2BoCuXYQAvD_BwE&gclsrc=aw.ds*
16. *https://www.homedepot.com/p/Maytag-UKF8001-Refrigerator-Water-Filter-UKF8001/100671093*

APPENDIX B – FILTER KIT CONTENTS

DENVER WATER

Filter Kit Contents

Each participant of the Filter Lead Out of Water (FLOW) Pilot will receive a filter kit via direct mail or door-to-door hand delivery. Each filter kit includes the following:

Kit Items:

- FLOW Pilot Letter
- Frequently Asked Question (FAQ) summary for lead service lines and FLOW Pilot program questions
- One (1) ZeroWater 10-cup water pitcher - NSF certified for lead removal with one (1) filter cartridge
- Three (3) pitcher replacement cartridges
- Pitcher filter instructions and maintenance guidelines in English, Spanish, and French
- Initial Survey (5116)
- Reusable bag
- Magnet with reminders to use filtered water for infant formula, drinking, and cooking, cartridge date change information, program contact information, website, and telephone number
- Door hanger

The ZeroWater 10-cup pitcher should be used for all infant formula, drinking water, and cooking. The manufacturer's instructions for use and maintenance should be followed and the filter should be replaced in accordance with the manufacturer's guidelines.

ZEROWATER
GET MORE OUT OF YOUR WATER™

10 CUP PITCHER

WITH FREE WATER QUALITY METER

PRODUCT HIGHLIGHTS:

- ZeroWater's premium 5-stage filtration vs. competitors 2-stage filtration
- Certified by NSF to reduce Lead and other heavy metals
- Removes 99.6% of all dissolved solids, 2X more than leading brand filters
- FREE Water Quality Meter included to test your water
- Contoured handle for and non-slip ergonomic grip
- One-hand push to dispense spigot
- 80 oz capacity
- BPA Free

DIMENSIONS: 11.63” x 5.93” x 11" MSRP: $34.99

REMOVES TDS | NSF CERTIFIED | REMOVES LEAD | BPA-FREE | 5 STAGE FILTRATION

5-STAGE FILTRATION

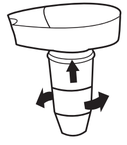
1. Removes suspended solids such as dust and rust that make your water appear cloudy
2. Removes additional suspended solids
3. Removes organic contaminants; pesticides, herbicides, Mercury, Chlorine, Chloramine, and stops bacteria from growing
4. Removes inorganic compounds i.e. metals, nonmetals and radiological contaminants.
5. Removes remaining suspended solids, holds the resin in place

#SS-ZP010-01

ASSEMBLY INSTRUCTIONS
INSTRUCCIONES DE MONTAJE

1 **REMOVE** lid and water reservoir from top of the pitcher and remove filter from packaging. Unscrew the blue protective cap (if applicable).

QUITE la tapa y el depósito de agua de arriba de la jarra y retire el filtro del empaque. Desenrosque la tapa protectora azul (cuando proceda).

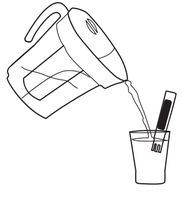


2 **TWIST** filter into the bottom of reservoir (from below) and tighten filter to obtain a complete seal with the reservoir. ***Do not drop the filter in from above.*** Tighten until there is a complete seal between the filter, o-ring and reservoir.

GIRE el filtro en el fondo del depósito (desde abajo) y apriételo hasta que haya un sellado perfecto con el depósito. No deje caer el filtro desde arriba. Apriete hasta que haya un sello completo entre el filtro, el aro en O y el depósito.

3 **FILL** reservoir by pouring/filling with cold tap water (directly into the filter) and place lid on top. Allow all the water to pass through the filter before filling again.

LLENE el depósito con agua fría de la llave (directamente en el filtro) y coloque la tapa. Permita que el agua pase por el filtro antes de volver a llenar.



4 **POUR OR DISPENSE** using spigot (if applicable) to fill your cup or glass once the reservoir has emptied into the body.

VIERTA EL AGUA para llenar su taza o vaso utilizando una boquilla (si procede) una vez que el depósito se haya vaciado en el cuerpo de la jarra.

CLEANING INSTRUCTIONS // INSTRUCCIONES DE LIMPIEZA

Clean your device in warm water using mild soap. Rinse and dry thoroughly.

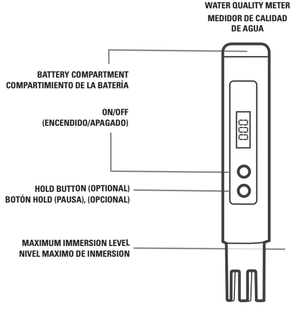
Limpie su dispositivo en agua tibia con un jabón suave. Enjuáguelo y séquelo perfectamente.

ZEROWATER
7 Neshaminy Interplex, Suite 116
Trevose, PA 19053

TDS WATER QUALITY METER
MEDIDOR DE TDS PARA CALIDAD DEL AGUA

The TDS meter supplied is intended to detect and measure TDS (total dissolved solids) in PPM. ***Test your water regularly.***

El medidor de TDS suministrado está diseñado para detectar y medir TDS (sólidos disueltos totales) en PPM (partes por millón). ***Haga pruebas a su agua de manera regular.***



FOR WATER QUALITY METER: Remove cap, turn on, submerge in water, change filter when it reads ***006 or higher***.

PARA EL MEDIDOR DE CALIDAD DE AGUA: Quite la tapa, encienda, sumerja en agua, y cambie el filtro cuando la lectura sea de ***006 o mayor***.

REPLACEMENT BATTERY INSTRUCTIONS: Meter includes (2) alkaline batteries. Do not mix old and new batteries. Do not mix alkaline, standard or rechargeable batteries.

INSTRUCCIONES DE REEMPLAZO DE LA BATERIA: El medidor incluye dos (2) pilas alcalinas. No mezcle baterías viejas y nuevas. No mezcle baterías alcalinas, estándar o recargables.

TDS meters included with select ZeroWater pitchers/dispensers
Los medidores de TDS vienen incluidos con ciertas jarras/despachadores ZeroWater

TROUBLESHOOTING TRY THESE TIPS...
DETECCIÓN DE PROBLEMAS PRUEBE ESTOS CONSEJOS...

1. Not getting a "000" reading? Ensure that the filter is threaded correctly and fully seated in the water reservoir. Watch for cross-threading and ensure that the rubber gasket is seated properly and has not gotten stuck in one of the threads.

   ¿No está obteniendo una lectura de "000"? Asegúrese de que el filtro esté roscado correctamente y asentado completamente en el depósito de agua. Observe si está roscado de manera incorrecta yasegúrese de que el empaque de hule esté bien asentado y no se haya atascado en la rosca.

2. Rinse and dry your pitcher/dispenser, TDS meter, and parts completely. Left over tap water, soap residue or a dirty TDS meter may give false meter readings.

   Enjuague y seque perfectamente la jarra/despachador, el medidor de TDS y todas las piezas. Si se deja agua de la llave, residuos de jabón o un TDS sucio, el medidor podría dar lecturas falsas.

3. Check the O-ring on your filter. If there is no O-ring present on your filter, unfiltered tap water will flow around the filter and into the dispenser.

   Revise el aro en O del filtro. Si no está presente el aro en O en su filtro, el agua de la llave no filtrada podría fluir alrededor del filtro y hacia el despachador.

4. Make sure you are pouring your filtered water into a clean glass. The indicator may pick up trace residue from previous use or soap.

   Asegúrese de verter el agua filtrada en un vaso limpio. El indicador podría detectar residuos de jabón o de usos anteriores.

5. Check for cracks in the reservoir or filter. If you have a crack, please contact customer service for additional instructions.

   Revise si el depósito o el filtro tienen grietas. Si tienen alguna grieta, comuníquese con el servicio al cliente para que le den más instrucciones.

For all other issues, please contact our customer service center at **1-800-503-2939** or email **customerservice@zerowater.com**.

Para otros tipos de problemas, comuníquese con nuestro centro de servicio al cliente al **1-800-503-2939** o envíe un correo electrónico a **customerervice@zerowater.com**.

#2-810INSERTSP-01

FILTRACIÓN PREMIUM EN CINCO ETAPAS

SOLO ZEROWATER DEJA 000 SÓLIDOS DISUELTOS[3]

PARA EL AGUA CON EL SABOR MÁS PURO[2]

PREMIUM 5-STAGE FILTRATION

ONLY ZEROWATER LEAVES

000

DISSOLVED SOLIDS[3]

FOR THE PUREST TASTING WATER[2]

MEDIDOR INCLUIDO:
MIDE LOS SÓLIDOS REMANENTES DISUELTOS[5]

CERTIFICADO PARA REDUCIR EL PLOMO Y OTROS METALES PESADOS[4]

LIMITED WARRANTY FOR ZEROWATER DISPENSER, PITCHER, BOTTLE FILTRATION SYSTEM, TRAVEL BOTTLE & TDS METER Zero Technologies, LLC warrants the ZeroWater Dispenser, Pitcher, Bottle Filtration System, Travel Bottle and TDS Meter to be free from manufacturing defects for 90 days from the date of purchase, when used in compliance with the Owner's Manual. During this 90-day period, if you discover a manufacturing defect in your ZeroWater Dispenser, Pitcher, Bottle Filtration System, Travel Bottle or TDS Meter (excluding the filter), we will replace the parts free of charge. To file a warranty claim, call 1-800-503-2939 or visit www.zerowater.com/contactsus.aspx. Dated proof of purchase required.

FILTER CARTRIDGE LIMITED WARRANTY Zero Technologies, LLC warrants its filters to be free from manufacturing defects for 30 days from the date of purchase, when used in compliance with the Owner's Manual. During this 30-day period, if you discover a manufacturing defect in your filter, we will replace it free of charge (minus shipping costs). Dated proof of purchase required. To place a claim for a defective filter, you must first call 1-800-503-2939 and speak to customer service to trouble shoot the problem. If a potential manufacturing defect is identified, we will provide instructions on how to return the filter for laboratory testing. If the lab determines that the filter is defective, we will replace it free of charge. If no defect is found, your filter will be returned to you. *NOTE: This warranty does not guarantee the life of the filter for any specific period or volume of use. For more information about expected filter life, see www.zerowater.com/filtration-filter-life.aspx.*

For information about warranty, service or how to use your ZeroWater product, please call Customer Service toll free 8am-8pm CT, Mon-Fri, at 1-800-503-2939, or visit our website at www.zerowater.com.

GARANTÍA LIMITADA EN EL DISPENSADOR DE AGUA ZEROWATER, LA JARRA, EL SISTEMA DE FILTRACIÓN DE BOTELLAS, LA BOTELLA DE VIAJE Y MEDIDOR DE TDS Zero Technologies, LLC garantiza durante 90 días a partir de la fecha de compra, que el dispensador, la jarra, el sistema de filtración de botellas, la botella de viaje y el medidor de TDS de ZeroWater no tienen defectos de fabricación, cuando se utilicen de conformidad con el Manual del Propietario. Si descubre un defecto de fabricación en su dispensador, jarra, sistema de filtración de botellas, botella de viaje o medidor de TDS de ZeroWater (excluyendo el filtro), durante este período de 90 días, reemplazaremos las piezas sin cargo. Para presentar una reclamación de garantía, llame al 1-800-503-2939 o visite www.zerowater.com/contactsus.aspx. Se requiere comprobante de compra con fecha.

GARANTÍA LIMITADA DEL CARTUCHO DE FILTRO Zero Technologies, LLC garantiza durante 30 días a partir de la fecha de compra, que el filtro no tiene defectos de fabricación, cuando se utilice de conformidad con el Manual del Propietario. Si descubre un defecto de fabricación en su filtro, durante este período de 30 días, lo reemplazaremos de forma gratuita (menos los costos de envío). Se requiere comprobante de compra con fecha. Para presentar una reclamación por un filtro defectuoso, debe llamar primero al 1-800-503-2939 y hablar a servicio al cliente para resolver el problema. Si se identifica un posible defecto de fabricación, le proporcionaremos instrucciones sobre cómo devolver el filtro para las pruebas de laboratorio. Si el laboratorio determina que el filtro está defectuoso, lo reemplazaremos sin cargo. Si no se encuentra ningún defecto, su filtro le será devuelto. NOTA: Esta garantía no cubre la vida útil del filtro por algún período o volumen específico de uso. Para obtener más información sobre la vida útil del filtro, visite www.zerowater.com/filtration-filter-life.aspx.

Para obtener información acerca de la garantía, el servicio, o cómo utilizar su producto ZeroWater, llame sin costo a servicio al cliente al 1-800-503-2939 de lunes a viernes de 8 am a 8 pm Hora del Centro, o visite nuestro sitio web en www.zerowater.com.

The ONLY filter certified to reduce Lead & Chromium
El ÚNICO filtro certificado que reduce el plomo y el cromo

	Leading Brand (standard model) Marca principal (modelo estándar)	ZeroWater
LEAD / PLOMO		✔
CHROMIUM (HEXAVALENT) / CROMO (HEXAVALENTE)		✔

Data reflected on this table was derived from the NSF International website. For a complete list visit www.ZeroWater.com. / Los datos de esta tabla se tomaron del sitio Web de NSF International. Si desea ver la lista completa visite www.ZeroWater.com.

ZeroWater® PERFORMANCE DATA SHEET. FOR MODELS: ZD-013D, ZD-013W, ZD-018, ZP-001, ZP-006, ZP-010, ZS-008, ZD-010RP, ZD-023-1, ZD-012RP, ZP-007RP, ZR-0810, ZR-0810G, ZBD-040, ZD-030RP, ZD-20RP, ZS-011RP // IMPORTANT NOTICE: Read this Performance Data Sheet and compare the capabilities of this unit with your actual water treatment needs. It is recommended that before purchasing a water treatment unit you have your water supply tested to determine your actual water treatment needs. All contaminants reduced by this water treatment device are not necessarily in your water supply. While testing was performed under standard laboratory conditions, actual performance may vary.

This system has been tested according to NSF/ANSI 42 and NSF/ANSI 53 for reduction of the substances listed below. The concentration of the indicated substances in water entering the system was reduced to a concentration less than or equal to the permissible limit for water leaving the system, as specified in the relevant standard.

Rated service life is 20 gallons. It is recommended to change the filter with replacement element ZR-001/ZF-201 at this point. Service flow rate is 2 gallons per day. Operating temperature is 40-90°F. This water treatment device is intended only for use with potable water. Do not use water that is microbiologically unsafe or of unknown quality without proper disinfection before or after the system.

HOJA DE DATOS DE RENDIMIENTO de ZeroWater® PARA LOS MODELOS: ZD-013D, ZD-013W, ZD-018, ZP-001, ZP-006, ZP-010, ZS-008, ZD-010RP, ZD-023-1, ZD-012RP, ZP-007RP, ZR-0810, ZR-0810G, ZBD-040, ZD-030RP, ZD-20RP, ZS-011RP. // AVISO IMPORTANTE: Lea esta Hoja de datos de rendimiento y compare las capacidades de esta unidad con sus necesidades reales de tratamiento de agua. Se recomienda que antes de comprar una unidad de tratamiento de agua haga una prueba de su abastecimiento de agua para determinar sus necesidades reales de tratamiento de agua. No todos los contaminantes reducidos por este dispositivo de tratamiento de agua están necesariamente en su abastecimiento de agua. Aunque las pruebas se realizaron en condiciones estándar de laboratorio, el rendimiento real puede variar.

Este sistema ha sido probado conforme NSF/ANSI 42 y NSF/ANSI 53 para la reducción de las sustancias enumeradas a continuación. La concentración de las sustancias indicadas en el agua que ingresa al sistema se redujeron a una concentración menor o igual al límite permitido para que el agua salga del sistema de acuerdo a como lo especifica la norma correspondiente.

La vida útil nominal es de 20 galones (76 l). En ese momento, se recomienda cambiar el filtro con el elemento de reemplazo ZR-001/ZF-201. El caudal de servicio es de 2 galones (7.5 l) por día. La temperatura de funcionamiento es de 40-90°F (4.4-32.2°C). Este dispositivo de tratamiento de agua está diseñado solo para su uso con agua potable. No se use con agua microbiológicamente antihigiénica o de calidad desconocida sin desinfectar adecuadamente el sistema antes o después.

This system has been tested and certified by NSF International under NSF/ANSI Standards 53 or 42 for the reduction of substances
Este sistema ha sido probado y certificado por NSF International bajo las normas NSF/ANSI 53 o 42 para la reducción de sustancias

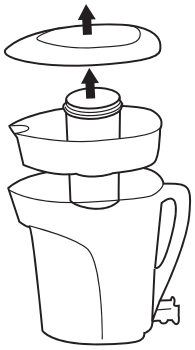
SUBSTANCE SUSTANCIA	Overall Percent Reduction	Influent Challenge Concentration (mg/L)	Maximum Effluent Concentration (mg/L)	Maximum Permissible Effluent Concentration (mg/L)
NSF/ANSI Standard 53 - Health Effects				
Norma NSF/ANSI 53 - Efectos sobre la salud				
Chromium, Tri and Hexavalent, pH 6.5	99.6	0.3 ± 10%	0.003	0.050
Chromium, Tri and Hexavalent, pH 8.5	99.6	0.3 ± 10%	0.003	0.050
Lead, pH 6.5	99.7	0.15 ± 10%	0.000	0.050
Lead, pH 8.5	99.7	0.15 ± 10%	0.000	0.050
Mercury, pH 6.5	95.9	0.15 ± 10%	0.0005	0.010
Mercury, pH 8.5	96.7	0.15 ± 10%	0.0005	0.010
NSF/ANSI Standard 42 - Aesthetic Effects	96.0	0.006 ± 10%	0.0002	0.500
Norma NSF/ANSI 42 - Efectos estéticos (sabor, olor y apariencia)	96.0	0.006 ± 10%	0.0002	0.500
Chlorine	0.0004		0.0004	0.002
	97.5	2.0 ± 10%	0.05	50% of influent
	Reducción porcentual total	Concentración de referencia de agua prefiltrada (mg/L)	Concentración máxima de agua filtrada (mg/L)	Concentración máxima permisible de agua filtrada (mg/L)

System Tested and Certified by NSF International against NSF/ANSI Standard 42 for reduction of hydrogen sulfide and chlorine taste and odor and against NSF/ANSI Standard 53 for reduction of lead, chromium and mercury.
Sistema probado y certificado por NSF Internacional con respecto a la norma NSF/ANSI 42 en reducción de sabor y olor de sulfuro de hidrógeno y cloro, y con respecto a la norma 53 NSF/ANSI en reducción de plomo, cromo y mercurio.

www.zerowater.com

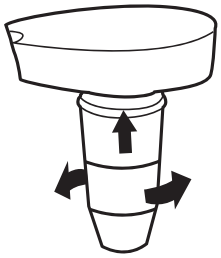
ASSEMBLY INSTRUCTIONS
6 CUP, 8 CUP, 10 CUP, 12 CUP

INSTRUCTIONS D'ASSEMBLAGE
6 TASSES, 8 TASSES, 10 TASSES, 12 TASSES



1 **REMOVE** lid and water reservoir from top of the pitcher and remove filter from packaging. Unscrew the blue protective cap (if applicable).

ENLEVEZ le couvercle et le réservoir d'eau du dessus de la carafe puis retirez le filtre de son emballage. Dévissez le capuchon de protection bleu (le cas échéant).

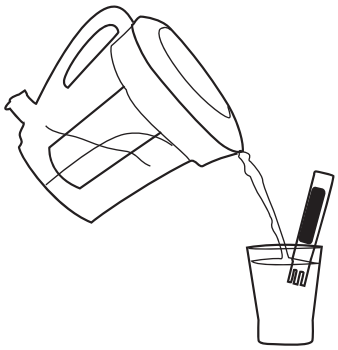


2 **TWIST** filter into the bottom of reservoir (from below) and tighten filter to obtain a complete seal with the reservoir. ***Do not drop the filter in from above.*** Tighten until there is a complete seal between the filter, o-ring and reservoir.

VISSEZ le filtre dans le fond du réservoir (par en-dessous) et serrez-le pour obtenir une étanchéité totale avec le réservoir. ***Ne pas installer le filtre en le laissant tomber du dessus.*** Serrez jusqu'à ce qu'il y ait une étanchéité totale entre le filtre, le joint torique et le réservoir.

3 **FILL** reservoir with cold tap water and place lid on top. Allow all water to pass through the filter before filling again.

REMPLISSEZ le réservoir d'eau froide et placez le couvercle dessus. Laissez toute l'eau s'écouler à travers le filtre avant de le remplir à nouveau.



4 **POUR OR DISPENSE** using spigot (if applicable) to fill your cup or glass once the reservoir has emptied into the body.

VERSEZ à l'aide du robinet (le cas échéant) pour remplir votre verre une fois le réservoir vide.

CLEANING INSTRUCTIONS
Clean your device in warm water using mild soap. Rinse and dry thoroughly.

INSTRUCTIONS DE NETTOYAGE
Nettoyez votre appareil à l'eau tiède avec un détergent doux. Rincez et séchez complètement.

ZEROWATER®
IF IT'S NOT ALL ZEROS - IT'S NOT ZEROWATER

THANK YOU FOR YOUR PURCHASE OF A NEW ZEROWATER® PRODUCT

Other valuable information enclosed:

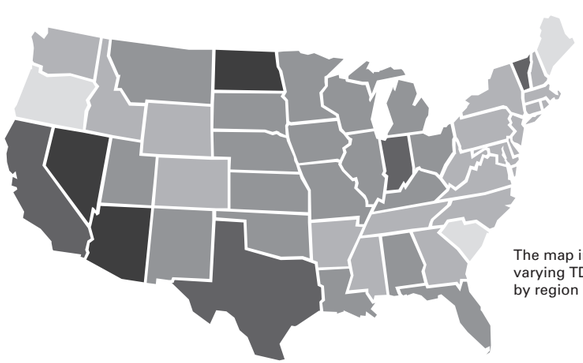
- **$30.00 in future filtration savings**
- **How ZeroWater improves the taste of drinking water**

Visit us at **www.zerowater.com** or find us on Facebook

DO YOU HAVE HIGH TDS?

Very high TDS will reduce filter life more quickly. Since ZeroWater is removing virtually all TDS from your tap water, your filters may wear out faster.

Contact ZeroWater today to find out about saving more on your filter purchases. Call **1-800-503-2939** and ask about the ZeroWater Continuity Program and start saving today!



The map indicates varying TDS levels by region

002-050 | 051-200 | 201-300 | 301-400 | 401+

ZeroWater customer readings as of May 2010

SHARE & COMPARE

Enter your tap water's TDS reading at www.zerowater.com to save on future filter purchases.

ZEROWATER'S PATENTED 5-STAGE FILTER
vs.
STANDARD 2-STAGE FILTER

ZeroWater's Patented 5-Stage Filter

2-Stage Filter (Old Technology)

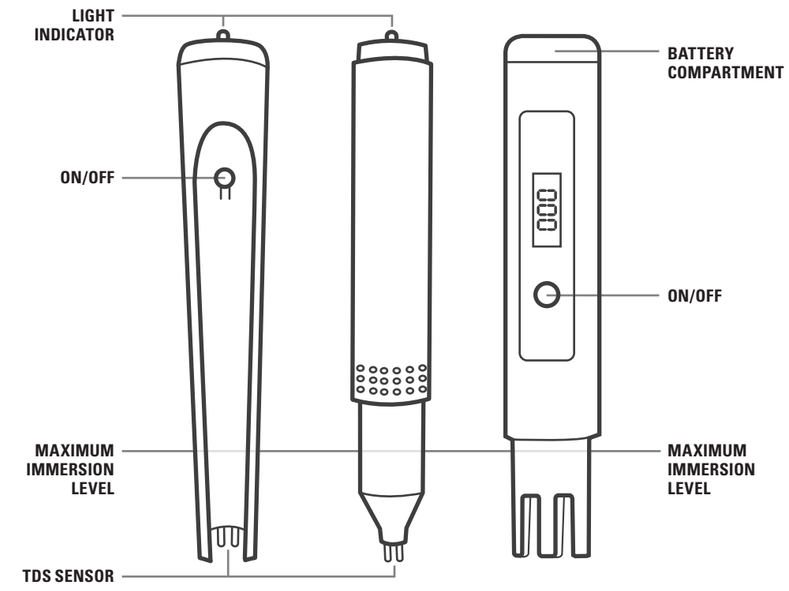
THE BIG DIFFERENCE

Most conventional carbon filters only filter certain substances from your water. ZeroWater's patented Ion Exchange System, with **FIVE** combined technologies, provides the only filtered water that meets the FDA definition of purified bottled water.*

*Filtered potable tap water tested by an independent lab (not the FDA) to meet specifically the water quality requirements for using the label "purified." Compared to water produced by leading gravity fed filters.

A TDS METER WILL SHOW YOUR TAP WATER READING

Visit **www.zerowater.com** and purchase your own TDS meter.
Enter "**mymeter**" at checkout for a discount.



TDS meters included with select ZeroWater pitchers/dispensers

ZEROWATER®
IF IT'S NOT ALL ZEROS - IT'S NOT ZEROWATER

ZEROWATER FILTER DISPENSER, PITCHER & TDS METER WARRANTY

Zero Technologies, LLC warrants to the consumer for the period of ninety (90) days from the date of purchase, the ZeroWater Dispenser/Pitcher (except for the filter cartridge which is warranted for 30 days) against all defects in materials and workmanship, when used in compliance with the Owner's Manual. During this 90-day period, if you discover that any parts of the ZeroWater Dispenser/Pitcher are damaged or broken, due to any manufacturing defects, we will replace the parts free of charge by calling: 1-800-503-2939 in the United States. The warrantor assumes no responsibility for incidental or consequential damages; for damages arising out of misuse of the product or the use of any unauthorized attachment. Some states do not allow the exclusion or limitation of incidental or consequential damages, the above limitation or exclusion may not apply to you. To the extent permitted by local law, this warranty is in lieu of any other warranty, express or implied, including any implied warranty of merchantability or fitness and precludes any other obligation on the part of the manufacturer, distributor, or dealer, including any liability for special, incidental or consequential damages. This warranty gives your specific legal rights, and you may also have other rights which vary from state to state in the United States.

REPLACEMENT FILTER CARTRIDGE WARRANTY & RETURN POLICY

Though replacement filter cartridges do have a 30 day warranty for manufacturing defects, there is no money back guarantee otherwise. To place a claim for a defective cartridge, you must first speak to a customer service representative who will help you trouble shoot any problems. If a problem is found that may be due to a manufacturing defect, they will then give you instructions on how to send back the cartridges to be tested by our laboratory. Depending on whether or not the lab determines the cartridges to be defective, they will either be replaced or returned to you. Please remember that we do not and cannot warrant the life of the filter cartridges since there are many variables that affect the life of each cartridge, including: weather, your local treatment facility, consumption rate, etc. We can only provide estimates based on the experiences of other customers. A shortened cartridge life alone does not necessarily mean that you have a defective cartridge.

RETURN POLICY

We want you to be completely satisfied with your purchase. We stand behind our products with a 30 day, money back guarantee. If for any reason you are not completely happy with the water filter systems that you receive, just return to us within 30 days of receiving the merchandise for a refund of your product purchase price (less shipping and handling). Returns must be received within 30 days of your receipt of the item. Returns after 30 days may not be accepted at all or may be subject to restocking/refurbishing charges. Return policy applies to direct sales only, retail sales do not apply. Please also note that all components of a filter system, including the digital TDS water meter, must be returned in good condition to be accepted as returned merchandise.

Should service be required or you have any questions regarding how to use your ZeroWater product, please call Customer Service toll free 8am-8pm CT, Mon-Fri, at 1-800-503-2939, or visit our website at: www.zerowater.com

Complete warranty registration at **www.zerowater.com**

Zero Technologies, LLC,
4510 Adams Circle, Suite G, Bensalem, PA 19020

THREE WAYS TO SAVE!

1. Register at **zerowater.com** OR call customer service at 1-800-503-2939
2. Fill out the form below and mail to: **ZeroWater Savings 4510 Adams Circle, Unit G • Bensalem, PA 19020**

Sign me up to receive coupons for ZeroWater® Patented Ion Exchange Filter Replacements by mail.

Name:_____ E-mail:_____

Street Address:_____

City:_____ State/Province:_____ Zip/Postal Code:_____

3 IMMEDIATE SAVINGS

MANUFACTURER'S COUPON | EXPIRES 12/31/15

$2.50 OFF

2-Pack ZeroWater® Replacement Filters

storefinder at www.zerowater.com

0188781-008487

5 88781 00084 1

CONSUMER: Take this coupon to the checkout stand and save $2.50 on a 2-Pack of ZeroWater Replacement Filters. Limit one coupon per store visit. No doubling of coupon allowed. Coupon cannot be assigned, transferred or reproduced. Coupon good only on product indicated, any other use constitutes fraud. **RETAILER:** You will be reimbursed for the face value of this coupon plus .08 cents handling allowance, if submitted in compliance with Standard Coupon Redemption Policies. Manufacturer reserves the right to request invoices proving purchase of sufficient stock to cover coupons presented for redemption. Void where taxed, restricted, prohibited, or presented by other than retailers of our products. Cash Value: 1/100th of a cent. Coupon must be redeemed by 12/31/15. **MAIL TO:** PMCI $2.50 Coupon Offer Dept. 6356, PO BOX 5011, Stacy, MN 55078-5011. © 2014 Zero Technologies, LLC.

MANUFACTURER'S COUPON | EXPIRES 12/31/15

$2.50 OFF

4-Pack ZeroWater® Replacement Filters

storefinder at www.zerowater.com

0188781-008488

5 88781 00084 1

CONSUMER: Take this coupon to the checkout stand and save $2.50 on a 4-Pack of ZeroWater Replacement Filters. Limit one coupon per store visit. No doubling of coupon allowed. Coupon cannot be assigned, transferred or reproduced. Coupon good only on product indicated, any other use constitutes fraud. **RETAILER:** You will be reimbursed for the face value of this coupon plus .08 cents handling allowance, if submitted in compliance with Standard Coupon Redemption Policies. Manufacturer reserves the right to request invoices proving purchase of sufficient stock to cover coupons presented for redemption. Void where taxed, restricted, prohibited, or presented by other than retailers of our products. Cash Value: 1/100th of a cent. Coupon must be redeemed by 12/31/15. **MAIL TO:** PMCI $2.50 Coupon Offer Dept. 6356, PO BOX 5011, Stacy, MN 55078-5011. © 2014 Zero Technologies, LLC.

ZEROWATER®
IF IT'S NOT ALL ZEROS - IT'S NOT ZEROWATER

MERCI DE VOTRE ACHAT DU NOUVEAU PRODUIT ZEROWATER®

Sont inclues les informations importantes suivantes:

- **Économies de 30,00 $ sur des achats ultérieurs de filtres**
- **La façon dont ZeroWater améliore le goût de l'eau potable**

Visitez notre site à **www.zerowater.com** ou retrouvez-nous sur Facebook

EST-CE QUE VOTRE TAUX DE MTD EST ÉLEVÉ?

Un taux de MTD très élevé réduit la vie utile du filtre. Dans la mesure où ZeroWater prélève pratiquement toutes les MTD de l'eau du robinet, les filtres peuvent s'user plus rapidement.

Contactez ZeroWater aujourd'hui pour obtenir de plus amples informations sur les économies que vous pourriez réaliser sur des achats des filtres. Appelez le +1 (800) 503-2939 pour obtenir de plus amples informations sur le programme ZeroWater Continuity et commencez dès aujourd'hui à faire des économies!

La carte indique les divers niveaux de MTD par région

002-050	051-200	201-300	301-400	401+

Relevés des clients ZeroWater à compter du mois de mai 2010

PARTAGER ET COMPARER

Saisissez le relevé de vos MTD de l'eau du robinet sur le site www.zerowater.com et constatez les économies que vous pourriez réaliser sur les futurs achats des filtres.

FILTRE BREVETÉ 5 ÉTAPES DE ZEROWATER
vs.
FILTRE STANDARD 2 ÉTAPES

Filtre à 5 étapes breveté de ZeroWater

Filtration en 2 étapes (ancienne technologie)

LA GRANDE DIFFÉRENCE

La plupart des fi ltres carbones traditionnels ne fi ltrent que certaines substances de votre eau. Le système breveté échangeur d'ions de ZeroWater, avec **CINQ** technologies combinées, offre la seule eau fi ltrée qui réponde à la défi nition de la FDA de l'eau en bouteille purifi ée.*

*Eau du robinet potable filtrée testée par un laboratoire indépendant (qui n'est pas la FDA) afin de satisfaire aux exigences de qualité de l'eau pour pouvoir utiliser le label « purifiée ». Comparée à l'eau produite en la conduisant à des filtres d'alimentation par gravité.

ZEROWATER®
IF IT'S NOT ALL ZEROS - IT'S NOT ZEROWATER

GARANTIE POUR LE DISTRIBUTEUR ET LA CARAFE Á FILTRE ET L'APPAREIL DE MESURE DES MDT DE ZEROWATER
Zero Technologies, LLC garantit au consommateur pour une période de quatre-vingt-dix (90) jours á partir de la date d'achat, le distributeur/la carafe ZeroWater (sauf la cartouche á filtre qui garantie 30 jours) pour tout défaut des matériaux ou de fabrication quand ils sont utilises conformément au manuel d'utilisation. Durant cette période de 90 jours, si vous découvrez qu'une piéce du distributeur/de la carafe ZeroWater est endommagée ou cassée á cause d'un défaut de fabrication, nous remplacerons la piéce gratuitement si vous appelez le 1-800-503-2939 aux Etats-Unis. Le garant n'assume aucune responsabilité pour les dommages accidentels ou indirects; pour les dommages résultant d'une mauvaise utilisation du produit ou l'utilisation de tout accessoire non autorisé. Certains états ne permettent pas l'exclusion ou la limitation des dommages accidentels ou indirects, la limitation ou l'exclusion susmentionnée peut ne pas vous être appliquée. Dans la mesure où cela est permis par la loi locale, cette garantie tient lieu et place de toute autre garantie, formelle ou implicite, y compris toute garantie implicite de commercialisation ou de conformité et exclut toute autre obligation de la part du fabricant, du distibuteur ou du revendeur, y compris toute responsabilité pour des dommages spéciaux, accidentels ou indirects. Cette garantie vous donne des droits légaux spécifiques et vous autorise également á avoir d'autres droits pouvant varier d'un état á l'autre aux Etats-Unis.

GARANTIE DE REMPLACEMENT ET POLITIQUE DE RETOUR DE LA CARTOUCHE Á FILTRE
Bien que les cartouches á filtre de remplacement ont une garantie de 30 jours pour les défauts de fabrication, il n'existe pas d'autre garantie de remboursement. Pour déposer une plainte pour une réclamation en cas de cartouche défectueuse, vous devez d'abord contacter un représentant du service clientéle qui vous aidera á résoudre le probléme quel qu'il soit. Si un probléme est constaté pouvant être dû á un défaut de fabrication, il vous sera alors donné des instructions sur la façon de renvoyer les cartouches sont defectueuses, elles seront remplacées ou vous seront renvoyées. Veuillez garder en mémoire que nous ne garantissons pas et ne pouvons pas garantir la durée de vie des cartouches á filtre car bon nombre de variables impactent la vie de chaque cartouche, comme : les conditions météorologiques, votre installation locale de traitement, le taux de consommation, etc… Nous pouvons seulement fournir des estimations basées sur l'expérience d'autres clients. Une durée de vie courte de la cartouche ne signifie pas nécessairement que vous ayez une cartouche défectueuse.

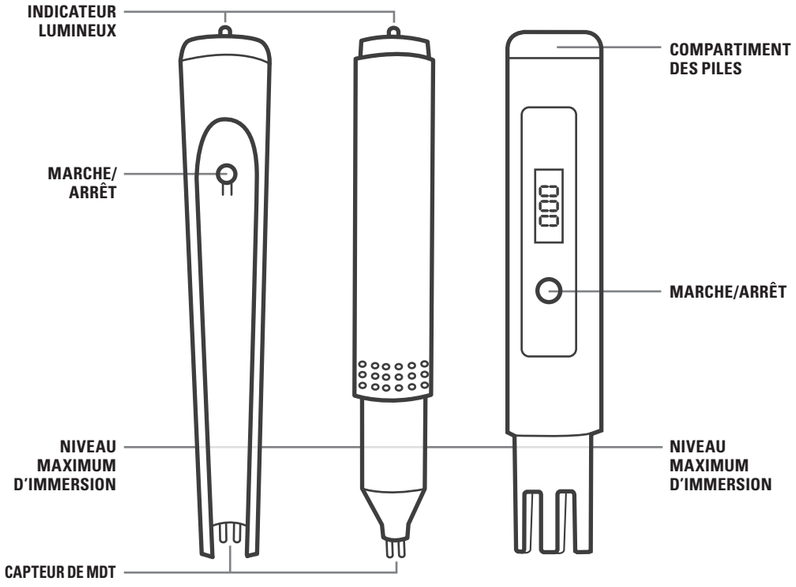
POLITIQUE DE RETOUR
Nous voulons que vous soyez pleinement satisfait de votre achat. Nous répondons de nos produits par une garantie de remboursement de 30 jours. Si pour une raison quelconque vous n'êtes pas complétement satisfait des systémes de filtration d'eau que vous recevez, il vous suffit de nous renvoyer le produit dans les 30 jours suivant la reception de la merchandise pour le remboursement de votre produit au prix d'achat (moins les frais d'expédition et de traitement). Les retours doivent être acceptés ou peuvent être soumis á des frais de restockage / de remise á neuf. La politique de retour ne s'applique qu'aux ventes directes, non aux ventes au detail. Veuillez également noter que tous les composants d'un systéme de filtrage, y compris l'appareil numérique de mesure des MDT dans l'eau, doivant être retournés en bon état pour être acceptes comme merchandise retournée.

Si vous avez besoin d'un service ou si vous avez des questions concernant la façon d'utiliser votre produit ZeroWater, veuillez appeler le service clientele gratuitement entre 8h00 et 20h00 CT, du lundi au – vendredi au 1-800-503-2939, ou visitez notre site Web á: www.zerowater.com

Zero Technologies, LLC,
4510 Adams Circle, Suite G, Bensalem, PA 19020

UN COMPTEUR DE MTD INDIQUERA LE RELEVÉ DE L'EAU DE VOTRE ROBINET

Consultez notre visite **www.zerowater.com** pour acheter votre compteur TDS.
Saisissez **« mymeter »** lorsque vous passez à la caisse pour bénéficier d'une remise.



Le compteur de MTD (matières dissoutes totales) inclut un pichet/distributeur ZeroWater

DUEX FAÇONS D'ÉCONOMISER!

1. S'inscrire sure **zerowater.com** OU appeler le serice clientele au 1-800-503-2939
2. Renseigner le formulaire ci-dessous et l'envoyer á:
   ZeroWater Savings
   4510 Adams Circle, Unit G
   Bensalem, PA 19020

Inscrivez-moi pour recevoir les coupons pour des remplacements de filter échangeur d'ions brevet ZeroWaterMD par courrier.

Nom:_____

Adresse:_____

Ville:_____ State/Province:_____ Zip/Postal Code:_____

Courriel: _____

APPENDIX C - RESIDENT LETTER

DENVER WATER

DENVER WATER

1600 West 12th Ave
Denver, CO 80204-3412
303.628.6000
denverwater.org

7/10/2019

Dear Denver Water Customer,

Denver Water wants your help with the Filter Lead Out of Water pilot study

We need your help and participation in a study on the use of water pitchers in the home. Why? Because the age of your home indicates that your service line may be made of lead.

At Denver Water, your safety is our most important responsibility. While the water we provide is safe and lead-free, lead can get into the water as it moves through household plumbing and customer-owned service lines — the pipes that bring water from Denver Water's pipe in the street to the plumbing in your home.

As we continue to help address this community issue, we're launching a Filter Lead Out of Water pilot study, in partnership with two local nonprofit organizations, Groundwork Denver and Mile High Youth Corps. Your help in this study will provide us with a better understanding of how customers may use these filters for everyday drinking and cooking activities.

We are providing you with a water pitcher filter and a three-month supply of replacement cartridges that are certified to significantly reduce lead concentrations, if present, in your household drinking water. In addition to the water pitcher filter, we are also sending set-up instructions and a few short survey questions.

Next Steps:

- Use your filter for drinking water, cooking and preparing infant formula.
- Complete the survey you received with your filter kit, as well as follow-up surveys mailed in the future.

If you are interested in an in-home meeting to talk more about lead or your filter experience, please contact us at flow@denverwater.org or 303-628-6655.

To learn more about lead in drinking water and what you can do to reduce your exposure to lead in drinking water, visit denverwater.org/Lead.

We appreciate your help in this important study. Please return the survey you received in your filter kit and follow-up surveys that will be mailed in the future.

Sincerely,

Denver Water

DENVER WATER

1600 West 12th Ave
Denver, CO 80204-3412
303.628.6000
denverwater.org

7/10/2019

Estimado(a) Cliente de Denver Water,

Denver Water quiere su ayuda con el estudio piloto Filtre el plomo del agua

Necesitamos su ayuda y participación en un estudio sobre el uso de jarras de agua en el hogar. ¿Por qué? Porque la fecha de construcción de su casa indica que su línea de servicio principal de agua puede ser hecha de plomo.

En Denver Water su seguridad es nuestra principal responsabilidad. A pesar de que el agua que suministramos es segura y sin plomo, este puede meterse al agua a medida que pasa por las tuberías de la casa y por las líneas de servicio principales particulares, que son las tuberías que llevan el agua desde la tubería de Denver Water en la calle, hasta las tuberías en su hogar.

Al tiempo que abordamos este problema de la comunidad, estamos lanzando el estudio piloto llamado Filtre el plomo del agua, en asociación con dos organizaciones locales sin fines de lucro, Groundwork Denver y Mile High Youth Corps. Su ayuda en este estudio nos permitirá entender mejor cómo los clientes pueden usar estos filtros para el agua de beber diaria y la de cocinar.

Le estamos suministrado una jarra con filtro para el agua y los cartuchos de repuesto para tres meses, que están certificados para reducir de manera considerable la concentración de plomo, si está presente en el agua potable de su hogar. Además de la jarra con filtro para el agua, le estaremos enviando instrucciones de uso y una encuesta corta.

Los siguientes pasos:

- Use su filtro para el agua que va a beber, con la que va a cocinar y preparar biberones.
- Complete la encuesta que recibió con el kit del filtro, así como las encuestas de seguimiento que recibirá por correo más adelante.

Si le interesa que alguien venga a su hogar para hablarle sobre el plomo o sobre su experiencia con el filtro, comuníquese con nosotros en flow@denverwater.org o al 303-628-6655.

Para obtener más información sobre el plomo en el agua potable y sobre lo que usted puede hacer para reducir su exposición al plomo en el agua potable, visite la página web denverwater.org/Lead.

Agradecemos su ayuda en este importante estudio. Por favor complete la encuesta que recibió con su kit del filtro, así como las encuestas de seguimiento que recibirá por correo más adelante.

Cordialmente,

Denver Water

APPENDIX D - SURVEY QUESTIONS

DENVER WATER

DENVER WATER

Filter Pilot Survey Question Matrix

Questions	Initial Survey (5116)	Use Survey (5122)	Alternative Filter Survey (5125)	Ongoing Surveys (5132)
1. Do you use your filter for drinking water? • Yes • No		X	X	X
2. Do you use your filter for water used for cooking? • Yes • No		X	X	X
3. Do you have a lead service line? • Yes • No • I do not know	X			
4. What is your household's primary source of drinking water? (Check one) ☐ Unfiltered faucet ☐ Bottled water ☐ Filtered - refrigerated water/ice dispenser ☐ Filtered - pitcher filter ☐ Filtered - under sink filter ☐ Filtered - faucet mounted filter ☐ Filtered - whole house filter ☐ Other (specify)	X			
5. What is your household's primary source of water used for cooking? (Check one) ☐ Unfiltered faucet ☐ Bottled water ☐ Filtered - refrigerated water/ice dispenser ☐ Filtered - pitcher filter ☐ Filtered - under sink filter ☐ Filtered - faucet mounted filter ☐ Filtered - whole house filter ☐ Other (specify)	X			

DENVER WATER

Filter Pilot Survey Question Matrix

Questions	Initial Survey (5116)	Use Survey (5122)	Alternative Filter Survey (5125)	Ongoing Surveys (5132)
6. If you have an existing water filter system, what is the make and model number for your filter? (Fill in)	X			
7. Do you currently or do you plan in the future to use filtered or bottled water for infant formula? Yes/No/NA	X	X	X	X
8. If you do not primarily use the water filter provided, what issues are you experiencing? (Check all that apply) ☐ Filter pitcher isn't large enough ☐ Filter pitcher doesn't fit in refrigerator ☐ The filter pitcher takes too much time to fill ☐ It's too much effort to use the filter pitcher ☐ I'm not interested in filtering my drinking water ☐ Other, please specify: (fill in the blank) ☐ Not Applicable (no issues)		X		X
9. If the water filter provided does not meet your needs, would you be more likely to use an alternative filter? (Check one) ☐ Faucet-mounted filter ☐ Refrigerator filter ☐ Larger pitcher filter ☐ Not Applicable (the water filter meets my needs)		X		X
10. Are you familiar with filter maintenance and cartridge replacement requirements? E.g. replacing the filter cartridge, cleaning the pitcher (if applicable)? Yes/No		X	X	X
11. What questions or comments do you have about the filter pilot?	X	X	X	X
12. How could we improve the filter pilot?	X	X	X	X
13. Want to stay informed about the FLOW pilot? Provide your email or phone number.	X	X	X	X

To be added to every survey: FILTER LEAD OUT OF WATER

Please provide your email address or mailing address to receive your Amazon gift card.
Email: _____ Mailing Address: _____

Survey Lead-Ins:

Initial Survey

Thank you for participating in Denver Water's FLOW Pilot. Your feedback will help us understand information about how water is used in your home for drinking and cooking activities. Please use the ZeroWater® pitcher provided and return your completed survey by mail or online within two weeks of receiving the filter kit. **As our way of thanking you for your feedback and using your filter, upon receipt of the completed survey, Denver Water will send you a $15 Amazon gift card.** For an online survey, go to denverwater.org/Lead-survey or scan the QR code at the bottom of this survey.

Use Survey

Thank you for participating in Denver Water's FLOW Pilot. Your feedback will help us understand information about how water is used in your home for drinking and cooking activities and your preference for filters. Please use the ZeroWater® pitcher provided and return your completed survey by mail or online by July 31, 2019. **As our way of thanking you for your feedback and using your filter, upon receipt of the completed survey, Denver Water will send you a $15 Amazon gift card.** For an online survey go to denverwater.org/FLOW-survey or scan the QR code at the bottom of this survey.

Alt Survey

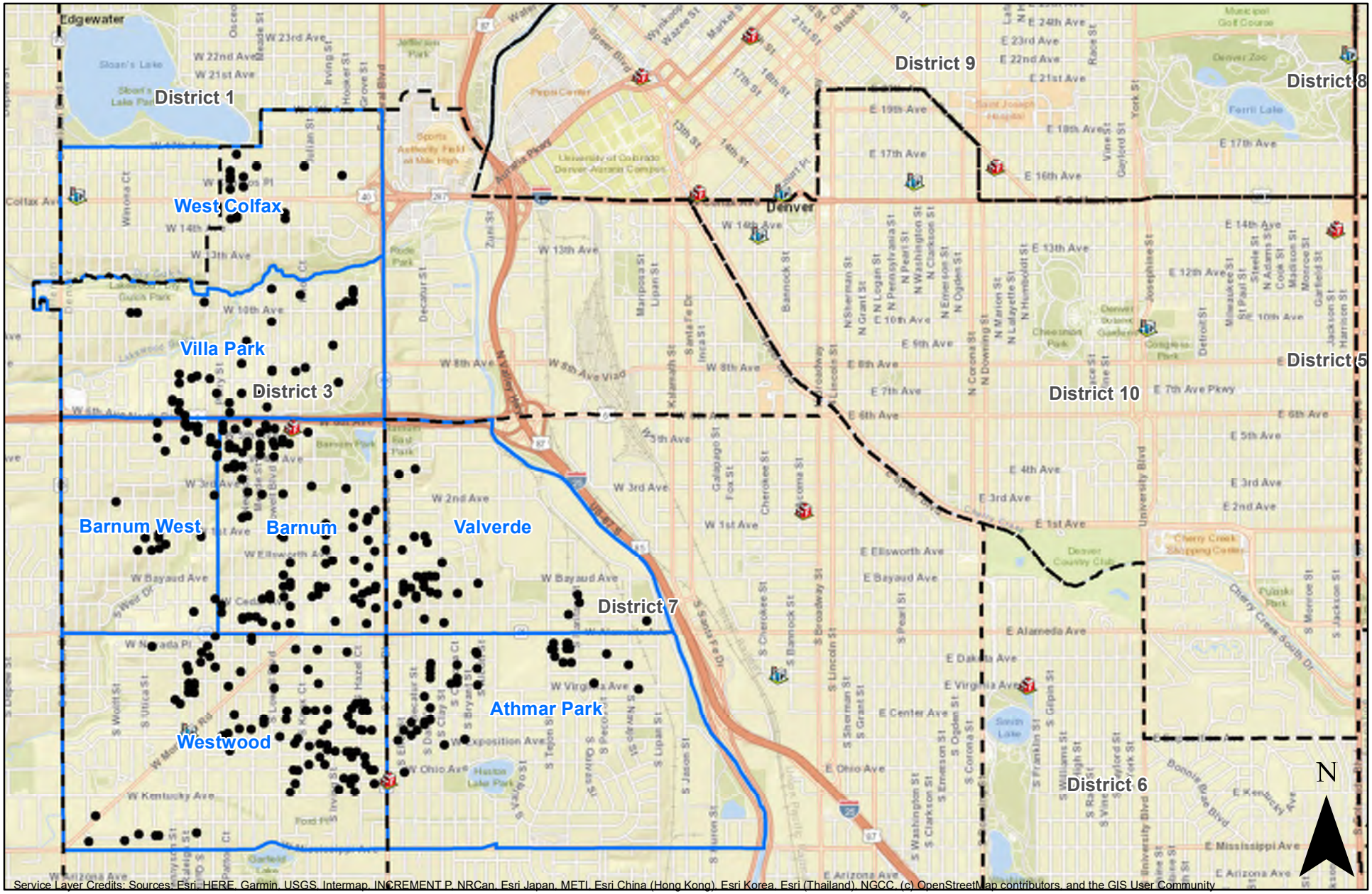
Thank you for participating in Denver Water's FLOW Pilot. Your feedback will help us understand information about how water is used in your home for drinking and cooking activities. Please use the alternative filter provided and return your completed survey by mail or online by August 30, 2019. **As our way of thanking you for your feedback and using your filter, upon receipt of the completed survey, Denver Water will send you a $15 Amazon gift card.** For an online survey go to http://bit.do/LSL-AltFilter or scan the QR code at the bottom of this survey.

Ongoing Surveys

Thank you for participating in Denver Water's FLOW Pilot. Your feedback will help us understand information about how water is used in your home for drinking and cooking activities. Please use your provided filter and return your completed survey by mail or online by TBD. **As our way of thanking you for your feedback and using your filter, upon receipt of the completed survey, Denver Water will send you a $15 Amazon gift card.** For an online survey go to http://bit.do/LSL-Ongoing or scan the QR code at the bottom of this survey.

APPENDIX E - MAPS

DENVER WATER



Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

0 0.25 0.5 1 1.5 2 Miles

Fire Stations

Police Stations

Filter Pilot Locations (331)

Council Districts

Neighborhoods

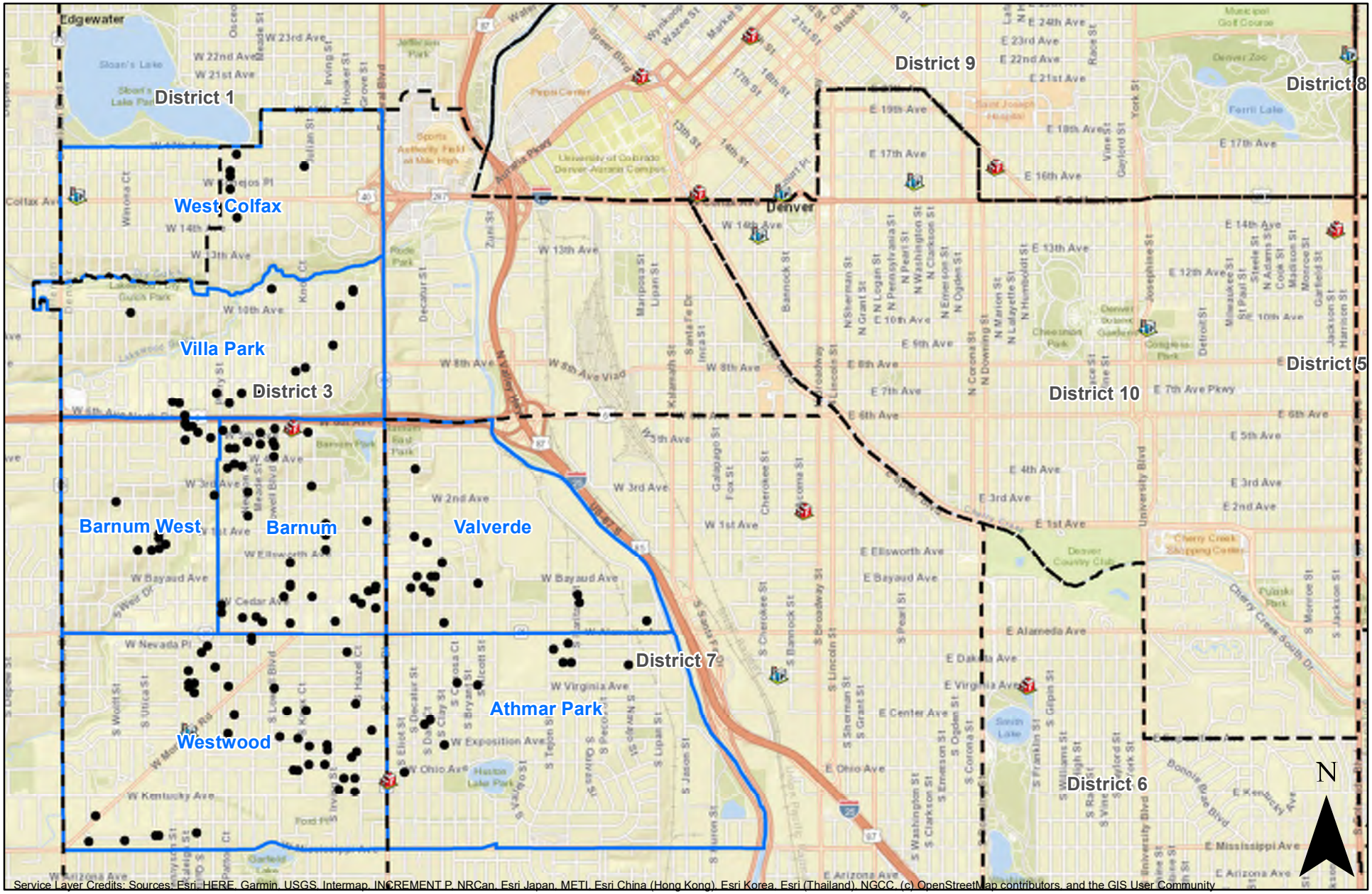
Registered Neighborhood Organizations

Filter Pilot Area

DENVER WATER

Author: R. Avery

Map Date: 2019-07-08



Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

0 0.25 0.5 1 1.5 2 Miles

Filter Pilot Hand Delivery Locations

Fire Stations

Police Stations

Filter Pilot Hand Delivery Locations (142)

Council Districts

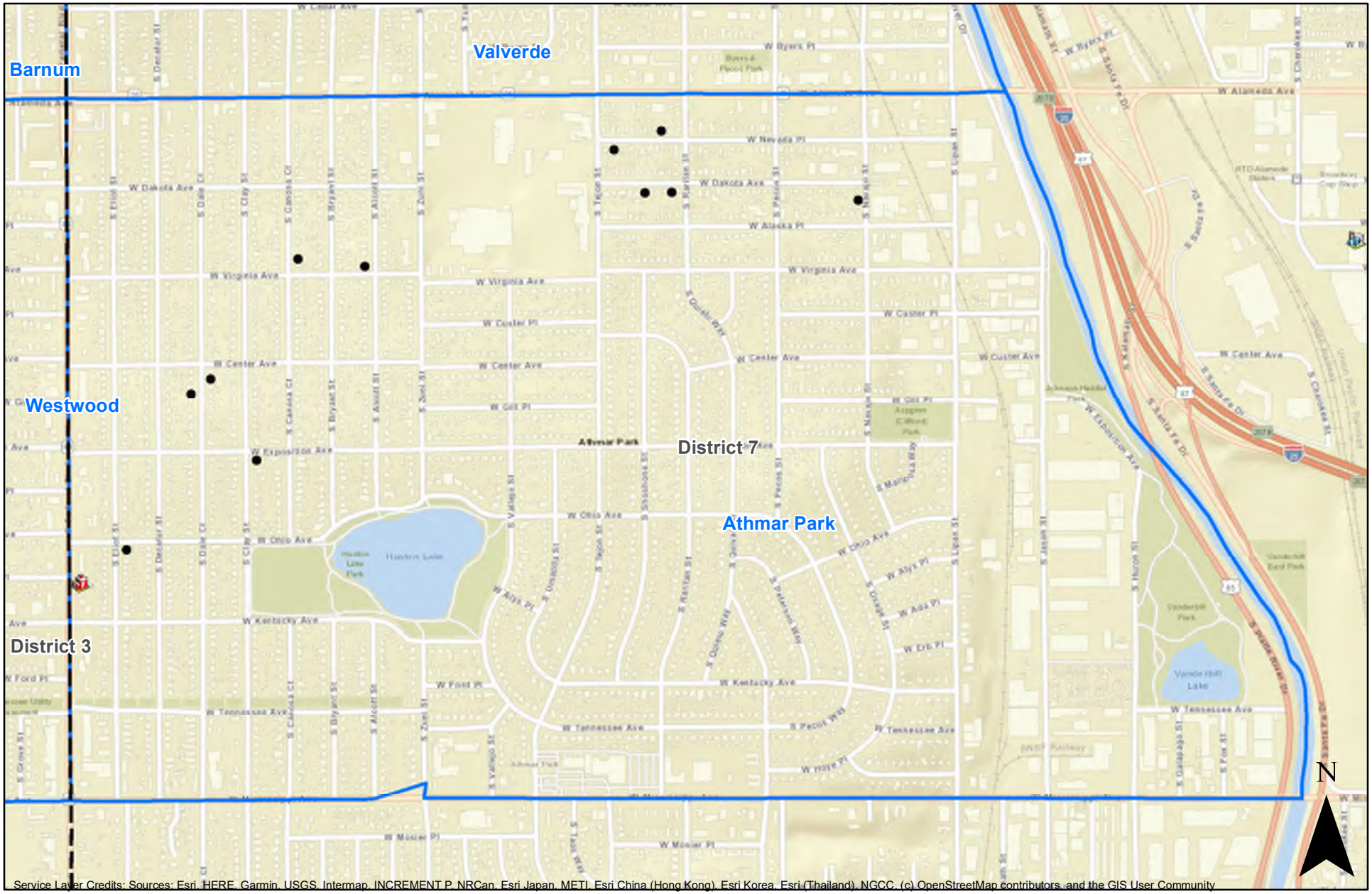
Neighborhoods

Registered Neighborhood Organizations

DENVER WATER

Author: R. Avery

Map Date: 2019-07-08



Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

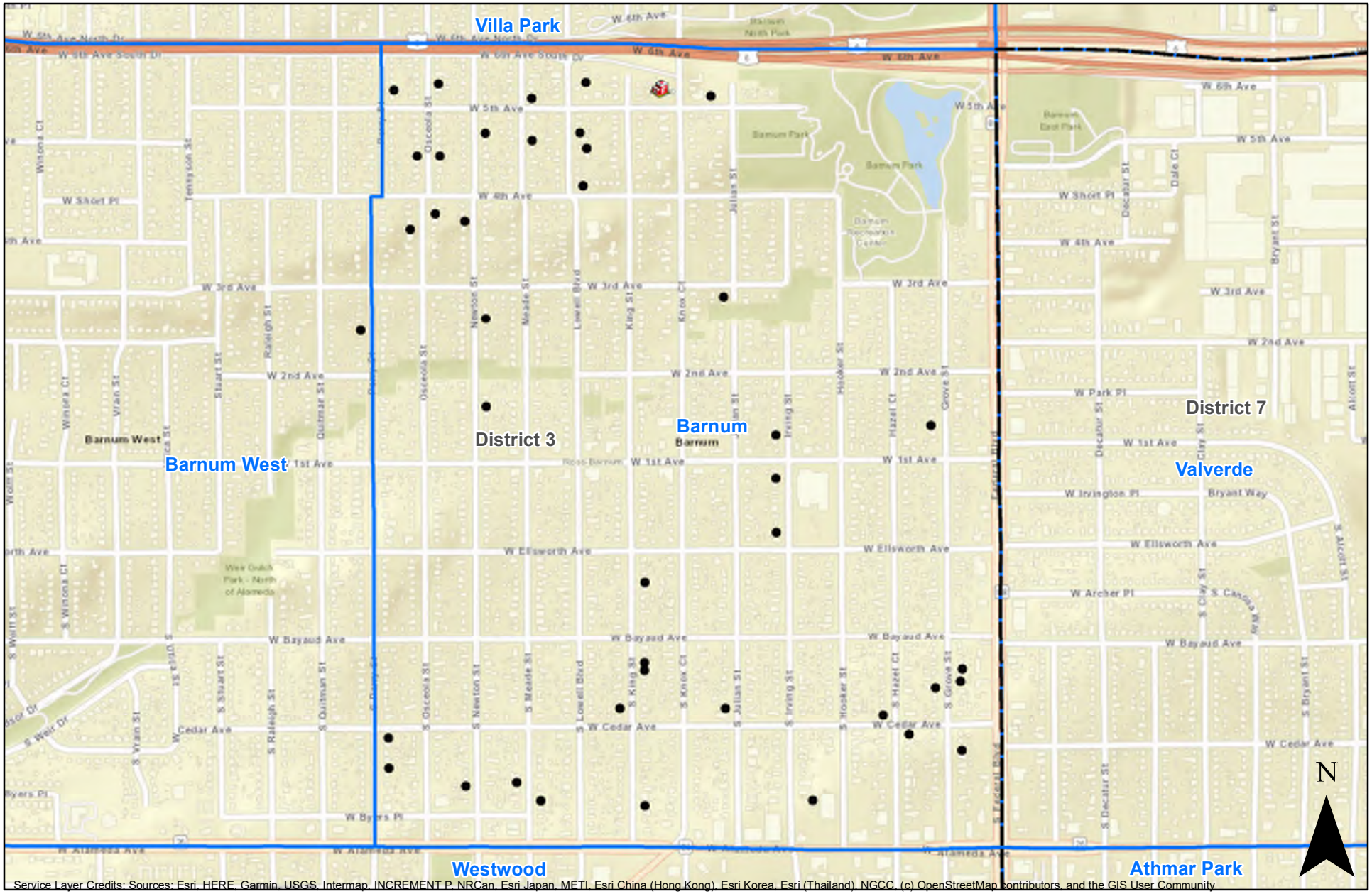
0 420 840 1,680 2,520 3,360 Feet

Filter Hand Delivery Locations: Athmar Park

Fire Stations
Police Stations
Filter Pilot Hand Delivery Locations (11)
Council Districts
Neighborhoods
Registered Neighborhood Organizations

DENVER WATER

Author: R. Avery
Map Date: 2019-07-08



Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

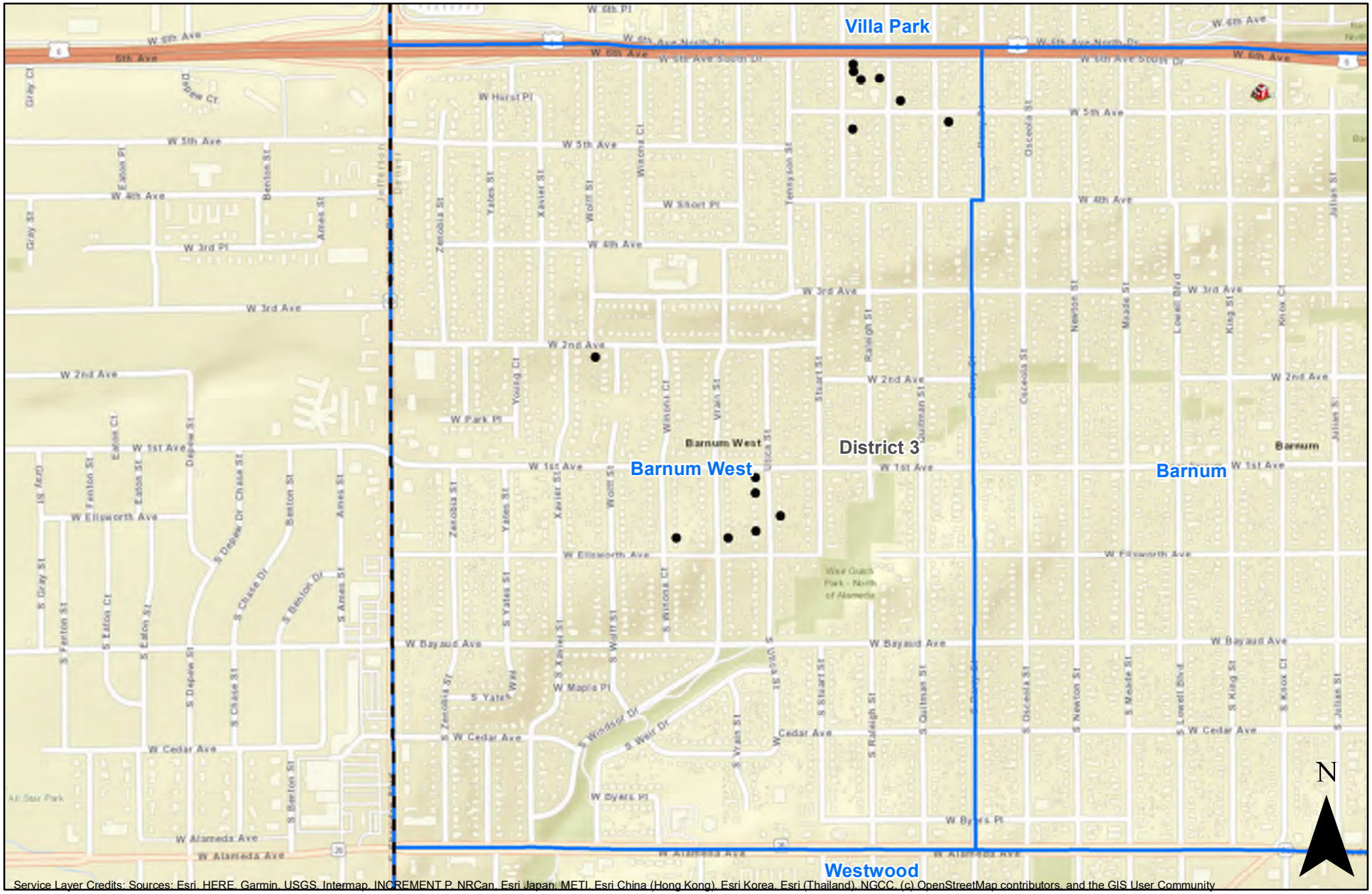
0 365 730 1,460 2,190 2,920 Feet

Filter Hand Delivery Locations: Barnum

Fire Stations
Police Stations
Filter Pilot Hand Delivery Locations (41)
Council Districts
Neighborhoods
Registered Neighborhood Organizations

DENVER WATER

Author: R. Avery
Map Date: 2019-07-08



Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

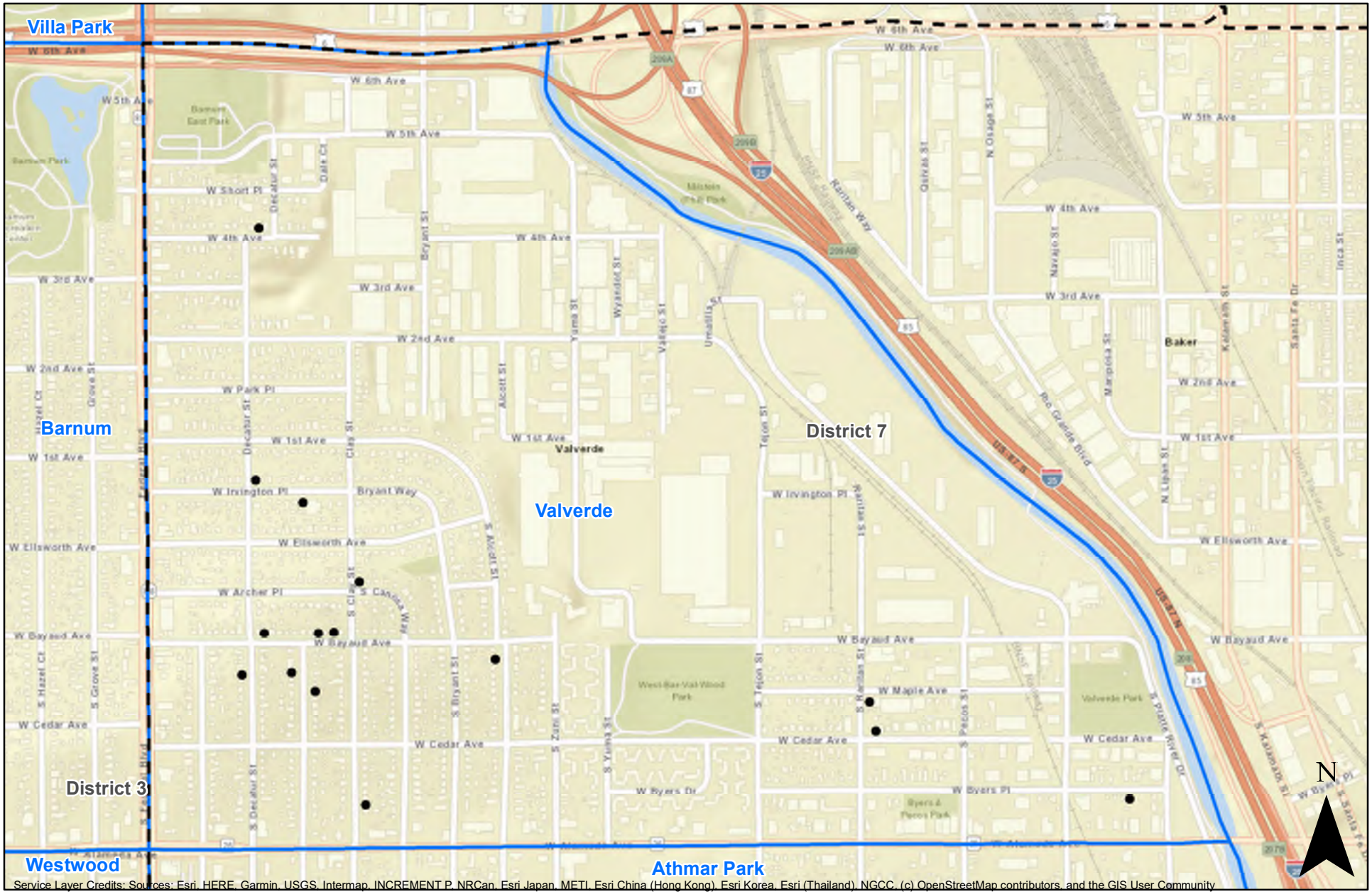
0 365 730 1,460 2,190 2,920 Feet

Filter Hand Delivery Locations: Barnum West

Fire Stations
Police Stations
Filter Pilot Hand Delivery Locations (14)
Council Districts
Neighborhoods
Registered Neighborhood Organizations

DENVER WATER

Author: R. Avery
Map Date: 2019-07-08



Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

0 362.5 725 1,450 2,175 2,900 Feet

Filter Hand Delivery Locations: Valverde

Fire Stations

Police Stations

Filter Pilot Hand Delivery Locations (15)

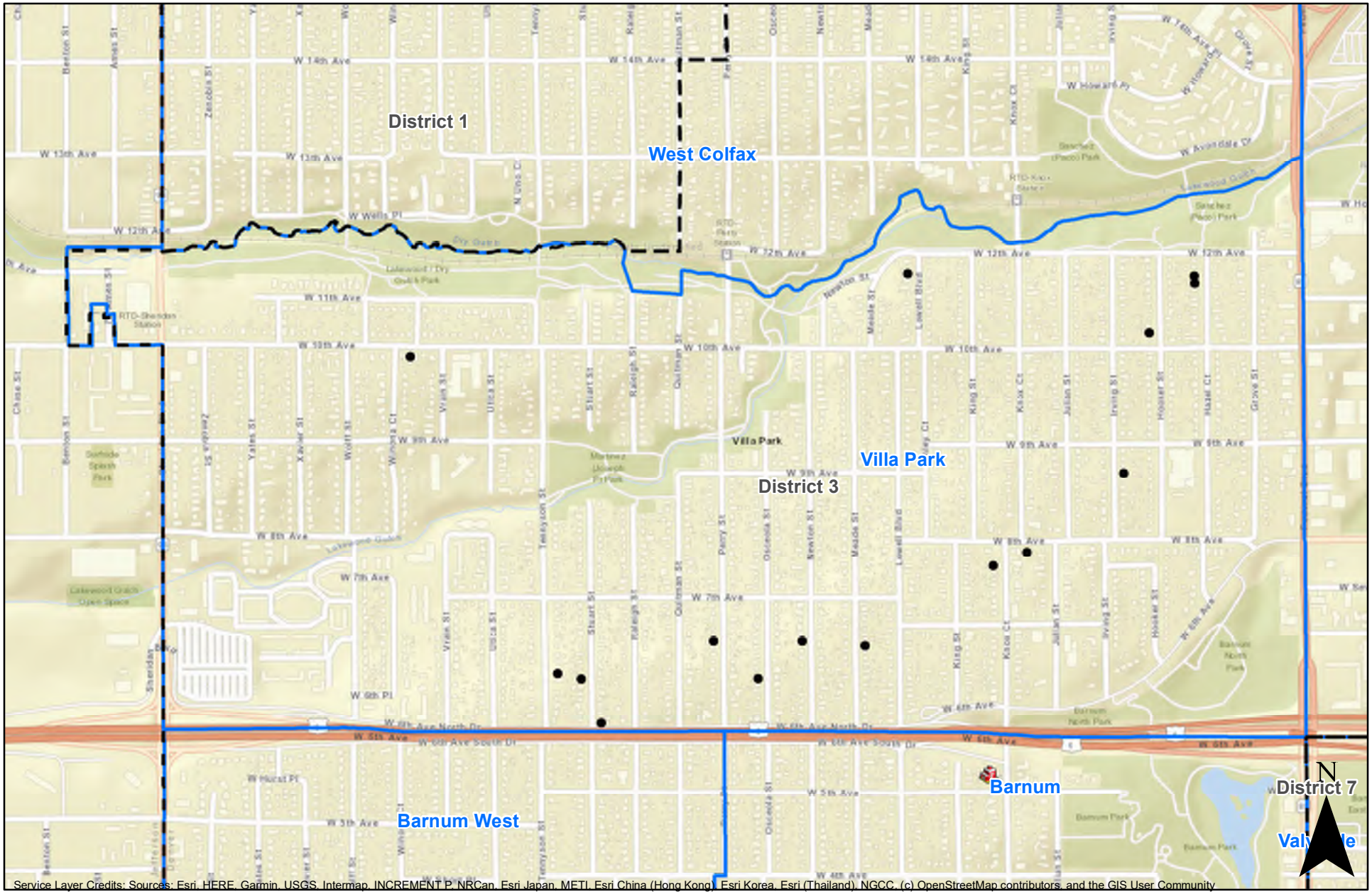
Council Districts

Neighborhoods

Registered Neighborhood Organizations

DENVER WATER

Author: R. Avery
Map Date: 2019-07-08



Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

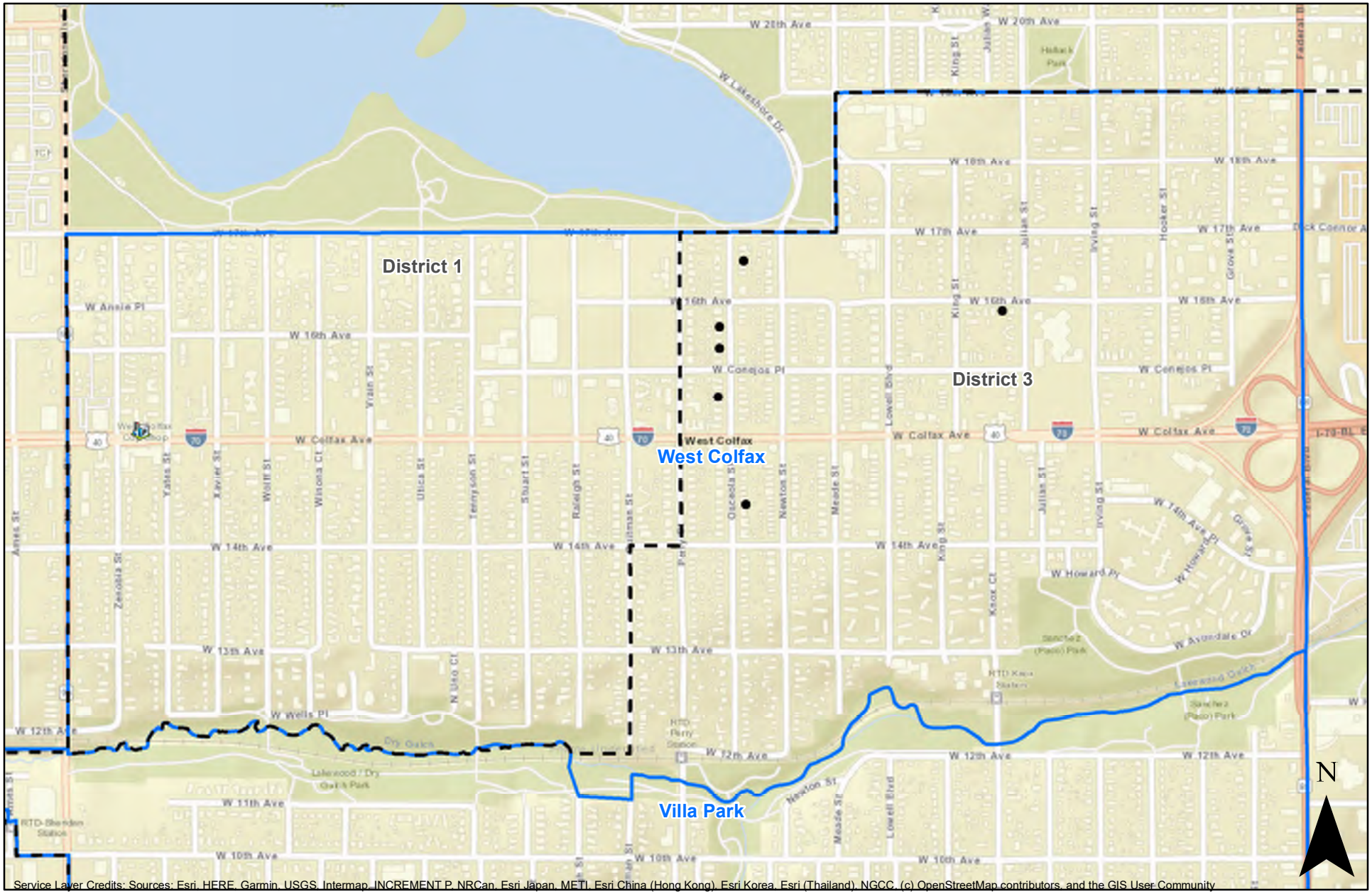
0 385 770 1,540 2,310 3,080 Feet

Filter Hand Delivery Locations: Villa Park

Fire Stations
Police Stations
Filter Pilot Hand Delivery Locations (15)
Council Districts
Neighborhoods
Registered Neighborhood Organizations

DENVER WATER

Author: R. Avery
Map Date: 2019-07-08



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0 355 710 1,420 2,130 2,840 Feet

Filter Hand Delivery Locations: West Colfax

Fire Stations

Police Stations

Filter Pilot Hand Delivery Locations (6)

Council Districts

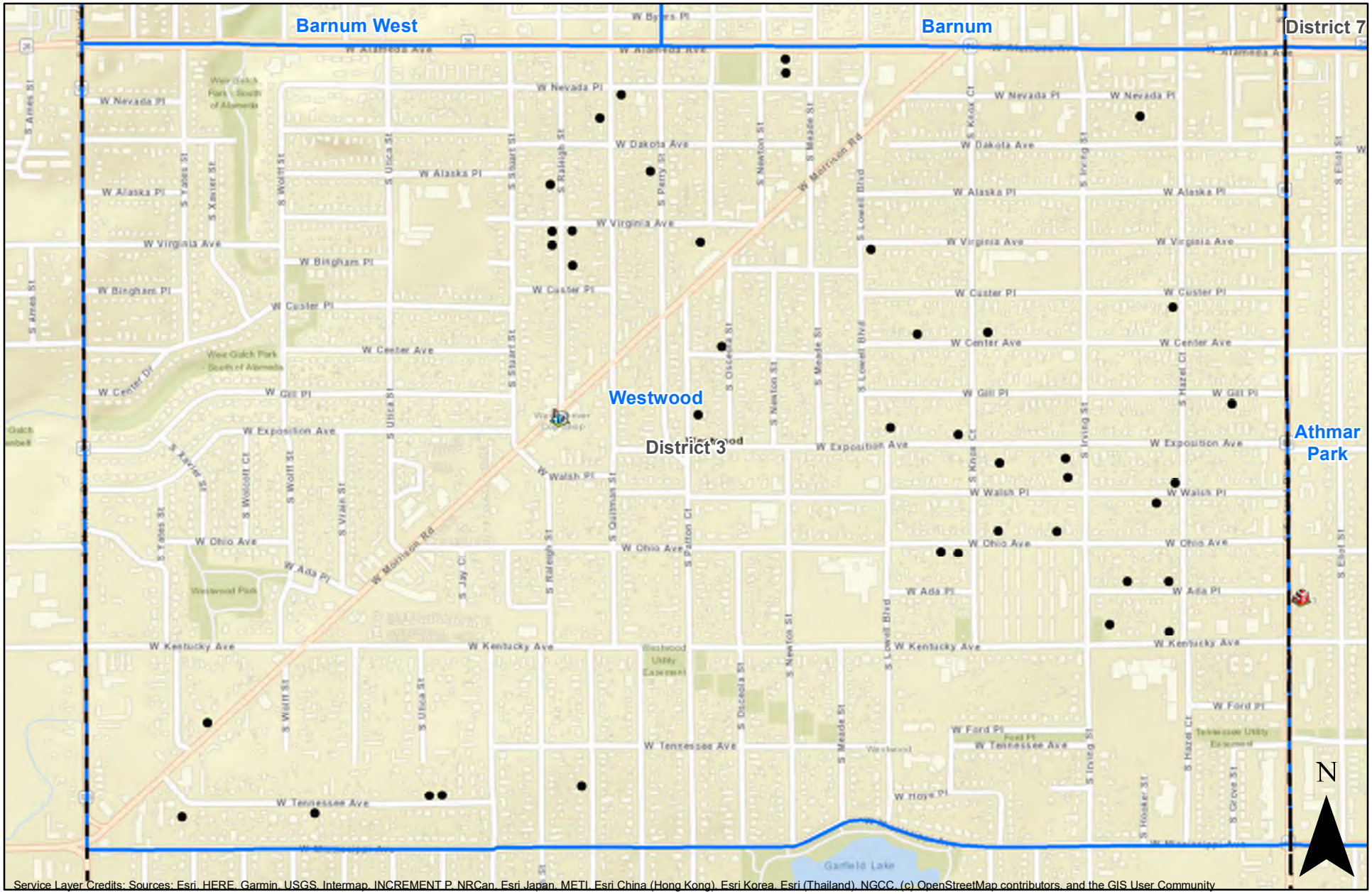
Neighborhoods

Registered Neighborhood Organizations

DENVER WATER

Author: R. Avery

Map Date: 2019-07-08



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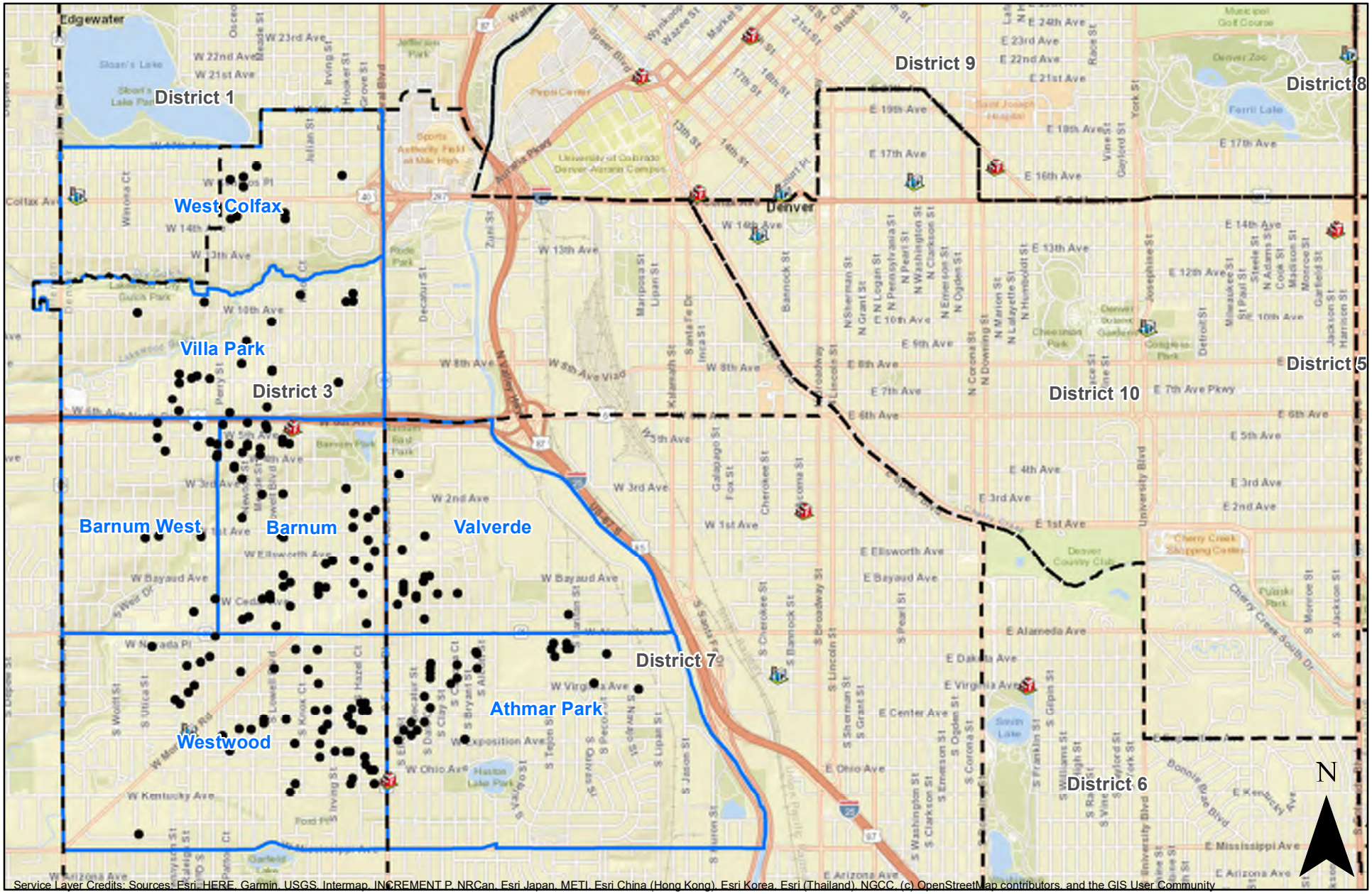
0 370 740 1,480 2,220 2,960 Feet

Filter Hand Delivery Locations: Westwood

Fire Stations
Police Stations
Filter Pilot Hand Delivery Locations (40)
Council Districts
Neighborhoods
Registered Neighborhood Organizations

DENVER WATER

Author: R. Avery
Map Date: 2019-07-08



Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

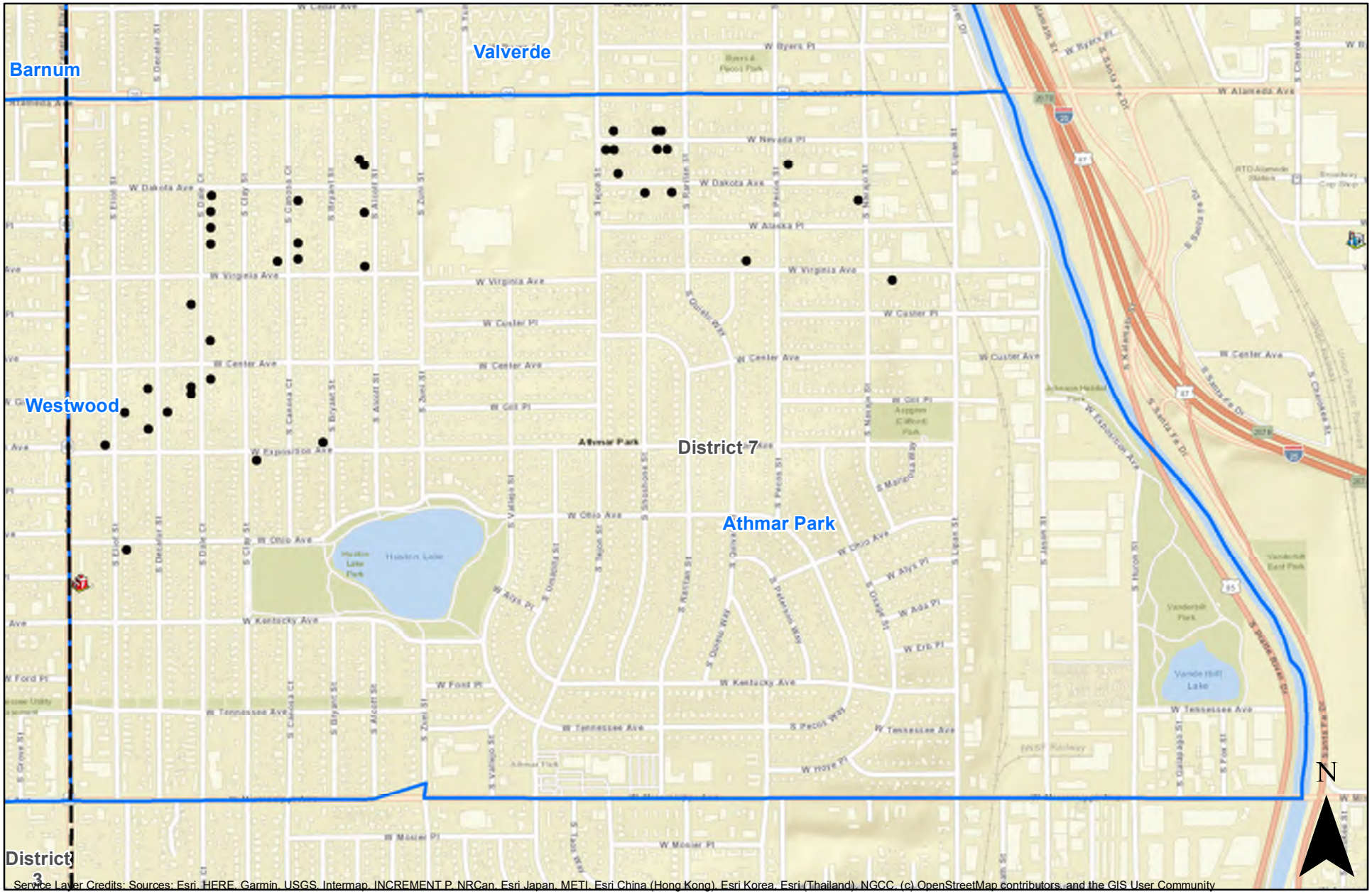
0 0.25 0.5 1 1.5 2 Miles

Filter Pilot Mail Delivery Locations

Fire Stations
Police Stations
Filter Pilot Mail Delivery Locations (189)
Council Districts
Neighborhoods
Registered Neighborhood Organizations

DENVER WATER

Author: R. Avery
Map Date: 2019-07-08



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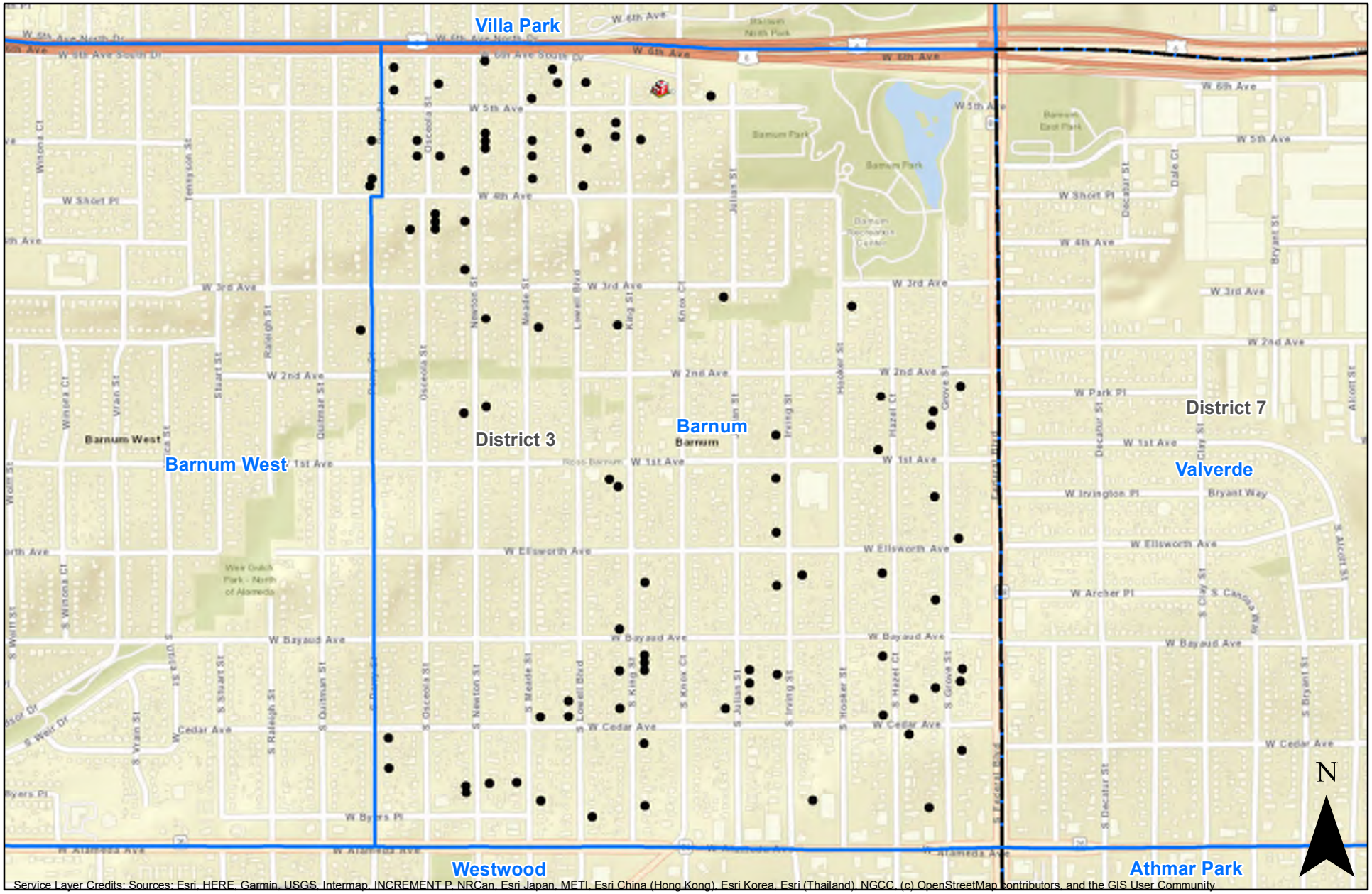
0 420 840 1,680 2,520 3,360 Feet

Filter Pilot Locations: Athmar Park

Fire Stations
Police Stations
Filter Pilot Locations (39)
Council Districts
Neighborhoods
Registered Neighborhood Organizations

DENVER WATER

Author: R. Avery
Map Date: 2019-07-08



Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

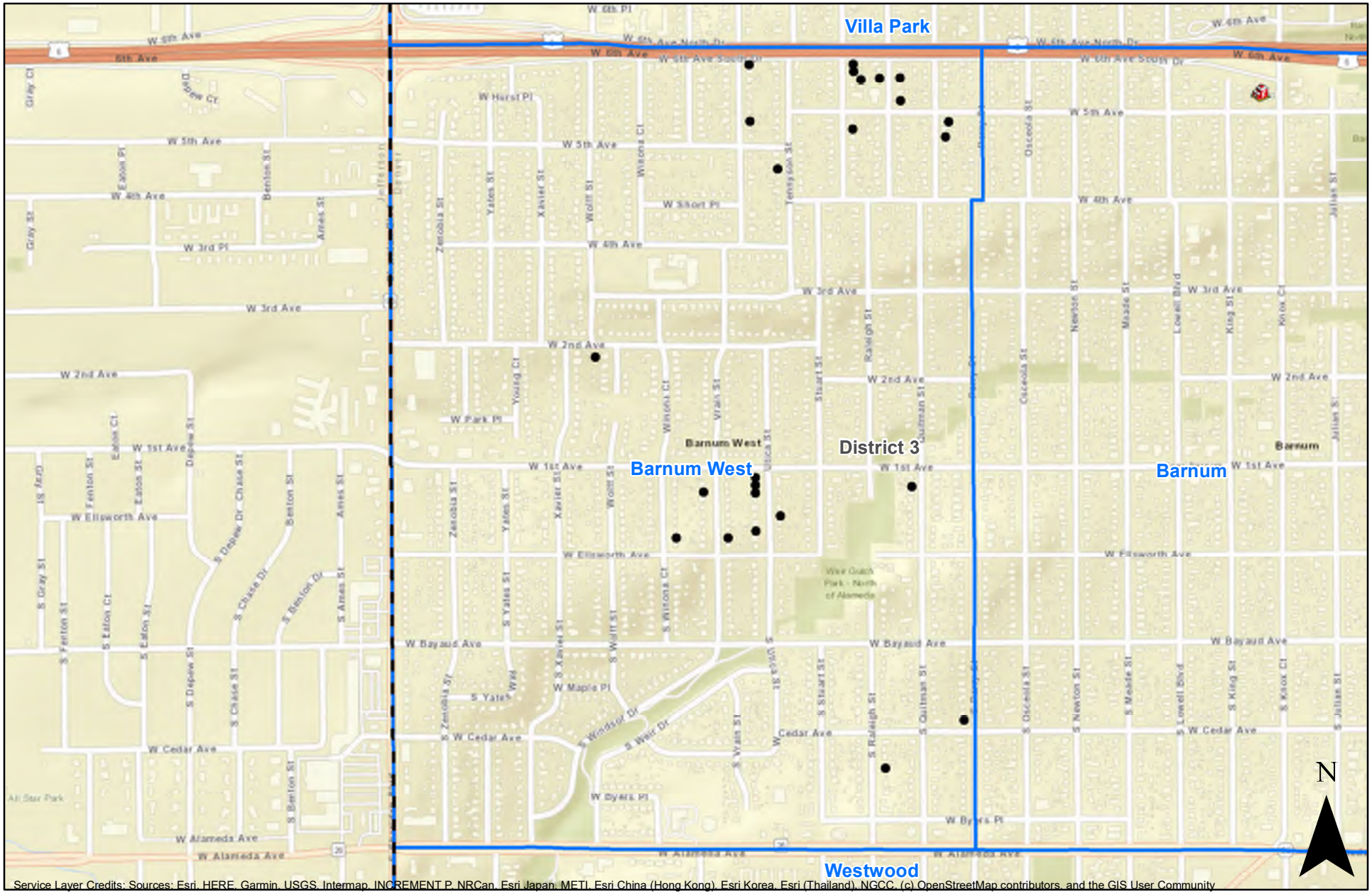
0 365 730 1,460 2,190 2,920 Feet

Filter Pilot Locations: Barnum

Fire Stations
Police Stations
Filter Pilot Locations (93)
Council Districts
Neighborhoods
Registered Neighborhood Organizations

DENVER WATER

Author: R. Avery
Map Date: 2019-07-08



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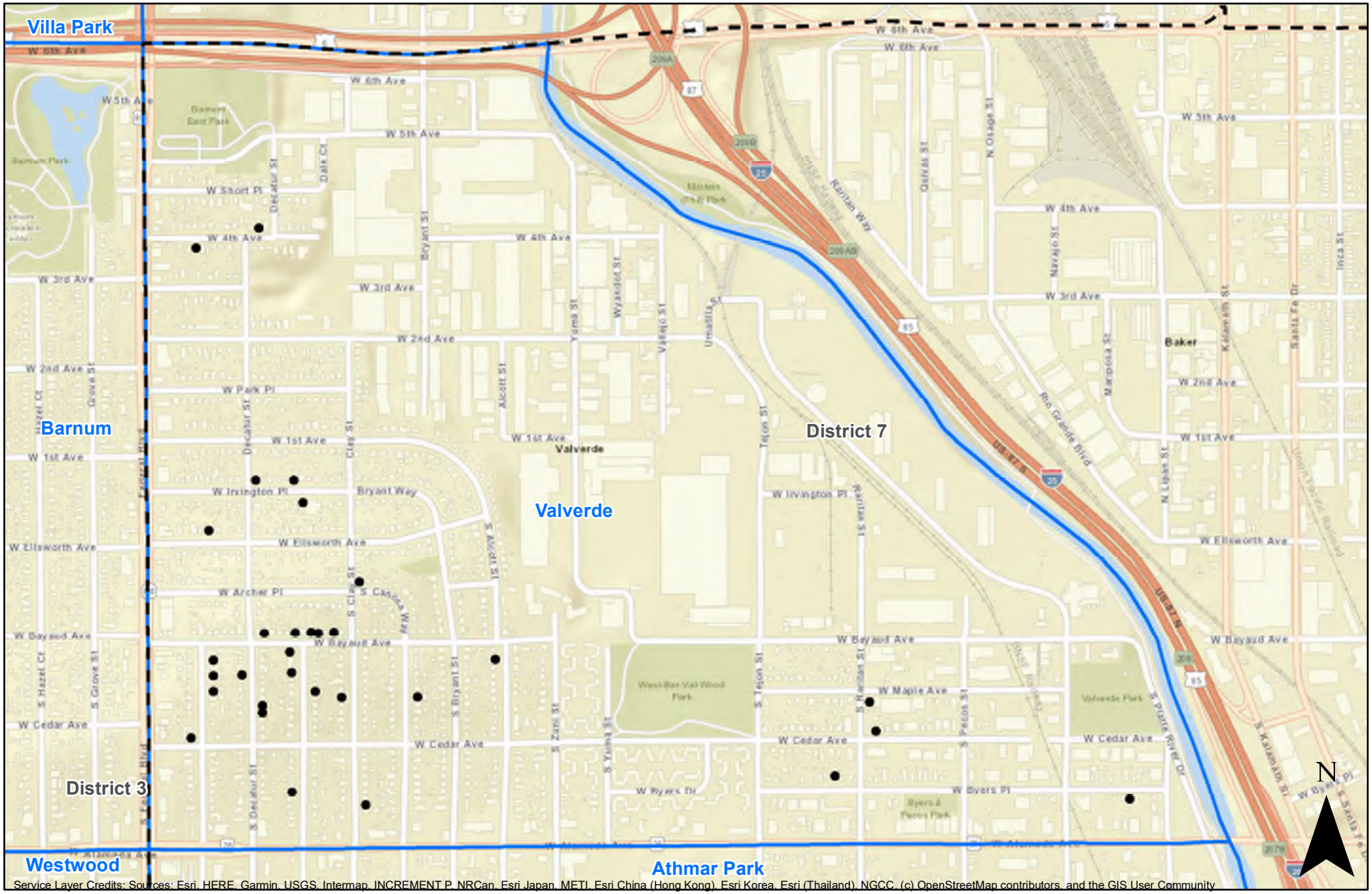
0 365 730 1,460 2,190 2,920 Feet

Filter Pilot Locations: Barnum West

Fire Stations
Police Stations
Filter Pilot Locations (24)
Council Districts
Neighborhoods
Registered Neighborhood Organizations

DENVER WATER

Author: R. Avery
Map Date: 2019-07-08



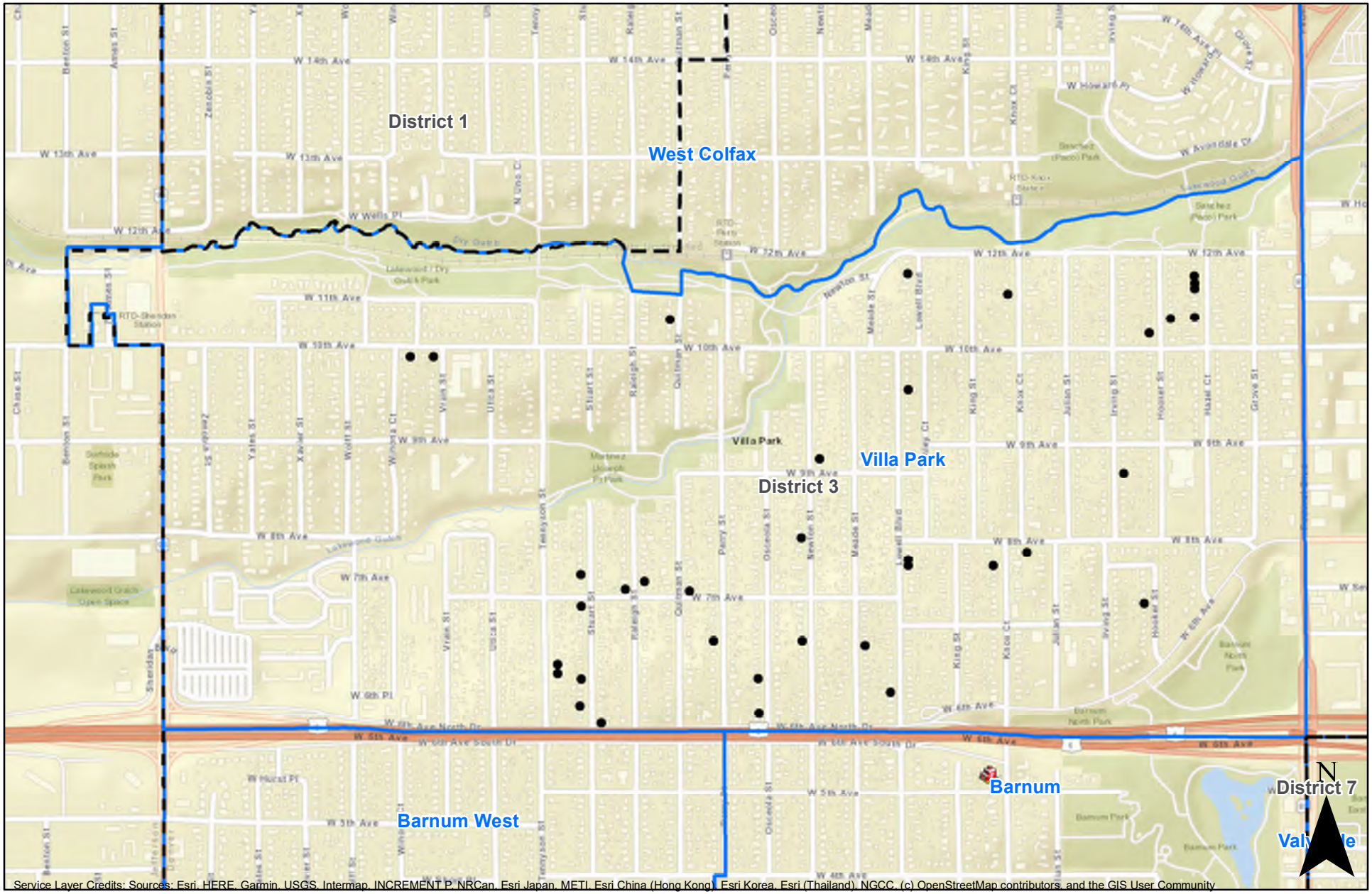
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

Filter Pilot Locations: Valverde

Fire Stations
Police Stations
Filter Pilot Locations (31)
Council Districts
Neighborhoods
Registered Neighborhood Organizations

DENVER WATER

Author: R. Avery
Map Date: 2019-07-08



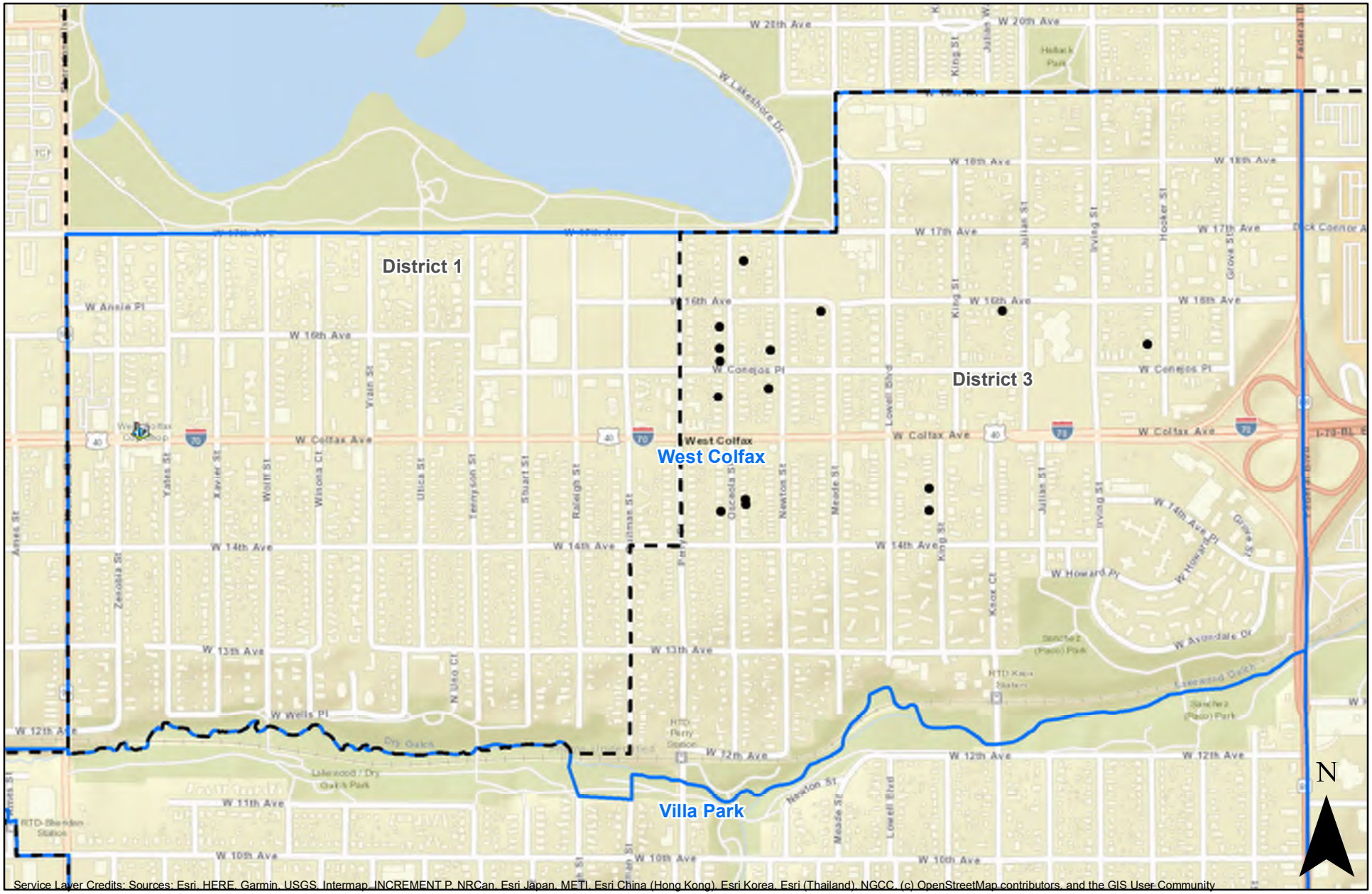
0 385 770 1,540 2,310 3,080 Feet

Filter Pilot Locations: Villa Park

Fire Stations
Police Stations
Filter Pilot Locations (36)
Council Districts
Neighborhoods
Registered Neighborhood Organizations

DENVER WATER

Author: R. Avery
Map Date: 2019-07-08



Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

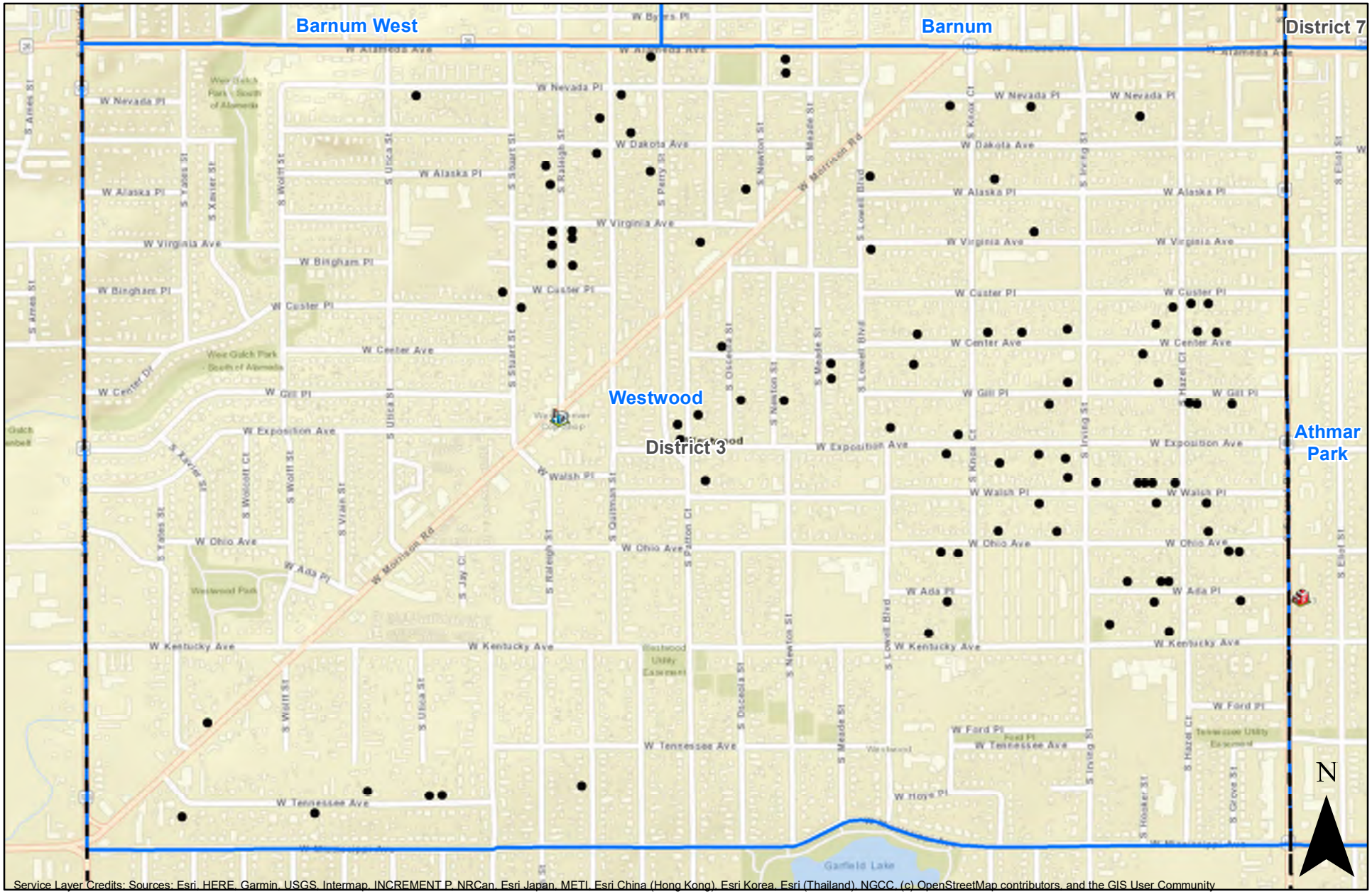
0 355 710 1,420 2,130 2,840 Feet

Filter Pilot Locations: West Colfax

Fire Stations
Police Stations
Filter Pilot Locations (15)
Council Districts
Neighborhoods
Registered Neighborhood Organizations

DENVER WATER

Author: R. Avery
Map Date: 2019-07-08



Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

0 370 740 1,480 2,220 2,960 Feet

Filter Pilot Locations: Westwood

Fire Stations

Police Stations

Filter Pilot Locations (93)

Council Districts

Neighborhoods

Registered Neighborhood Organizations

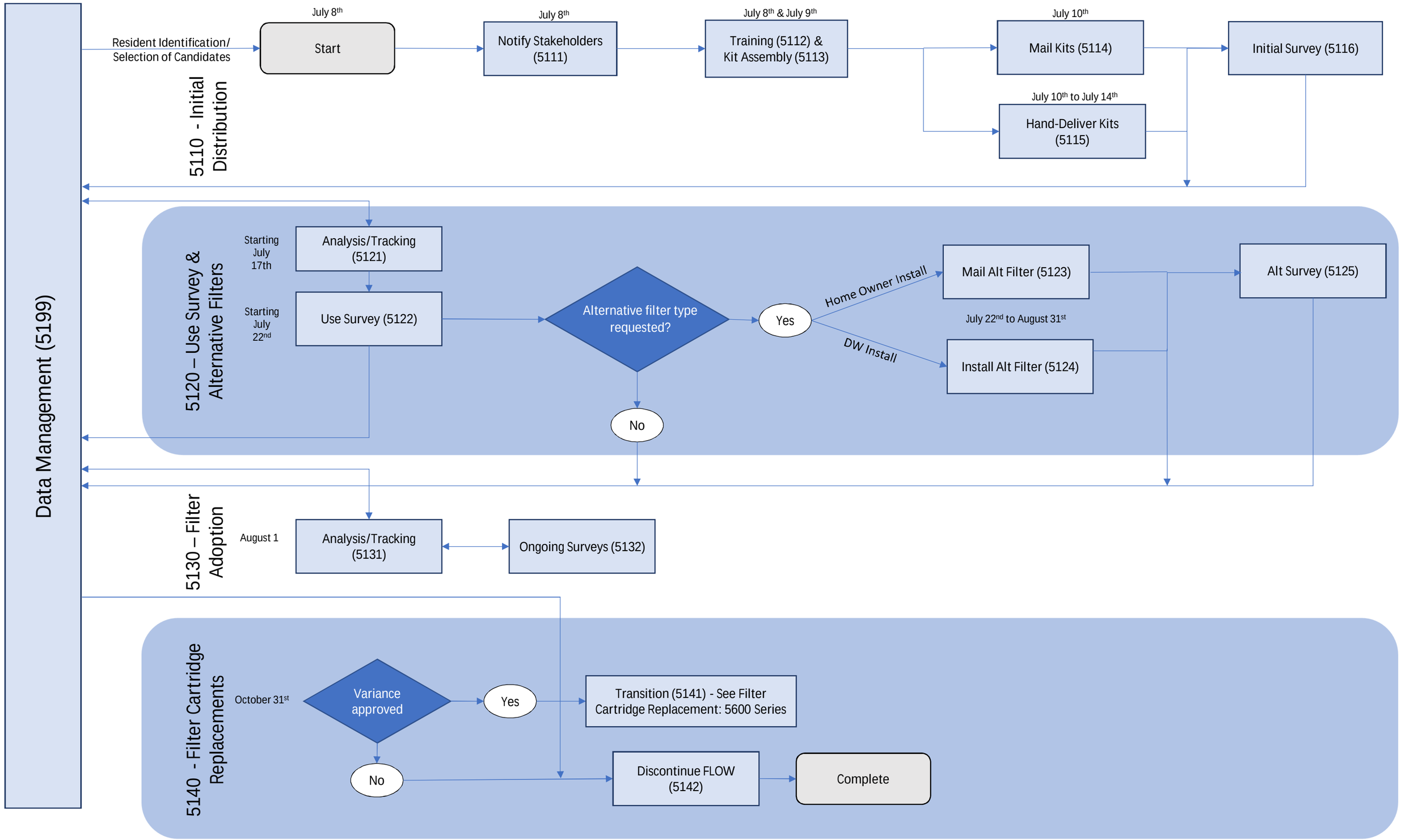
DENVER WATER

Author: R. Avery
Map Date: 2019-07-08

APPENDIX F - FLOW PILOT FLOWCHART

DENVER WATER

FILTER PILOT – 5100 SERIES: WORKFLOW/FLOWCHART



APPENDIX G - COE

DENVER WATER

Community Outreach and Education (COE)

The overarching Lead Reduction Program Communication's Strategy, process, procedures, and guidelines will apply to the Filter Lead Out of Water (FLOW) Pilot. The success of the FLOW Pilot is paramount to provide Denver Water with the necessary data and information to support the variance request.

The collateral developed for the filter kit will be transitioned into the full-scale filter distribution effort. All COE materials will be bilingual for ease of use. The FLOW Pilot kit included the following COE materials:

Introduction Letter (Appendix C)

The introduction letter was our first touch point with Denver Water households who received the filter kit via USPS and door-to-door delivery. This letter provided the context as to why the Denver Water household received a filter kit, shared information about the FLOW Pilot, and provided contact information for additional support and questions.

Frequently Asked Questions (FAQ) (Appendix G1)

The FAQ document provided additional information beyond the introduction letter for recipients of the FLOW Pilot. The FAQ developed specifically for the FLOW Pilot has duplicative information from the full-scale FLOW Program initiative FAQ approved by the EPA and CDPHE, with additional context as to why participants are receiving the filter kit, the length of the FLOW Pilot, information about the surveys, and more.

Magnet Reminder Card (Appendix G2)

A refrigerator magnet was provided as a reminder to encourage filter pitcher use for infant formula, drinking, and cooking. The magnet provides a reminder to users to change their filter cartridge every 30-days. Program contact information is included on the magnet.

Door-hanger (Appendix G3)

100 of the 300 FLOW Pilot participants will have door-to-door delivery of the filter kits. For these 100 FLOW Pilot participants, a door-hanger was left on doors with the filter kit to notify Denver Water households of the FLOW Pilot, inform them of the contents of the filter kit, and provide contact information, should the Denver Water household residents not be home during the initial door to door delivery attempt.

Survey Card (Appendix G4)

An initial survey was included in the filter kit. FLOW Pilot participants were encouraged to complete the initial survey and return their comments to Denver Water within two weeks of receiving their filter kit. Future surveys will be mailed to the FLOW Pilot participants with incentives such as Amazon gift cards offered for the completion of each survey.

The designs of other materials used for the FLOW Pilot, including T-shirts, tote bags, and information cards are also included in this appendix.

LEAD REDUCTION PROGRAM
FREQUENTLY ASKED QUESTIONS

How does lead get into drinking water?

The water delivered to homes and businesses is lead-free, but lead can get into water as it moves through customers' lead-containing household plumbing and service lines (the pipes that bring water from Denver Water's main in the street to the plumbing in your home or building).

If Denver Water's water is lead-free, why is Denver Water focusing on lead reduction?

When it comes to lead in drinking water, no levels are safe. That is why Denver Water is working with the Colorado Department of Public Health and Environment and the Environmental Protection Agency to reduce the risks of lead exposure as drinking water moves through those homes and businesses.

In 2012, water quality sample results exceeded the level the EPA requires for taking action. The action level is an indicator that additional steps may need to be taken to optimize corrosion control treatment. While Denver Water has not exceeded the lead action level since 2012, it is committed to implementing the best method to permanently reduce lead in tap water.

In the meantime, Denver Water has already taken a number of measures to minimize the presence of lead in water, such as:

- Using a pH adjustment to reduce the risk of lead, copper and other metals from getting into drinking water from service lines or household plumbing.
- Replacing customer lead service lines free of charge when such piping is discovered during normal operations and maintenance activities.
- Partnering with Denver Public Schools, Douglas County Schools and Littleton Public Schools to develop and assist with their own lead-testing programs, testing over 15,000 samples.
- Offering free lead testing for customers.

What solutions are being considered?

Denver Water conducted a study on multiple treatment options to reduce the potential for lead entering drinking water from lead service lines and household plumbing. Based on the results, CDPHE, the state regulatory agency that oversees drinking water regulations, required Denver Water to begin adding orthophosphate in accordance with regulatory requirements. Orthophosphate, a food additive, would be added to all drinking water provided by Denver Water to provide additional coating for pipes to minimize corrosion and reduce the amount of lead released from lead-containing pipes and fixtures.

While orthophosphate has been safely and successfully used for decades across the country, concerns have been raised about the potential impacts of this additive to wastewater treatment plants and downstream reservoirs, streams and rivers. CDPHE, Denver Water and others are studying these potential impacts to determine ways to protect the environment if this approach moves forward.

Denver Water is proposing an alternative, holistic approach that directly tackles the biggest issue, customer-owned lead service lines, at its source by accelerating the removal of those lines through a Lead Reduction Program. The approach has multiple components:

- Increasing the pH level, which reduces the corrosivity of the water.
- Providing at-home water filters for all customers in Denver Water's service area with a suspected lead service line, free of charge.
- Replacing the estimated 50,000 to 90,000 lead service lines with copper lines in Denver Water's service area at no charge to the customer over the next 15 years.

DENVER WATER

LEAD REDUCTION PROGRAM
FREQUENTLY ASKED QUESTIONS

The EPA will begin accepting comments about this option this summer and is expected to decide whether Denver Water's proposed alternative meets Safe Drinking Water Act requirements by the end of the year. CDPHE will then make a decision whether to change the March 2018 orthophosphate designation, if appropriate. Regardless of whether the alternative option is selected, the implementation of optimal corrosion control will begin in March 2020.

How can I find out if I have a lead service line and what can I do about it?

In Denver Water's experience, homes and buildings most likely to have lead service lines are those built before 1951 in the Denver metro area (**denverwater.org/neighborhod-age**). Homes built before 1987 may have lead solder in their plumbing. Homes that do not fall within these two categories are less likely to be at risk for lead contamination in the water.

All Denver Water customers can get a free, at-home water quality test for lead by visiting **denverwater.org/Lead** or calling 303-893-2444. For those who are not Denver Water customers, we recommend you contact your local water utility or a certified lab in your area.

If your home has a lead service line, the best long-term action is to replace it with a copper service line. We recommend using a certified plumber. The cost of replacing a lead service line is approximately $5,000-$10,000, which can be a financial challenge. Denver Water has a partnership with the Denver Urban Renewal Authority to provide financing for homeowners to replace lead service lines. Under the program, DURA issues eligible property owners no- or low-interest loans based on income. DURA obtains bids and oversees the contractors retained. If you are interested, contact DURA at 303-534-3872 to learn the eligibility requirements for this limited-time program.

It is worth noting that Denver Water is currently working to develop a program that could replace property owners' lead service lines at no cost to them. Decisions on whether to implement this program may not occur until the end of 2019.

If you suspect your home has lead in the plumbing, there are a few immediate steps you can take to minimize exposure:

Use a filter certified by the National Safety Foundation to remove lead for drinking and cooking. Replace the filter cartridge according to the manufacturer's instructions.

Use only cold water for drinking, cooking and making baby formula. Remember, boiling water does not remove lead from water and hot water often contains higher levels of lead than cold water.

If water has not been used in the home for a few hours, such as first thing in the morning or when getting home from work, run the kitchen or any bathroom faucet for five minutes (remember to capture the water and reuse it!). You can also run the dishwasher, take a shower, or do a load of laundry to help flush water in your internal plumbing before drinking or cooking.

Regularly clean your faucet's screen (also known as an aerator). View step-by-step instructions at **denverwater.org/lead-flushing.**

Where can I go to ask questions and get more information?

You can call Denver Water at 303-893-2444, visit **denverwater.org/Lead** or email **lead@denverwater.org**.

DENVER WATER

FILTER LEAD OUT OF WATER
FREQUENTLY ASKED QUESTIONS

What is the purpose of the Filter Lead Out of Water (FLOW) pilot?

As part of the ongoing analysis this summer for Denver Water's proposed alternative to orthophosphate, Denver Water is conducting the FLOW pilot with a small number of customers with known lead service lines to better understand preferences and usage around water filters. This will help inform how the full-scale program would be implemented.

How were customers identified to participate in the FLOW pilot?

Customers were identified based on properties, with suspected lead service lines, in neighborhoods reflecting a diverse base of Denver Water customers, namely West Colfax, Villa Park, Barnum West, Barnum, Valverde, Westwood and Athmar Park. Identified properties are also owner-occupied.

Is the water in my home safe to use for drinking and cooking?

Based on Denver Water's ongoing inventory analysis, it is believed participants for the FLOW pilot likely have a customer-owned lead service line. This means that there is potential for lead to leach into your water as it moves through your service line. No levels of lead in drinking water are safe, which is why we are recommending the use of a filter for all of the water you use for drinking and cooking.

Should I use my water filter pitcher for all cooking and food preparation?

It is recommended to use filtered water for food preparation, such as preparing rice, beans, soup and other recipes where water is a base ingredient or absorbed into the dish. Keep in mind that boiling water does not remove lead. Filtered water should also be used to prepare infant formula.

Is my water safe for pets?

Changes in pet behavior as a result of drinking lead contaminated water are not likely to be noticeable. In general, pets are more likely to obtain lead as a result of eating an object containing much higher lead levels (lead paint chips). To be safe, check with your veterinarian and/or give your pet filtered water.

Is my water safe to use for a shower or bath?

Yes, bathing and showering is safe for you and your children, even if the water contains lead over EPA's action level. Human skin does not absorb lead in water at levels that cause a health concern.

Where can I go to ask questions and get more information on the filter pilot?

Call 303-628-6655 or email **flow@denverwater.org** for more information on the filter pilot. You can also go to **denverwater.org/Lead** to learn more about Denver Water's Lead Reduction Program.

denverwater.org/Lead
flow@denverwater.org
303-628-6655

DENVER WATER

PROGRAMA DE REDUCCIÓN DE PLOMO
PREGUNTAS FRECUENTES

¿Cómo llega el plomo al agua potable?

El agua que llega a las casas y negocios no contiene plomo, pero el plomo puede meterse en el agua a medida que pasa por las líneas de servicio y tuberías residenciales que contienen plomo (las tuberías que llevan el agua desde la tubería principal de Denver Water localizada en la calle, hasta su hogar o edificio).

Si el agua de Denver Water no contiene plomo, ¿por qué Denver Water se está enfocando en la reducción de plomo?

Cuando se trata de plomo en el agua, ningún nivel es seguro. Es por esto que Denver Water está trabajando con el Departamento de Salud Pública y del Medio Ambiente en Colorado y con la Agencia para la Protección del Medio Ambiente, para reducir los riesgos de exposición al plomo a medida que el agua potable pasa por esos hogares y negocios.

En 2012, los resultados de muestras de control de la calidad del agua sobrepasaron el nivel en el que EPA exige tomar medidas. Este nivel es un indicador de que puede ser necesario tomar medidas adicionales para mejorar el tratamiento para el control de la corrosión. A pesar de que desde 2012 Denver Water no ha sobrepasado el nivel en el que se deben tomar medidas, la entidad está comprometida a implementar el mejor método para reducir de manera permanente el plomo en el agua potable.

Mientras esto pasa, Denver Water ya ha tomado varias medidas para minimizar la presencia de plomo en el agua, como son:

- Hacer un ajuste al pH para reducir el riesgo de que el plomo, cobre u otros metales pasen al agua potable desde las líneas de servicio o la tubería del hogar.
- Reemplazar las líneas de servicio de plomo de manera gratuita para los clientes, cuando dichas tuberías sean descubiertas durante actividades normales de operación y mantenimiento.
- La asociación con las escuelas públicas de Denver, escuelas del condado de Douglas y escuelas públicas de Littleton para el desarrollo y ayuda con sus propios programas de hacer pruebas de plomo, examinando más de 15,000 muestras.
- Ofrecer a los clientes pruebas de plomo gratuitas.

¿Qué soluciones se están considerando?

Denver Water llevó a cabo un estudio sobre varias opciones de tratamiento para reducir la posibilidad de que el plomo llegue al agua potable debido a la existencia de líneas de servicio y tuberías de plomo en el hogar. Basado en los resultados, CDPHE, la agencia estatal reguladora que supervisa las regulaciones de agua potable, le exigió a Denver Water que agregara ortofosfato según los requerimientos reglamentarios. El ortofosfato, un aditivo alimentario, se agregaría a toda el agua potable provista por Denver Water, con el objetivo de brindar un recubrimiento adicional a las tuberías para reducir la corrosión y la cantidad de plomo liberado de las tuberías y griferías que contienen plomo.

A pesar de que el ortofosfato se ha usado por décadas de manera segura y con éxito en todo el país, ha surgido la preocupación del impacto que este aditivo pueda tener en las plantas de tratamiento de aguas residuales, arroyos, ríos y los depósitos a donde llega esa agua agua.

CDPHE, Denver Water y otros están estudiando estos posibles efectos para determinar maneras de proteger el medio ambiente si esta propuesta sigue adelante.

Denver Water propone una alternativa, con un enfoque holístico, que aborda directamente el asunto principal que son las líneas de servicio de plomo particulares, agilizando el remplazo de estas líneas a través del programa de reducción de plomo. Este enfoque tiene varios componentes:

- Aumentar el nivel de pH, lo cual reduce el factor corrosivo del agua.
- Proveer, sin costo alguno, filtros de agua para los hogares de todos los clientes en el área de servicio de Denver Water en donde se sospecha existen líneas de servicio de plomo.
- Reemplazar con cobre, sin costo alguno para los clientes y durante los siguientes 15 años, las estimadas 50,000 a 90,000 líneas de servicio de plomo, en el área de servicio de Denver Water.

PROGRAMA DE REDUCCIÓN DE PLOMO
PREGUNTAS FRECUENTES

La EPA empezará este verano a recibir comentarios sobre esta opción, y se espera que al final del año se decida si la alternativa propuesta por Denver Water cumple con las exigencias de la Ley de Agua Potable Segura. A continuación, y de ser apropiado, CDPHE decidirá si va a cambiar la designación de marzo de 2018 sobre el ortofosfato. Independientemente de si se selecciona la opción alternativa, la implementación del control óptimo de corrosión empezará en marzo de 2020.

¿Cómo averiguo si tengo líneas de servicio de plomo y qué puedo hacer al respecto?

Con base en la experiencia de Denver Water, los hogares y edificios con más probabilidad de tener líneas de servicio de plomo son aquellos construidos antes de 1951 en la zona metropolitana de Denver (**denverwater.org/neighborhod-age**). Los hogares construidos antes de 1987 pueden tener soldadura de plomo en sus tuberías. Los hogares que no estén en ninguna de estas dos categorías tienen menos probabilidad de estar en riesgo de contaminación de plomo en el agua.

Todos los clientes de Denver Water reciben de manera gratuita una prueba para revisar la presencia de plomo en el agua, visitando **denverwater.org/Lead** o llamando al 303-893-2444. A aquellas personas que no son clientes de Denver Water, les recomendamos se pongan en contacto con la compañía local de agua o con un laboratorio certificado local.

Si su hogar tiene una línea de servicio de plomo, la mejor solución a largo plazo es reemplazarla con una línea de servicio de cobre. Recomendamos que use un plomero certificado. El costo de reemplazar una línea de servicio de plomo es aproximadamente entre $5,000 y $10,000, lo que puede presentar una dificultad económica. Denver Water se ha asociado con Denver Urban Renewal Authority para ofrecer financiamiento a los propietarios para que reemplacen las líneas de servicio de plomo. Con este programa, DURA emite préstamos sin interés o de bajo interés, de bajo interés, basados en ingresos, para los propietarios elegibles. DURA hace las licitaciones y supervisa a los contratistas asignados. Si le interesa, comuníquese con DURA al 303-534-3872 para obtener más información sobre las condiciones de elegibilidad para este programa de tiempo limitado.

Vale la pena notar que Denver Water está trabajando en el desarrollo de un programa que podría reemplazar las líneas de servicio de plomo de los propietarios sin costo alguno para ellos. La decisión sobre la implementación de este programa puede que no se conozca hasta finales de 2019.

Si sospecha que su casa tiene plomo en las tuberías, hay unas medidas que puede tomar inmediatamente para reducir la exposición a este material:

Use un filtro certificado por la Fundación Nacional de Seguridad para eliminar el plomo del agua para beber y cocinar. Reemplace el cartucho del filtro siguiendo las instrucciones de fabricante.

Use solamente agua fría para tomar, cocinar y preparar biberones. Recuerde que hervir el agua no elimina el plomo del agua y el agua caliente generalmente contiene niveles más altos de plomo que el agua fría.

Si no se ha usado el agua en casa por unas horas, como a primera hora en la mañana o cuando llega a casa del trabajo, abra 5 minutos el grifo del fregadero o el de cualquier baño (¡recuerde recoger esta agua y reusarla!). También puede usar el lavavajillas, tomar una ducha o lavar una carga de ropa para ayudar a descargar el agua en su tubería interna, antes de beber o cocinar.

Limpie con frecuencia el filtro de su grifo (conocido también como el aireador). Vea las instrucciones paso a paso en **denverwater.org/lead-flushing.**

¿A dónde puedo ir a hacer preguntas y obtener más información?

Puede llamar a Denver Water al 303-893-2444, visitar denverwater.org/Lead o enviar un correo electrónico a **lead@denverwater.org**.

DENVER WATER

FILTRE EL PLOMO DEL AGUA
PREGUNTAS FRECUENTES

¿Cuál es el propósito del programa piloto Filtre el plomo del agua (FLOW)?

Como parte del análisis en marcha este verano para la propuesta de la alternativa al uso del ortofosfato, Denver Water está llevando a cabo el piloto del programa FLOW con un número pequeño de clientes de quienes se conoce tienen líneas de servicio para entender mejor las preferencias y uso de los filtros de agua. Esto nos ayudará a reunir más información para saber cómo se debería implementar el programa a gran escala.

¿Cómo se identificaron los clientes para participar en el programa piloto FLOW?

Los clientes se identificaron con base en las propiedades en las que se sospecha que hay líneas de servicio de plomo, en vecindarios con una composición cultural diversa de clientes de Denver Water, específicamente West Colfax, Villa Park, Barnum West, Barnum, Valverde, Westwood y Athmar Park. Las propiedades que se identificaron también estaban habitadas por los propietarios.

¿Es el agua de mi hogar segura para beber y cocinar?

Con base en el análisis en marcha del inventario de Denver Water, se cree que los participantes del programa piloto FLOW probablemente tienen una línea de servicio de plomo particular. Esto significa que existe la posibilidad de que el plomo entre al agua a medida que pase por su línea de servicio. No existe ningún nivel de plomo seguro en el agua potable, por lo cual estamos recomendando el uso de un filtro para toda el agua que usa para beber o cocinar.

¿Debería usar mi jarra para filtrar el agua para todo lo que cocine y prepare de comer?

Se recomienda usar agua filtrada para la preparación de alimentos como para preparar arroz, frijoles, sopas y otras recetas en donde el agua es el ingrediente base o se absorbe en los ingredientes. Tenga en cuenta que hervir el agua no elimina el plomo del agua. El agua filtrada también debe usarse para preparar biberones y lavarlos, así como para el agua de beber de los bebés.

¿Es el agua de mi hogar segura para las mascotas?

Es probable que no se note un cambio en el comportamiento de las mascotas como resultado de beber agua contaminada con plomo. En general, las mascotas tienen más probabilidad de ingerir plomo por haber comido un objeto que contiene niveles mucho más altos de plomo (pedazos de pintura con plomo). Para mayor seguridad, pregunte a su veterinario o de a su mascota agua filtrada.

¿Es el agua de mi hogar segura para ducharse o tomar un baño?"

Sí, bañarse o tomar una ducha es seguro para usted y sus niños, incluso si el agua contiene plomo a un nivel en el que la EPA exige tomar medidas. La piel humana no absorbe plomo en el agua en un nivel que pueda causar un problema de salud.

¿A dónde puedo ir a hacer preguntas y obtener más información sobre el programa piloto de filtros?

Llame al 303-628-6655 o escriba a **flow@denverwater.org** para obtener más información sobre el programa piloto de filtros. También puede visitar **denverwater.org/Lead** para obtener más información sobre el programa piloto de filtros.

denverwater.org/Lead
flow@denverwater.org
303-628-6655

DENVER WATER

FILTER LEAD OUT OF WATER

Denver Water delivers safe, lead-free water, but lead can get into water from plumbing and pipes in the home.

REMINDER

Use your filter for:

Drinking Water

Cooking

Infant Formula

Change your filter cartridges every 30 days on:

FILTRE EL PLOMO DEL AGUA

Denver Water provee agua segura y sin plomo, pero el plomo puede pasar al agua por medio de las tuberías de la casa.

RECORDATORIO

Use su filtro para:

Beber Agua

Cocinar

Preparar Biberones

Cambie los cartuchos del filtro cada 30 días el:

denverwater.org/Lead

flow@denverwater.org **303-628-6655**

DENVER WATER

WE MISSED YOU!

Our crews stopped by today and left a water filter pitcher kit at your front door for your household's use.

The water filter pitcher kit is being provided as a precautionary measure. The age of your home indicates that you may have or had a lead service line. If so, there may also be lead particles present in your service line or plumbing. This water pitcher is certified to remove 99.6% of detectable dissolved solids, including lead, if present.

The kit includes:

- NSF certified 10-cup filter pitcher.
- A three-month supply of replacement cartridges.
- Filter Lead Out of Water program info.
- A reminder magnet.
- A reusable tote bag.

denverwater.org/Lead
flow@denverwater.org
303-628-6655

DENVER WATER

¡SENTIMOS NO HABERLE ENCONTRADO!

Hoy pasamos a visitarle y le dejamos
un kit en la puerta de su casa de una jarra con filtro
para el agua de uso en el hogar.

Le estamos dando este kit de jarra con filtro como una medida de precaución. La fecha de construcción de su casa indica que puede tener o haber tenido tuberías de plomo. De ser así, puede haber partículas de plomo en las tuberías o en la línea de suministro principal. La jarra para el agua está certificada para filtrar el 99.6% de sólidos disueltos detectables, incluso plomo, de estar presente.

El kit incluye:

- Jarra con filtro para 10 tazas, certificada por la NSF.
- Cartuchos de repuesto para tres meses.
- Información sobre un programa para filtrar el plomo del agua.
- Un imán de recordatorio.
- Una bolsa reusable.

denverwater.org/Lead
flow@denverwater.org
303-628-6655

DENVER WATER

FILTER LEAD OUT OF WATER

Thank you for participating in Denver Water's FLOW pilot. Your feedback will help us understand information about how water is used in your home for drinking and cooking activities. Please use the ZeroWater® pitcher provided and return your completed survey by mail or online within two weeks of receiving the filter kit. **As our way of thanking you for your feedback and using your filter, upon receipt of the completed survey, Denver Water will send you a $15 Amazon gift card. For an online survey, go to denverwater.org/Lead-survey or scan the QR code at the bottom of this survey.**

Please provide your email address so that we can send you the Amazon gift card. _____

Without your email address we will not be able to send you the gift card.

1. Do you know if you have a lead service line?

☐ Yes ☐ No
☐ I do not know

2. What is your household's primary source of drinking water? (Check one)

☐ Unfiltered faucet ☐ Bottled water
☐ Filtered – refrigerated water/ice dispenser
☐ Filtered – pitcher filter
☐ Filtered – under sink filter
☐ Filtered – faucet mounted filter
☐ Filtered – whole house filter
☐ Other (specify) _____

3. What is your household's primary source of water used for cooking? (Check one)

☐ Unfiltered faucet ☐ Bottled water
☐ Filtered – refrigerated water/ice dispenser
☐ Filtered – pitcher filter
☐ Filtered – under sink filter
☐ Filtered – faucet mounted filter
☐ Filtered – whole house filter
☐ Other (specify) _____

4. If you have an existing water filter system, what is the make and model number for your filter? (Fill in)

_____

5. Do you currently or do you plan in the future to use filtered or bottled water for infant formula?

☐ Yes ☐ No ☐ NA

6. What questions or comments do you have about the filter pilot?

_____
_____

7. How could we improve the filter pilot?

_____
_____

8. Want to stay informed about the FLOW pilot? Provide your email or phone number.

Email: _____
Phone: _____

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DENVER WATER

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DENVER WATER
LEAD REDUCTION PROGRAM
1600 W 12TH AVE
DENVER CO 80204-9963

FILTRE EL PLOMO DEL AGUA

Gracias por participar en el programa piloto FLOW de Denver Water. Sus comentarios nos van a ayudar a entender cómo se usa el agua para beber y cocinar en su hogar. Por favor use la jarra para agua de ZeroWater® que le hemos dejado y envíe por correo o en línea su encuesta completa, en las primeras dos semanas después de haber recibido el kit. **Una vez recibamos su encuesta completa, como agradecimiento por sus comentarios y por usar el filtro, Denver Water le enviará una tarjeta de regalo de Amazon por un valor de $15. Para completar la encuesta en línea, visite denverwater.org/Lead-survey o escanee el código QR al final de la encuesta.**

Incluya su correo electrónico de modo que podamos enviarle la tarjeta de regalo de Amazon. _____

Sin su correo electrónico no podremos enviarle la tarjeta de regalo.

1. ¿Sabe si tiene una líneas de servicio principal de agua hecha de plomo?

☐ Sí ☐ No
☐ No sé

2. ¿Cuál es la principal fuente de agua potable en su hogar? (Marque una)

☐ Agua sin filtrar del grifo ☐ Embotellada
☐ Filtrada – Del refrigerador o dispensador de hielo.
☐ Filtrada – Jarra con filtro
☐ Filtrada – Filtro debajo del fregadero
☐ Filtrada – Filtro instalado en el grifo
☐ Filtrada – Filtro para toda la casa
☐ Otra (Especifique) _____

3. ¿Cuál es la fuente principal de agua para cocinar en su hogar?

☐ Agua sin filtrar del grifo ☐ Embotellada
☐ Filtrada – Del refrigerador o dispensador de hielo.
☐ Filtrada – Jarra con filtro
☐ Filtrada – Filtro debajo del fregadero
☐ Filtrada – Filtro instalado en el grifo
☐ Filtrada – Filtro para toda la casa
☐ Otra (Especifique) _____

4. Si tiene un sistema de filtro para el agua, ¿cuál es la marca y el número del modelo del filtro? (Escríbalos)

_____

5. ¿Usa o piensa usar agua filtrada o embotellada para preparar biberones?

☐ Sí ☐ No ☐ No aplica

6. ¿Qué preguntas o comentarios tiene sobre el programa piloto de filtros?

_____
_____

7. ¿Cómo podemos mejorar el programa piloto de filtros?

_____
_____

8. ¿Quiere mantenerse informado(a) sobre el programa piloto FLOW? Incluya su correo electrónico o número telefónico.

Correo electrónico: _____
Teléfono: _____

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DENVER WATER
PROGRAMA DE REDUCCIÓN DE PLOMO
1600 W 12TH AVE
DENVER CO 80204-9963

FILTER LEAD OUT OF WATER

Thank you for participating in Denver Water's FLOW Pilot. Your feedback will help us understand information about how water is used in your home for drinking and cooking activities and your preference for filters. Please use the filter pitcher provided and return your completed survey by mail or online by July 31, 2019. **As our way of thanking you for your feedback and using your filter, upon receipt of the completed survey, Denver Water will send you a $15 Amazon gift card. For an online survey go to denverwater.org/FLOW-survey or scan the QR code at the bottom of this survey.**

Please provide your email address or mailing address to receive your Amazon gift card. Email: _____

Mailing Address: _____

1. **Do you use your filter for drinking water?**
   ☐ Yes ☐ No
2. **Do you use your filter for water used for cooking?**
   ☐ Yes ☐ No
3. **Do you currently or do you plan in the future to use filtered or bottled water for infant formula?**
   ☐ Yes ☐ No ☐ NA
4. **If you do not primarily use the water filter provided, what issues are you experiencing? (Check all that apply)**
   ☐ Filter pitcher isn't large enough
   ☐ Filter pitcher doesn't fit in refrigerator
   ☐ The filter pitcher takes too much time to fill
   ☐ It's too much effort to use the filter pitcher
   ☐ I'm not interested in filtering my drinking water
   ☐ Other (specify) _____
   ☐ Not applicable (no issues)
5. **If the water filter provided does not meet your needs, would you be more likely to use an alternative filter? (Check one)**
   ☐ Faucet-mounted filter ☐ Refrigerator filter
   ☐ Larger pitcher filter ☐ Not applicable (the water filter meets my needs)
6. **Are you familiar with filter maintenance and cartridge replacement requirements? E.g., replacing the filter cartridge, cleaning the pitcher (if applicable)?**
   ☐ Yes ☐ No
7. **What questions or comments do you have about the filter pilot?**
   _____
   _____
8. **How could we improve the filter pilot?**
   _____
   _____
9. **Want to stay informed about the FLOW pilot? Provide your email or phone number.**
   Email: _____
   Phone: _____

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LEAD REDUCTION PROGRAM
1600 W 12TH AVE
DENVER CO 80204-9963

FILTRE EL PLOMO DEL AGUA

Gracias por participar en el programa piloto FLOW de Denver Water. Sus comentarios nos ayudarán a entender cómo usted usa el agua para beber y cocinar en su hogar, así como su preferencia en filtros. Por favor use la jarra para agua de que le hemos dejado y complete su encuesta por correo o por internet a más tardar el 31 de julio de 2019. **Una vez que recibamos su encuesta completa, como agradecimiento por sus comentarios y por usar el filtro, Denver Water le enviará una tarjeta de regalo de Amazon con un valor de $15. Para completar la encuesta en línea, visite denverwater.org/FLOW-survey o escaneé el código QR al final de la encuesta.**

Por favor escriba su correo electrónico o dirección de residencia para recibir una tarjeta de regalo de Amazon.

Correo electrónico: _____ **Dirección de residencia:** _____

1. ¿Usted filtra el agua que toma?

☐ Si ☐ No

2. ¿Usted filtra el agua que usa para cocinar?

☐ Si ☐ No

3. ¿Usa agua filtrada o embotellada para preparar biberones de sus niños (o piensa usarla en el futuro)?

☐ Si ☐ No ☐ No aplica

4. Si usted generalmente no usa agua filtrada, ¿qué problemas está experimentando? (Seleccione todos los que apliquen)

☐ La jarra con filtro no es lo suficientemente grande.
☐ La jarra con filtro no cabe en el refrigerador.
☐ La jarra con filtro se demora mucho en llenarse.
☐ Es mucho trabajo usar la jarra con filtro.
☐ No me interesa filtrar el agua que voy a tomar.
☐ Otra razón. Por favor especifique: _____
☐ No aplica (no tengo problemas)

5. ¿Si la jarra con filtro que le dimos no satisface sus necesidades, ¿sería más probable que usara otro tipo de filtro como alternativa? (Marque una)

☐ Filtro instalado en el grifo ☐ Filtro en el refrigerador
☐ Una jarra con filtro más grande
☐ No aplica (el filtro de agua cubre mis necesidades)

6. ¿Conoce los pasos necesarios para hacerle mantenimiento al filtro y para reemplazar el cartucho del filtro? Por ejemplo, ¿sabe cómo reemplazar el cartucho del filtro o limpiar la jarra (si aplica)?

☐ Si ☐ No

7. ¿Qué preguntas o comentarios tiene sobre el programa piloto de filtros?

_____
_____

8. ¿Cómo podemos mejorar el programa piloto de filtros?

_____
_____

9. ¿Quiere seguir recibiendo información sobre el programa piloto FLOW? Escriba su correo electrónico o número de teléfono.

Correo electrónico: _____
Teléfono: _____

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DENVER WATER
PROGRAMA DE REDUCCIÓN DE PLOMO
1600 W 12TH AVE
DENVER CO 80204-9963

DENVER WATER

Lime Green Shirt
Bright White Ink

2.5" Wide per email

v2

Imprint dimensions: 5"w x 5.04" H

Ink Color = White

DENVER WATER

For more information about our Lead Reduction Program, please visit denverwater.org/Lead.

Para obtener más información sobre nuestro programa de reducción de plomo, visite la página web denverwater.org/Lead.

lead@denverwater.org 303-893-2444

DENVER WATER

denverwater.org/Lead

lead@denverwater.org • 303-893-2444

APPENDIX H - FILTER DATA SUMMARY

DENVER WATER

FILTER LEAD OUT OF WATER INITIAL SURVEY											
Online or Paper Survey	Date	Language	* Do you know if you have a lead service line?	* What is your household's primary source of drinking water?	If other, please specify	* What is your household's primary source of water used for cooking?	If other, please specify	If you have an existing water filter system, what is the make and model number for your filter?	* Do you currently or do you plan in the future to use filtered or bottled wate for infant formula?	What questions or comments do you have about the filter pilot?	How could we improve the pilot?
Online	7/11/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet		no I do not	Not applicable	I really like the option of either being able to pour it in my glass or i can use the spigot.	
Online	7/11/2019	English	I do not know	Filtered- refrigerated water/ice dispenser		Unfiltered faucet		I don't know how to find this information	Not applicable		
Online	7/14/2019	English	Yes	Unfiltered faucet		Unfiltered faucet			Yes	I would like to know the steps being taking to fix the lead problem in our tap water so we do not need to use a filter.	It would be nice for low income Families to be able to get free filters considering these do not last very long and also giving free mineral drops since this filter takes all the necessary minerals out of our water for our health.
Online	7/17/2019	Español	I do not know	Unfiltered faucet		Unfiltered faucet			Yes		
Online	7/17/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet			Not applicable	Will replacement filters be provided, or offered on a subscription basis?	
Online	7/18/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet		Refrigerator - Whirlpool WRS571CIDM01	Not applicable	Should I be concerned?	I think this is very impressive!
Online	7/22/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet			Yes	I appreciate the filter and will use it	Info on how to test home water for lead
Online	7/23/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet		N/A	Not applicable		
Online	7/23/2019	English	I do not know	Filtered- pitcher filter		Unfiltered faucet			Not applicable	How expensive are the replacement filters? Where do I get the replacement filters? What exactly does the zero water filter out? Is a 148 test really bad?	More information about all of it would be nice.
Online	7/24/2019	Español	I do not know	Unfiltered faucet		Unfiltered faucet			Yes	This is a good program and thank you for caring for the citizens.	An announcement on the tv or radio would be helpful to let the citizens know about issues of lead in water.
Online	7/24/2019	Español	I do not know	Bottled water		Filtered - whole house filter			Not applicable	Very good program, will help the economy of this family, since weekly bottled water is bought.	
Online	7/25/2019	English	I do not know	Bottled water		Unfiltered faucet			Yes		
Online	7/25/2019	English	I do not know	Filtered- refrigerated water/ice dispenser		Unfiltered faucet			Not applicable		
Online	7/25/2019	English	Yes	Filtered- refrigerated water/ice dispenser		Filtered- refrigerated water/ice dispenser		GE refrigerator	Not applicable		
Online	7/25/2019	English	I do not know	Bottled water		Filtered- refrigerated water/ice dispenser		Samsung	Not applicable	no	
Online	7/29/2019	English	No	Unfiltered faucet		Unfiltered faucet		None	No		
Online	8/4/2019	Español	Yes	Filtered- pitcher filter		Filtered- pitcher filter		n/a	Not applicable	me gusta	no se
Paper	7/12/2019	English	I do not know	Bottled water		Unfiltered faucet			Yes		
Paper	7/12/2019	English	I do not know	Bottled water		Unfiltered faucet		N/A We have none	Not applicable	How long is this pilot for? And will we be notified if the proposed alternative to orthophosphate is used?	
Paper	7/13/2019	English	I do not know	Filtered - refrigerated water/ice dispenser		Unfiltered faucet		N/A	Not applicable	N/A	N/A
Paper	7/17/2019	English	Yes	Unfiltered faucet		Unfiltered faucet		None	Yes	Good idea	Maybe a filter for sink in kitchen
Paper	7/25/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet			Not applicable	How could I figure out if I have lead service line?	
Paper	7/25/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet		N/A	Yes	How long will you provide filters?	
Paper	7/25/2019	English	I do not know	Filtered - pitcher filter		Filtered - pitcher filter			Not applicable	Does my home have lead pipes?	
Paper	7/19/2019	English	I do not know	Filtered - refrigerated water/ice dispenser		Unfiltered faucet		Amana fridge	Not applicable	The water tastes great!	The lid is hard to remove and replace
Paper	7/17/2019	English	Yes	Filtered - under sink filter		Filtered - under sink filter		Culligan RC E2-4	Not applicable	I'm glad this is happening, but let's replace the service lines!	This is a good first step, but you should be specifically notifying everyone who has lead.
Paper	7/15/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet			Not applicable		Provide refill filters
Paper	7/15/2019	English	I do not know	Filtered - pitcher filter		Unfiltered faucet		Brita filter	No	If there is lead in my water, when will my pipes be replaced?	
Paper	7/15/2019	English	I do not know	Filtered - under sink filter		Filtered - under sink filter		General Electric water filtration system GXSL55F	Not applicable	None	Need to know how to get my water tested for lead. What about blood tests for residents of home?
Paper	7/15/2019	English	Yes	Filtered - pitcher filter		Unfiltered faucet		Pur	No	Where to get more when they run out?	Excellent already
Paper	7/15/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet		N/A	No	Do I need to send the filters back in?	
Paper	7/15/2019	Spanish	I do not know	Filtered - refrigerated water/ice dispenser		Unfiltered faucet			Yes	Cada cuando hay que cambiar el filtro de la jarra? (When do you have to change the filter?)	Avernos quisado si quisieramos a ver aseptado participado en el programa? (Do you want to see if we participate in the program?)
Paper	7/16/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet		N/A	Not applicable	Good idea to see if I do have lead in my drinking/cooking water	Not sure at this time - just received in mail. Began using it on 7/15/2019

FILTER LEAD OUT OF WATER INITIAL SURVEY											
Online or Paper Survey	Date	Language	* Do you know if you have a lead service line?	* What is your household's primary source of drinking water?	If other, please specify	* What is your household's primary source of water used for cooking?	If other, please specify	If you have an existing water filter system, what is the make and model number for your filter?	* Do you currently or do you plan in the future to use filtered or bottled wate for infant formula?	What questions or comments do you have about the filter pilot?	How could we improve the pilot?
Paper	7/23/2019	English	I do not know	Filtered - pitcher filter		Unfiltered faucet		Brita/Generic Target filter	Not applicable	Thank you! Water definitely tastes better.	
Paper	7/23/2019	English	Yes	Filtered - pitcher filter		Unfiltered faucet			Not applicable		
Paper	7/26/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet			Not applicable	Water tastes better/just started using. Plan on using for cooking also.	Smaller filter
Paper	7/22/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet		N/A	No	Do we continue to receive filters after the first 3 months?	
Paper	7/22/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet		N/A	No	How bad is the water I have been drinking for the past 3 years?	Provide more filters
Paper	7/22/2019	English	I do not know	Bottled water		Unfiltered faucet			Not applicable	None	
Paper	7/23/2019	English	I do not know	Bottled water		Unfiltered faucet		Fridge filter	Not applicable		
Paper	7/23/2019	English	I do not know	Bottled water		Unfiltered faucet		None	Yes		
Paper	7/23/2019	English	No	Bottled water		Bottled water			No		
Paper	7/23/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet		N/A	Not applicable	Is my water safe to drink?	
Paper	7/24/2019	English	I do not know	Filtered - pitcher filter		Unfiltered faucet		Brita pitcher	Not applicable		
Paper	7/23/2019	English	Yes	Unfiltered faucet		Unfiltered faucet			No	How long can we expect help from Denver Water?	Home faucet filtration system
Paper	7/23/2019	English	I do not know	Bottled water		Unfiltered faucet			Not applicable		
Paper	7/23/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet			Not applicable		
Paper	7/27/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet			Yes	None	Not sure if it could get any better
Paper	7/26/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet		N/A	Not applicable	None - product is great. I need to buy a bigger one.	Not sure. Mine was reading 188 before filter. After filter, it reads 000.
Paper	7/26/2019	English	Yes	Unfiltered faucet		Unfiltered faucet		N/A	Not applicable	None	
Paper	7/26/2019	English	I do not know	Bottled water		Filtered - faucet mounted filter		Don't have one	Not applicable		At this time I don't have one, only a water heater, thank you.
Paper	7/26/2019	English	I do not know	Filtered - faucet mounted filter		Filtered - faucet mounted filter		Pur Maxion	Not applicable	None. It's a good idea.	
Paper	7/26/2019	English	Yes	Bottled water		Unfiltered faucet			No	Don't know yet.	?
Paper	7/29/2019	English	Yes	Other	5 gallon jugs refilled at grocery store	Other	5 gallon jugs refilled at grocery store		Not applicable	How long will filters be provided?	We're excited about it! Would love to learn if/when service line replacement is part of pilot program.
Paper	7/29/2019	English	Yes	Bottled water		Unfiltered faucet		Clear2H2O	No		
Paper	7/29/2019	English	No	Bottled water		Unfiltered faucet		No	Yes	How often do we need to change cartridges/filters?	It is a small container/jar. Can I buy or get bigger size?
Paper	7/29/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet		NA			
Paper	7/30/2019	English	I do not know	Filtered - faucet mounted filter		Filtered - faucet mounted filter		RF-9999	Yes	Only contact via email…DO NOT KNOCK ON MY DOOR!	
Paper	7/30/2019	English	Yes	Bottled water		Unfiltered faucet		None	No		
Paper	7/31/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet		NA	Not applicable	Why is there standing water in the upper (feed) reservoir?	A faster flow from the push button would be nice.
Paper	8/1/2019	English	I do not know	Filtered - refrigerated water/ice dispenser		Filtered - whole house filter			Not applicable		
Paper	8/1/2019	English	I do not know	Filtered - pitcher filter		Unfiltered faucet		Brita pitcher	Not applicable	Are lead pipes required to be replaced?	
Paper	7/22/2019	English	I do not know	Bottled water		Unfiltered faucet		NA	Yes	In the event water is tested and lead is found, but the resident is unable to replace due to finances, what will Denver Water's action be?	
Paper	8/3/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet			No		
Paper	8/3/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet			Yes	Will it continue on past what filters were provided?	Nothing. I'm very thankful!
Paper	8/6/2019	English	I do not know	Filtered - pitcher filter		Unfiltered faucet		Brita - less than 1 yr old	Not applicable	Why? Am I living in Flint, MI?! Feels sketch!	Educate us on why we need this. *sorry - read enclosed info after
Paper	8/6/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet		N/A	Not applicable	How much will it cost?	More than 3 months - 6 months at least
Paper	8/6/2019	English	No	Unfiltered faucet		Unfiltered faucet		N/A	Not applicable	Just starting out, but water tastes much better and looks cleaner	Right now, I don't know
Paper	8/12/2019	English	I do not know	Unfiltered faucet		Unfiltered faucet			Not applicable		

FILTER LEAD OUT OF WATER USE SURVEY											
Online or Paper Survey	Date	Language	*Do you use your filter for drinking water?	*Do you use your filter for water used for cooking?	Do you currently or do you plan in the future to use filtered or bottled wate for infant formula?	If you do not primarily use the water filter provided, what issues are your experiencing?	If other, please specify	If the water filter provided does not meet your needs, would you be more likely to use an alternative filter?	Are you familiar with filter maintenance and cartridge replacement requirements? e.g., replacing the filter cartridge, clenaing the pitcher?	What questions or comments do you have about the filter pilot?	How could we improve the filter pilot?
Online	7/24/2019	English	Yes	Yes	Not applicable	Not applicable (no issues)			Yes	Great idea!	Would be nice if more people could be in the program. Would be nice if the water department had a system to replace the piping.
Online	7/24/2019	English	Yes	Yes	Not applicable			Not applicable (the water filter meets my needs)	No		
Online	7/24/2019	English	Yes	Yes	Not applicable	Filter pitcher isn't large enough		Faucet-mounted filter	No		
Online	7/24/2019	English	Yes	No	Yes	Not applicable (no issues)		Not applicable (the water filter meets my needs)	No		
Online	7/25/2019	English	Yes	Yes	Yes	The filter pitcher takes too much time to fill		Faucet-mounted filter	Yes		A faucet filter would be great to have!
Online	7/25/2019	English	Yes	No	Not applicable	Other	Doesnt pour smoothly, too bulky, and takes a while to fill up. It's great! But the tester is reading 000 also for my tap water so not sure if that tester is working right.	Not applicable (the water filter meets my needs)	Yes		
Online	7/26/2019	English	Yes	No	Yes	The filter pitcher takes too much time to fill		Faucet-mounted filter	Yes	Please fix water line. What can we do to make program go thru?	Water delivery service
Online	7/26/2019	English	Yes	No	Not applicable	Not applicable (no issues)		Faucet-mounted filter	Yes	No	Everything has been great!
Online	7/26/2019	English	Yes	Yes	Not applicable	Filter pitcher isn't large enough		Faucet-mounted filter	No	Looking at installing his own filter	
Online	7/26/2019	English	Yes	Yes	Not applicable	Filter pitcher isn't large enough		Faucet-mounted filter	Yes		
Online	7/26/2019	English	Yes	No	No	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes	My water tastes better. Having a hard time working the reader, it isnt showing all 0's	
Online	7/27/2019	English	Yes	No	Not applicable	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes	Thanks for the pitcher, it's bigger than the one we had purchased ourselves	
Online	7/27/2019	English	Yes	No	Yes	The filter pitcher takes too much time to fill		Faucet-mounted filter	Yes	Having this filter pitcher you provided has made me more conscious of my water at home	A faucet mounted one would more useful for cooking purposes. But I like the pitcher for cold fridge water
Online	7/27/2019	English	Yes	No	Not applicable	Other	Too much effort to refil and use for cooking water	Faucet-mounted filter	Yes	A smaller pitcher for fridge would be helpful faucet filter might be preferable if it works with our current faucet	
Online	7/28/2019	English	Yes	Yes	No			Larger pitcher filter		Thank you for the filter I like it it really work and it help me out a lot	
Online	7/30/2019	English	Yes	Yes	Not applicable	Not applicable (no issues)		Faucet-mounted filter	No		Keep people informed on when our service line will be replaced. How can low-income households qualify to get these replaced sooner?
Online	7/30/2019	English	Yes	Yes	Not applicable	The filter pitcher takes too much time to fill		Faucet-mounted filter	Yes		It is unsettling to get this water filter and not to know what the quality of the water is. I work for a similar program with Aurora. I wish the initial materials had told us that our water is good but that our pipes may not be. Was left wondering how much at risk I am.
Online	7/30/2019	English	No	No	Not applicable	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes		
Online	7/31/2019	Español	No	No	Not applicable	Other	Didn't know what it was for, do buy bottled water for drinking	Refrigerator filter	No	Not sure, need to give it a try // Where do we get the filters?	For it to have a sign on it making it clear it was not sent in error - thought it was a mistake and meant for the neighbors or something
Online	7/31/2019	English	Yes	Yes	No	Not applicable (no issues)		Faucet-mounted filter	Yes		Water taste
Online	7/31/2019	English	Yes	Yes	Yes	Filter pitcher doesn't fit in refrigerator		Faucet-mounted filter	Yes		
Online	8/1/2019	English	Yes	Yes	Not applicable	The filter pitcher takes too much time to fill		Faucet-mounted filter	Yes		Sometimes the top lid falls off of the filter
Online	8/7/2019	English	Yes	Yes	No	Not applicable (no issues)		Faucet-mounted filter	Yes		
Online	8/7/2019	English	Yes	No	Not applicable	The filter pitcher takes too much time to fill		Faucet-mounted filter	Yes	Is the filter taking out any helpful minerals from our water?	
Online	8/12/2019	English	Yes	No	Yes	Other	Having a hard time pouring it out	Faucet-mounted filter	Yes	Pretty good size pitcher, and its helping us buy less bottled water	
Paper	7/23/2019	English	Yes	Yes	Yes	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes	Thankful, awesome program. Do it to other houses.	N/A
Paper	7/27/2019	English	Yes	Yes	NA	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes	N/A	N/A
Paper	7/27/2019	English	Yes	No	NA	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes	No	N/A
Paper	7/27/2019	English	Yes	Yes	NA	Not applicable (no issues)		Faucet-mounted filter	Yes		
Paper	7/27/2019	English	Yes	Yes	Yes	Not applicable (no issues)		Larger pitcher filter	Yes		
Paper	7/27/2019	English	Yes	No	Yes	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes		
Paper	7/27/2019	English	Yes	Yes	Yes	Filter Pitcher isn't large enough. The filter pitcher takes too much time to fill		Larger pitcher filter	No		Bigger pitcher/faster fill up
Paper	7/27/2019	English	Yes	Yes	NA	Filter Pitcher isn't large enough		Faucet-mounted filter	Yes	Nothing, thank you	Provide faucet filters for everyday use
Paper	7/27/2019	English	Yes	Yes	No	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes	Water tastes better	N/A
Paper	7/27/2019	English	Yes	Yes	Yes	The filter pitcher takes too much time to fill		Faucet-mounted filter	Yes	Want more info on lead	N/A
Paper	7/28/2019	English	Yes	No	No	The filter pitcher isn't large enough. The filter pitcher takes too much time to fill.		Faucet-mounted filter	Yes	Difficult for cooking	Faucet-mounted
Paper	7/28/2019	English	Yes	No	Yes	Filter pitcher doesn't fit in refrigerator			Yes	Use bottled water	Don't know
Paper	7/28/2019	English	No	No	Yes	Other	Taste is flat	Faucet-mounted filter	Yes	I'd like to know how much lead is in my pipes	
Paper	7/28/2019	English	Yes	Yes	No	Not applicable (no issues)		Refrigerator filter	Yes		
Paper	7/28/2019	English	Yes	No	Yes	Filter pitcher isn't large enough. Other	A lot of grandkids	Larger pitcher filter	Yes	Connect to faucet. Love the taste	
Paper	7/25/2019	English	Yes	Yes	NA	The filter pitcher takes too much time to fill		Faucet-mounted filter. Larger pitcher filter	Yes	The filters are expensive	
Paper	7/25/2019	Spanish	No	No	Yes	Filter pitcher doesn't fit in refrigerator. It's too much effort to use the filter pitcher. Other	I am 68 years old and with arthritis in my hands. It is very difficult to pour the water from the pitcher, but I really like filtered water.	Faucet-mounted filter	Yes	I think it is very good	I might like other types of filters, such as an under-sink filter
Paper	7/28/2019	English	Yes	Yes	NA	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes	None	N/A
Paper	7/29/2019	English	Yes	No	NA	Filter Pitcher isn't large enough. The filter pitcher takes too much time to fill		Faucet-mounted. Not applicable (the water filter meets my needs)	Yes	I use it. Nice gift	
Paper	7/29/2019	English	Yes	No	NA	Not applicable (no issues)		Faucet-mounted filter. Larger pitcher filter	No	Thank you!	Send more than one pitcher
Paper	7/30/2019	English	Yes	No	NA	Not applicable (no issues)		Faucet-mounted filter	Yes	Faucet-mounted filter would be great!	
Paper	7/30/2019	English	Yes	Yes	NA	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes	No. Thanks.	N/A
Paper	7/30/2019	English	Yes	Yes	Yes	Not applicable (no issues)		Faucet-mounted filter	Yes		
Paper	7/30/2019	English	No	No	NA	Not applicable (no issues)		Faucet-mounted filter	Yes		
Paper	7/27/2019	English	Yes	Yes	NA	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes		
Paper	7/27/2019	English	No	Yes	No	Filter pitcher isn't large enough. Not applicable (no issues)		Faucet-mounted filter	No	N/A	N/A
Paper	7/31/2019	English	Yes	Yes	NA			Faucet-mounted filter	Yes	None so far	I'm unsure
Paper	7/26/2019	English	Yes	Yes	Yes	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes	None	None
Paper	7/26/2019	English	Yes	Yes	NA	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes		
Paper	7/26/2019	English	Yes	No	NA	Filter pitcher isn't large enough		Faucet-mounted filter	Yes	More info on how to change the lead pipes would help	I do think more people in the house would use a faucet filter
Paper	7/26/2019	Spanish	Yes	Yes	Yes	Not applicable (no issues)		Refrigerator filter	Yes	No questions or comments	By keeping clean
Paper	7/26/2019	Spanish	Yes	Yes	NA						
Paper	7/25/2019	English	Yes	Yes	NA	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes	Will Denver Water continue to provide filters?	Provide the filters
Paper	7/27/2019	Spanish	Yes	Yes	NA	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes	It's good	With a faucet-mount filter
Paper	7/29/2019	English	Yes	Yes	No	Not applicable (no issues)		Larger pitcher filter	Yes	I think it works great! I have used others, and this is great!	
Paper	7/29/2019	English	Yes	Yes	NA	Filter pitcher isn't large enough		Larger pitcher filter. Refrigerator filter	Yes	Happy to learn about it/enroll, as we've been filtering on our own for years.	Offer options for financial assistance to replace service line.

FILTER LEAD OUT OF WATER USE SURVEY											
Online or Paper Survey	Date	Language	*Do you use your filter for drinking water?	*Do you use your filter for water used for cooking?	Do you currently or do you plan in the future to use filtered or bottled wate for infant formula?	If you do not primarily use the water filter provided, what issues are your experiencing?	If other, please specify	If the water filter provided does not meet your needs, would you be more likely to use an alternative filter?	Are you familiar with filter maintenance and cartridge replacement requirements? e.g., replacing the filter cartridge, clenaing the pitcher?	What questions or comments do you have about the filter pilot?	How could we improve the filter pilot?
Paper	7/29/2019	English	Yes	Yes	No	Filter pitcher isn't large enough		Larger pitcher filter. Faucet-mounted filter	Yes		
Paper	7/29/2019	Spanish	Yes	Yes	NA	Filter pitcher isn't large enough		Not applicable (the water filter meets my needs)	Yes	I can store containers with filtered water in my refrigerator	Mandar stickers y pegarlos con nombramientos de agua segura.
Paper	7/29/2019	English	Yes	Yes	NA	Filter pitcher doesn't fit in refrigerator. The filter pitcher takes too much time to fill		Faucet-mounted filter	Yes	The ZeroWater filter is good quality, but doesn't make enough water at a time.	An easier to use/more efficient filter or just helping us fix our pipes.
Paper	7/29/2019	English	Yes	Yes	NA	Filter Pitcher isn't large enough. The filter pitcher takes too much time to fill. It's too much effort to use the filter pitcher. It's too much effort to use the filter pitcher		Refrigerator filter	Yes	My water doesn't get to the "below 6" reading with the filter	Unsure of process. Will we get more filters?
Paper	7/29/2019	Spanish	No	No	NA	Not applicable (no issues)		Not applicable (the water filter meets my needs)	No	It's good for the health	Let the program continue.
Paper	7/29/2019	English	Yes	No	NA	The filter pitcher takes too much time to fill. It's too much effort to use the filter pitcher.		Refrigerator filter	Yes	None	It fine
Paper	7/31/2019	English	Yes	Yes	NA	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes	No	I am very happy with this item
Paper	8/1/2019	Spanish	Yes	Yes	NA	Filter pitcher isn't large enough. Filter pitcher doesn't fit in refrigerator		Larger pitcher filter	No	How often do I change the filter?	
Paper	7/30/2019	Spanish	Yes	Yes	No	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes		
Paper	7/30/2019	Spanish	Yes	No	Yes	Filter pitcher isn't large enough. Filter pitcher doesn't fit in refrigerator. The filter pitcher takes too much time to fill		Faucet-mounted filter. Refrigerator filter. Larger pitcher filter	Yes	We have always felt Denver had good water - why now we need filter?	Shape is odd and have to refill too often, lid hard to grab.
Paper	8/2/2019	English	Yes	Yes	NA	Filter pitcher isn't large enough. Other	Freezes	Faucet-mounted filter	Yes		
Paper	8/2/2019	English	Yes	No	NA	Not applicable (no issues)		Faucet-mounted filter	yes	N/A	N/A
Paper	8/6/2019	English	Yes	No	NA	Not applicable (no issues)		Not applicable (the water filter meets my needs)	Yes	N/A	N/A
Paper	8/8/2019	English	Yes	No	NA				Yes	None - just trying out	N/A
Paper	8/12/2019	English	Yes	Yes	NA	Filter pitcher isn't large enough. The filter pitcher takes too much time to fill. Other.	Spigot dispensing H2O is very slow	Larger pitcher filter	No	Do I have to buy filters? Do I foot the bill for replacement filters? How do I get them? How often should I test filtered H2O?	Include info about filters. I don't like the solid waste component of the filters. Recyclable?
Paper	8/12/2019	English	Yes	Yes	NA	Not applicable (no issues). Other.	Would be easier to use tap	Faucet-mounted filter	Yes		It's good. Thank you.
Paper	8/12/2019	English	Yes	Yes	NA	Not applicable (no issues)		Not applicable (no issues)	Yes		
Paper	8/12/2019	English	Yes	Yes	NA	Not applicable (no issues)		Not applicable (no issues)	Yes	I like it better than a Brita brand I had used prior.	Curious what happens in three months? Filters available?

APPENDIX III.C.3 - FILTER PROGRAM PLAN

September 2019

DENVER WATER

MOTT MACDONALD

TECHNICAL MEMORANDUM

To Denver Water
From Mott MacDonald
Date August 13, 2019
Project No. 507100139
Page Page 1 of 21
Subject Denver Water Lead Reduction Program (LRP)
Appendix III.C.3 Filter Program Plan

I. PURPOSE

The purpose of this Technical Memorandum (TM) is to summarize the framework for Denver Water's full-scale Filter Lead Out of Water (FLOW) Program, which targets properties with known, suspected, and possible lead service lines. The FLOW Program includes the distribution of filters to the target Denver Water households, on-going outreach / education to engage Denver Water households to filter their water for infant formula, drinking, and cooking and filter / filter cartridge replacement management. The basis for this TM is threefold:

1. Summarize the series for full-scale FLOW Program implementation.
2. Describe the methodology used to obtain confirmation of filter adoption by targeted Denver Water households for infant formula, drinking, and cooking:
   - **Adoption** = Additional reduction of lead through the use of a certified filter or use of an alternative source of lead-free water (i.e. bottled water).
   - **Non-Adoption** = Customer uses tap water.
3. Document how Denver Water will strive for 100% Filter Adoption over 15-years through use of the communications, outreach and education (COE) plan.

Denver Water's service line inventory dated August 8, 2019 includes:

- 319,700 service lines used for drinking water in the Denver Water service area.
- 84,546 service lines identified as known, suspected and possible lead service lines – these premises are candidates for FLOW.

Multi-family properties are included in the 84,546 service lines that are part of the filter program. A multi-family property has multiple household units. A household unit is an individual residence that receives a filter. Using available data, it is estimated that Filter Program participants consist of 119,250 Denver Water household units, with each household unit receiving a filter.

Presented herein is the background, filter distribution methods, customer notifications, filter kit materials, follow-up/survey information, filter use adoption validation basis, schedule, and reporting metrics.

II. BACKGROUND

General

Denver Water serves high-quality drinking water to approximately 1.4 million people and continuously monitors water quality. Drinking water entering the distribution system prior to the connection to the customer's service line is free of lead. However, lead may leach into the drinking water as it stagnates in the customer-owned lead service line and/or premise plumbing.

Denver Water is committed to taking steps to optimize its water system for control of lead by implementing a Lead Reduction Program (LRP). One element of Denver Water's LRP is the FLOW Program, which includes the distribution of filters certified to remove lead by NSF to approximately 119,250 Denver Water household units (84,546 service lines) with known, suspected, and possible lead service lines. Filters are used as the interim treatment barrier to remove lead from Denver Water households' drinking water until the lead service line is replaced. The filter provides a reliable barrier for dissolved and particulate lead. A Denver Water household will be removed from FLOW Program either six months after replacement of the lead service line or if a non-lead service line is confirmed at the property.

Denver Water is considering providing filters over 15 years as Denver Water progresses through the inventory of lead service line properties and replaces lead service lines. Denver Water will strive for 100% filter adoption to reduce lead exposure for all customers with a known, suspected, or possible lead service. Denver Water households not using a filter certified to remove lead by NSF will receive the benefit of a 40% to 65% reduction in lead levels from improved pH/alkalinity adjustment only. In addition to the pH/alkalinity adjustment, Denver Water households using a filter certified to remove lead by NSF will experience a >97% reduction in lead levels.

Upon LRP approval, it is expected that implementation of FLOW Program will commence immediately, following the multi-media public information campaign and customer notification model in accordance with the COE Plan. The success of the COE and FLOW Program is paramount to provide Denver Water with information and also to share information with Denver Water households that does as much as possible to encourage filter use and education. If the variance is not granted, filters will be distributed per Denver Water's current practices.

FLOW Program Participants

As presented earlier, FLOW participants consist of 119,250 Denver Water household units. The LSI map will be divided into 12 areas (approximately 10,000 filters per area) for use with distribution of the filters and communications within geographic areas.

The FLOW Program includes the distribution of filters to approximately 119,250 Denver Water household units by March 20, 2020 and the collection of follow-up surveys regarding adoption from a minimum of 1,059 randomly selected Denver Water households on an annual basis.

Filter Type

As part of Denver Water's current practice, a water pitcher filter is distributed to a Denver Water household:

- after the replacement of their lead service line, with five (5) months of replacement cartridges; or
- after potholing reveals a lead service line, with five (5) months of replacement cartridges.

Currently, Denver Water distributes a ZeroWater pitcher filter with the following features:

1. 10-cup capacity
2. NSF certified to remove lead
3. 5-stage filter with ion exchange that removes 99.6% of detectable dissolved solids, including lead and fluoride
4. filter cartridges replaced based upon average use (approximately 30-days for a Denver Water household household)

In addition to pitcher filters, other filters certified to remove lead by NSF include: filters attached to the kitchen faucet and refrigerators filters. Denver Water will purchase filters from multiple vendors that are NSF certified to remove lead and do not remove fluoride. A summary of available pitcher filters and available alternative filter types and replacement cartridges is included in Appendix A.

ZeroWater pitchers remove fluoride through ion exchange. Other filter types do not remove fluoride. Denver Water will distribute pitcher filters for FLOW that will remove nearly all the lead, but leave other important minerals, like fluoride.

Filter Kit

Each participant of the FLOW Program will receive a kit with the pitcher filter, a 6 month supply of filter cartridges, and education/outreach material. Details on the filter kit (education / outreach documents, pitcher filter and cartridge manufacturer instructions, packaging, and other contents) are included in Appendix B.

Filter Distribution

Denver Water households will be automatically enrolled and provided with a filter and replacement cartridges, based on the following three factors:

1. A known, suspected, or possible lead service line and included in the LSI.
2. Demographics for occupants at the property
3. Until the service line is confirmed to be non-lead or 6 months after a lead service line is replaced.

Denver Water will work closely with Distributors to determine if the notification/enrollment letter, filters, replacement cartridges, and COE will be provided directly by Denver Water or in collaboration with the appropriate Distributor.

The distribution of filters and replacement cartridges in the FLOW Program will be documented and tracked during the life of the LRP using an electronic database and GIS. The filters will be distributed to customers prior to implementation of the pH and alkalinity adjustment using various methods as follows:

PRIMARY (90%)

- Direct mail by Denver Water and/or distributor with delivery confirmation

SECONDARY (10%)

- Hand delivery by Denver Water or contractor via door-to-door canvasing
  - In-person transaction
  - Drop-off

EXCEPTIONS - DENVER WATER HOUSEHOLD PREFERENCE ONLY

- Pickup
  - Denver Water facility
  - Mobile unit
  - Community meetings / events
  - Other

Filter Cartridge Replacements

Replacement filter cartridges will be distributed to Denver Water households using the various methods identified for distribution of pitcher filters. It is estimated that approximately 690,000 pitcher and alternative filters and 2.8 million replacement cartridges will be distributed over the life of the FLOW Program (15-years), if only pitcher filters are implemented. As the LRP progresses, Denver Water will investigate the use of other filter types to promote filter adoption.

Filter Cartridge Waste Reduction

Some manufacturers provide solutions to mitigate waste created by lifetime filter cartridge replacements as follows:

1. The typical Brita pitcher filter life is 6 months. Brita recycles filter cartridges using Terracycle (https://www.terracycle.com/en-US/) using the following process:

   a. Brita cartridges are dried for a minimum of 3 days.
   b. Approximately 5 pounds of Brita cartridges are packaged for return to Terracycle.
   c. Shipping labels are printed from Brita's website with postage paid by Brita.
   d. The Brita cartridges are mailed to Terracyle for recycling.

   Brita's recycling system may be utilized by an individual Denver Water household or by Denver Water using cartridge drop-off locations placed throughout the city.

2. The typical DuPont pitcher filter life is 3 months. DuPont uses reusable cartridge housings:

a. The initial pitcher filter cartridge is a plastic housing for the media (carbon block).
b. Carbon blocks are provided separate from the plastic housing by DuPont.
c. Carbon blocks are placed into the plastic cartridge housing.
d. Used carbon blocks are removed from the cartridge housing, by the Denver Water household, following manufacturer's recommended safety precautions.
e. Plastic cartridge housings are replaced periodically when the housing has reached its service life (approximately 8 years).

Sustainable solutions will be investigated further during implementation and over the life of the FLOW Program.

Alternative Filters

Alternative filters (filters attached to the kitchen faucet and refrigerators filters) will be utilized throughout the FLOW Program, as the cartridges have a longer filter life, generally three to 10 months, providing a more sustainable approach for the 15-year lead service line replacement and filter plan. Alternative filters may require less maintenance, less involvement from FLOW Program staff, and may increase ease of use by Denver Water households, which may encourage filter adoption. They will be distributed to Denver Water households who have requested an alternative filter. Although typically a higher capital cost than a pitcher filter, alternative filters often have longer filter life and ease of use for infant formula, drinking, and cooking. Lessons learned from the FLOW Pilot regarding alternative filters will be implemented into the full-scale FLOW Program, as applicable. Alternative filters options are shown in Appendix A.

Alternative filters will be distributed to Denver Water households using the various methods identified for distribution of pitcher filters. It is anticipated that a portion of the alternative filters will require inspection and/or installation by Denver Water staff and/or contractors to assure correct installation.

It is anticipated that up to approximately 20% of the customers may request an alternative filter.

Customers will be provided with options for filter use and replacements as shown in Table III.C.3-1.

Table III.C.3-1 Alternative Filter Use and Replacement Options

Option	Replacements Provided
• One Pitcher Filter	Replacement pitchers after 8 years and cartridges
• Two Pitcher Filters	Replacement pitchers and cartridges
• Kitchen Faucet Filter	Replacement faucet filter and cartridges
• Refrigerator Filter	Replacement cartridges
• Refrigerator Filter and One Pitcher Filter	Replacement pitchers and cartridges

Replacement Filter Housing

It is anticipated that a typical pitcher filter will be usable for approximately eight years. Denver Water households will receive a replacement and/or additional pitcher filter and replacement cartridges as shown in Table III.C.3-2.

Table III.C.3-2 Replacement Pitcher Filter and Cartridge Distribution

Request Type	Identifier
Additional pitcher to supplement the initial pitcher to reinforce filter use	Denver Water household
Damaged and/or lost pitcher filters	Denver Water household
New homeowners and long-term rental property turnover	Denver Water billing changes, rental property owners, and management companies
Short term rental property (Air BnB, VRBO, etc.)	Rental property owners and management companies
Participant in the FLOW Program for eight years (replacement of filter pitcher in 8th year)	FLOW Program database

Notification Methods

Notification methods for the FLOW Program include:

- Direct mail and door-to-door delivery of filter kits (Appendix B) with a letter to the customer, detailed instructions regarding the FLOW Program, water filter cartridge use and replacement, survey/response form (multi language), a quick

response (QR) code for access to Denver Water's digital registration page (in lieu of mail in survey/response), and other related details. The material will be available on Denver Water's website (www.denverwater.org/lead).

- Door-to-door canvassing of neighborhoods campaigns
- Neighborhood meetings and additional strategic community outreach opportunities.
- Robocalls to impacted Denver Water households.
- Follow-up communication using mail, email, phone, and door to door survey.

Denver Water households that are confirmed as non-lead service lines that request a pitcher filter will receive educational materials regarding the FLOW Program and a water quality sample kit for assuring the Denver Water household that they are not required to filter their water, but may do so at their own expense.

In addition, water quality sampling and community outreach and education materials will be provided to customers not in the FLOW Program, as requested.

Survey

There are five categories of surveys to help gather information from FLOW Program participants about how filters are used for infant formula, drinking, and cooking activities. The surveys will be similar to the surveys used during the FLOW Pilot but will be revised as necessary during implementation of the FLOW Program to incorporate lessons learned.

- **Initial Survey:** The intent of this survey is to obtain initial feedback from the Denver Water household. This survey is included in the hand-delivered and mailed filter kits.
- **Use Survey:** The use survey will be sent to FLOW Program participants a few weeks after they have received their filter kit. The intent of this survey is to confirm if a Denver Water household is using the filter for infant formula, drinking, and cooking. This survey also includes an option for participants to elect for an alternative filter.
- **Adoption Survey:** Once a year, the adoption survey will be sent to approximately 1,250 random customers to generate the minimum 1,059 responses. Denver Water will use internal resources and community outreach services to enhance survey response rates. This survey will have the following three questions:
    - Do you use your filter or bottled water for drinking water? Yes/No
    - Do you use your filter or bottled water for water used in cooking? Yes/No
    - Do you use your filter or bottled water for infant formula preparation? Yes/No/Not Applicable (no infants)

  This survey question will be used for metrics to determine filter adoption. From June until December each year, follow-up calls and emails may be used in order

to achieve the 1,059 responses. In January, the adoption survey results will be submitted to CDPHE and EPA.

- **Alternative Survey:** Once a Denver Water household has an alternative filter installed, the alternative survey is sent to provide feedback on whether the FLOW Program participant is using their alternative filter for infant formula, drinking, and cooking.
- **Ongoing Surveys:** Twice a year, during the 15-year FLOW Program, ongoing surveys will be used to confirm if the Denver Water household is continuing to use the filter for infant formula, drinking, and cooking. This survey will also provide options for Denver Water households to opt for alternative filters and will obtain feedback of the COE and the FLOW Program.

The intent of the survey is to obtain confirmation of the primary water source used by FLOW Program participants for infant formula, drinking, and cooking:

- **Adoption** = Additional reduction of lead through the use of a certified filter or use of an alternative source of lead-free water (i.e. bottled water).
- **Non-Adoption** = Customer uses tap water.

Filter use data will be gathered using questions such as these and as included in Appendix C:

What is your household's primary source of drinking water? (Check one)

- ☐ Unfiltered Faucet
- ☐ Bottled water
- ☐ Filtered - refrigerated water/ice dispenser
- ☐ Filtered - pitcher filter
- ☐ Filtered - under sink filter
- ☐ Filtered - faucet-mounted filter
- ☐ Filtered - whole house filter
- ☐ Other (specify)

What is your household's primary source of water for cooking? (Check one)

- ☐ Unfiltered Faucet
- ☐ Bottled water
- ☐ Filtered - refrigerated water/ice dispenser
- ☐ Filtered - pitcher filter
- ☐ Filtered - under sink filter
- ☐ Filtered - faucet-mounted filter
- ☐ Filtered - whole house filter
- ☐ Other (specify)

What is your household's primary source of water for infant formula preparation? (Check one)

- ☐ Not Applicable (no infants)
- ☐ Unfiltered Faucet
- ☐ Bottled water
- ☐ Filtered - refrigerated water/ice dispenser
- ☐ Filtered - pitcher filter
- ☐ Filtered - under sink filter
- ☐ Filtered - faucet-mounted filter
- ☐ Filtered - whole house filter
- ☐ Other (specify)

Once a year in May, for return by July, a survey (the adoption survey) of a minimum of 1,059 randomly selected participants (Appendix C.III.1) will be undertaken to measure adoption rates (with at least a 95% confidence and no more than 5% error) and to determine reasons for non-adoption. Denver Water will use program resources, internal resources, and community outreach services to enhance survey response rates. From June until December each year, follow-up calls and emails will be used in order to achieve the 1,059 responses. In January, the adoption survey results will be submitted to CDPHE and EPA. More than 1,059 surveys may be sent out in order to achieve the minimum responses. Additional surveys of random customers may be issued between June and December to obtain the necessary minimum responses to support the adoption rate. The survey will evolve over time, as more is learned throughout the process of the FLOW Program.

The adoption survey will be random and proportional to the population of the total service area, in order to achieve a statistically sufficient number of responses for the area. Additional random surveys will be conducted of sub-areas to determine demographics but will not be considered as part of the annual adoption survey metrics.

For all surveys, Denver Water will provide an online survey option that is mobile friendly (Snap Survey).

For customers that either do not respond to the adoption survey or communicate that the filter was not used, Denver Water may follow-up with a phone-call, an email, or an in-person visit to provide additional education on methods to reduce lead exposure; determine whether or not an alternative lead reduction strategy is used; and to ultimately encourage the use of the filter.

Additionally, a survey of each customer will be provided during the Accelerated Lead Service Line Replacement (ALSLR) Program (approximately 4,267 surveyed based on the number of completed lead service line replacements each year). The results of the ongoing surveys will be evaluated and used to confirm adoption rates and make improvements to the Filter and COE Programs (learn-by-doing).

The FLOW Program will be adjusted based upon survey results and additional feedback acquired during public outreach and education. Specifically, "Adaptive Management" techniques will be implemented to adjust the COE to target and follow-up with specific sub-groups. The ALSLR Program may be advanced for a specific subgroup if it is determined that they are not participating in FLOW.

Vulnerable Populations

Vulnerable populations; such as pregnant women, children, and those of low socioeconomic standing; will be identified, contacted, and tracked using the following methods:

- Lead Service Inventory (LSI) - The lead service inventory will incorporate factors, such as proximity to schools, daycares, preschools, independent data sources, etc. to assist with the identification of vulnerable populations
- COE – Outreach to specific groups will be completed using focused community outreach, meetings, and individual interaction with Denver Water households using the tactics noted in Appendix III.A Communications, Outreach and Education Plan.
- Survey Questions - The survey questions will help identify expecting families, families with infants, and families of low socioeconomic standing.

The data above will be incorporated into the LSI for use with the predictive modelling effort (see LRP Plan Appendix III.B.3 Prediction Model and Prioritization), which will be used to prioritize and target filter distribution and annual ALSLR locations.

Filter Adoption

Filter adoption is defined as the following action by the customer to reduce lead in their infant formula, drinking, and cooking water by:

- Using and maintaining filters properly, as well as clean and/or replace the filter and cartridges at the appropriate time.

  or

- Using an alternative source of lead-free water (i.e. bottled water).

Filter adoption is assumed based on FLOW Program participant's responses to the adoption survey questions.

Based on a 2017 customer survey (1,432 responses) by Denver Water, the majority of customers reported that their household typically drink unfiltered tap water as shown by the survey results:

- 37% of customers use filters (type of filter and standard unknown)
- Less than one in ten customers reported that their household drinks bottled water regularly
- 54% of customers reported drinking unfiltered tap water

At a minimum, Denver Water must achieve filter adoption rates for customers with known, suspected, or possible lead service lines to at least 65% to provide equivalent protection to orthophosphate treatment.

Adoption Calculations

In order to achieve a minimum 65% filter adoption rate; 688 responses of 1,059 adoption surveys participants must indicate that the filters are being used for infant formula, drinking, and cooking. A failure of either of the adoption survey questions is considered a failure.

Minimum Survey Responses and Adoption:

- $Minimum\ 65\%\ Adoption: 1{,}059\ FLOW\ Survey\ Responses\ x\ 65\% = 688\ yes\ responses\ (for\ both\ drinking\ and\ cooking)$

Filter adoption rates will be tracked and data collected will be included in the annual adoption submittal to support filter adoption metrics. Filter adoption assumes customers are using and maintaining the filter properly, as well as replacing the filter cartridges at the appropriate time.

Denver Water will work with the LRP Leadership Committee to identify and implement additional outreach efforts directed at improving the adoption rate before the annual reporting date if the overall filter adoption rate is less than 65% by the end of year one. Failure to correct the non-adoption rate will trigger actions in accordance with the multi-tiered response plan.

Multi-Tiered Response Plan

If a customer chooses not to enroll in the FLOW Program and it cannot be determined if an alternative filter or drinking water supply is used, or does not employ a filter, the protocol that Denver Water may follow includes the following steps:

- Confirm materials of construction, pothole the property (if the service line material is suspected or unknown) and attempt to understand the materials used in premise plumbing (via visual inspection if allowed by the customer).
- Offer water quality sampling to quantify the magnitude of lead release, if not previously sampled.
- Interview the Denver Water households to determine whether or not an alternative means to reduce lead exposure is employed such as an existing filter system (confirmed NSF certified to remove lead) or if the Denver Water households rely on bottled water for infant formula, drinking, and cooking.
- Make two additional attempts to encourage the customer to use a filter, based on site specific information for materials of construction and the water quality sampling results.
- If the customer continues to choose to not filter (or opts out of the FLOW Program), the property will be placed on a Filter Non-Adoption List.

- Revisit on an annual basis to deliver additional education material and deliver a pitcher filter, replacement cartridges, and a water quality sampling kit.
- Regularly provide lead education with billing to encourage filter use until the lead service line is replaced or confirmed non-lead.
- Notify local health department at a frequency of every 6 months and request assistance by the local health department.
- Denver Water household contacted by the local health department and Denver Water coordination of next steps with the local health department.

Lessons Learned

Other entities have distributed filters to customers for lead and non-lead programs. The lessons learned from distribution of filters for other entities are shown in Table III.C.3-3.

Table III.C.3-3 Lessons Learned in Other Jurisdictions

Item No.	Description
1	Directions for filter use must be clear to ensure proper use of filters.
2	Reach out to Denver Water households through various methods: phone calls, emails, door-to-door, website videos, tables at community events, local TV stations, etc.
3	Impersonators may be an issue. Make sure all staff have ID badges and outreach material spells out what Denver Water households can expect from Denver Water staff.
4	Many man hours are needed for door-to-door delivery of pitchers.
5	Be prepared to field questions of why certain citizens are included in the filter program, and others are not. Make sure the criteria are clear and there is consensus on who is in the filter program and who may be added, as more information is gathered.

Lessons learned from the FLOW Pilot that will be implemented into the full-scale FLOW Program are shown in Table III.C.3-4.

Table III.C.3-4 Lessons Learned From the Filter Pilot Program

Item No.	Description
1	Provide advance targeted communications, outreach and education prior to filter distribution to introduce the program and explain the importance of filter use.
2	Reinforce the importance of using the filter for cooking and infant formula preparation (in addition to drinking water).
3	Inform participants the filters and replacement cartridges are provided at no cost to the customer for the duration of the program.
4	Provide alternative filters such as refrigerator, larger pitchers, and faucet mount.

Item No.	Description
5	Provide additional Spanish-speaking staff for field crews for initial distribution and follow-up visits.
6	Have one adoption survey after the participants have been contacted, are aware of the program, and have been using the filter for period of time.
7	Send filters addressed to tenants, not owners of the homes, if renters reside in the household.
8	Print individual participant's survey access codes directly on their survey in order to easily track the participant's responses.
9	Make survey questions clear, so that each answer doesn't have more than one meaning.
10	Have more outreach materials educating customers about how the service line is owned by the homeowner and how they can request a lead test kit.
11	Simplify outreach materials.
12	Update phone numbers in the database as project progresses.
13	Provide alternative filters and additional filters as filling the pitcher is cumbersome and slow.
14	Younger generation prefer online survey responses and electronic communications.
15	Not all residents have email addresses and internet access and hard copy surveys should continue to be provided.
16	Follow-up calls should be made from a Denver Water phone number.
17	Outreach staff should fill out and request a water quality sampling kit for concerned residents.
18	Include lead service line replacement information and talking points with filter program.
19	Follow-up visits and door-to-door outreach is not preferred for all participants. Some have requested communication via email only.
20	Simplify survey questions to prevent confusion.

General Water Quality - Flushing

To reduce your exposure to lead in drinking water, we recommend flushing your faucet before using the water, unless a faucet filter that removes lead is installed and cannot be

bypassed during flushing, following the steps highlighted on www.denverwater.org. (https://www.denverwater.org/your-water/water-quality/lead/reduce-your-risk)

When using water for drinking, cooking and making ice, beverages and infant formula:

- *Use cold water. Hot water dissolves lead faster and is likely to contain higher levels of lead.*
- *If water has not been used for a few hours, run the kitchen or any bathroom faucet for a few minutes. You also can run the dishwasher or take a shower.*

Flushing the faucet is not required if a faucet filter that removes lead is installed and cannot be bypassed. Flushing water through a faucet filter that cannot be bypassed will shorten the life of the filter.

III. FLOW PROGRAM

The framework for the FLOW Program consists of the following series:

- 5200 – Data Management
- 5300 – Distribution
- 5400 – Alternative Filters
- 5500 – Twice a Year Follow-Up
- 5600 – Transition off FLOW

Below is a general summary of each series. Separate from this TM, Denver Water will further develop each series by identifying the key steps, processes and workflows prior to implementation. For each series, office and field staff supporting the FLOW Program will be trained. Efforts outlined herein do not include COE tasks.

A. Data Management – 5200 Series:

A geodatabase will be developed and used to track & manage the FLOW Program:

- Initial FLOW Program Participants - Premise / Denver Water household data for 84,546 properties / 119,250 Denver Water household units.
- Change of Denver Water household (Move In/Move Out) – Denver Water billing changes, new account rental property owner registration, rental property management companies, others. Denver Water will provide monthly updates.
- Add/Delete Premise – Based upon field data, including service line material type, replacement of lead service, others.
- Field Data Collection - The Mott MacDonald Field Inspection Tools (MMFIT) application will be available during the ALSLR Program and the FLOW Program to field collect Denver Water household data regarding both lead service lines and filter use.
- Integration with Denver Water CIS/CC&B
- FLOW Program Surveys - Filter recipients will be asked to respond to several online surveys related to filter use. The surveys will be administered using the

survey tool, Snap Survey, to seamlessly collect data directly from FLOW participants.

A dashboard for tracking metrics and adoption rates for the FLOW Program will be developed.

B. Distribution – 5300 Series

- **Initial Distribution**
  - **Procure Filter Kits:** Coordinate with the suppliers to procure pitcher filters, cartridges, boxes, bags and other contents for 119,250 filter kits. Coordinate delivery to pick and pack warehouse in the Denver Area. It is expected that deliveries will be divided into 12 batches (10,000 filters) for use with distribution of the filters and communications within geographic areas.
  - **Training:** Office and field staff supporting FLOW will be trained.
    - Finalize filter kit education/outreach material, surveys, phone / in-person scripts, FAQs, and other key references, as included in Appendix D.
    - Conduct in-person training.
  - **Kit Assembly:** The filter kit contents (Appendix B) will be assembled for hand delivery and mailing.
  - **Mail Kits:** Boxed filter kits will be mailed directly to 90% of Denver Water households. Those Denver Water households that are enrolled in the Denver Water email subscription will also be emailed the letter highlighting that the filter kit package has been mailed, encourage participation, and request for the Denver Water household to contact Denver Water if the Denver Water household does not receive the kit within 5 days. The intent is to split into 12 batches (approximately 9,100 kits in a batch) to allow targeted distribution to specific areas within the Denver Water service area and provide staggered follow-up as required. The plan includes the goal of mailing one batch per week. The first batch will include the initial Denver Water households identified for lead service line replacement in 2020 to allow for adequate distribution and use prior to the start of the ALSLR Program in January 2020.
  - **Hand-Deliver Kits:** Bagged filter kits will be hand delivered (drop off) to 10% of Denver Water households. Those Denver Water households that are enrolled in the Denver Water email subscription will also be emailed the letter, highlighting that the filter kit package will be delivered and encourage participation in the FLOW Program. The intent is to split into 12 batches (approximately 1,000 kits in a batch) in coordination with the mailed kits to allow targeted distribution to specific areas within the Denver Water service area and provide staggered follow-up as required. Field staff will carry a Denver Water photo identification and for ease of identification.

- **Initial Survey**

- **Second Distribution** – It is estimated that pitcher filters should be replaced every 8 years. As technology advances, the 8-year replacement time period will be reviewed and adjusted, as needed. The Second Distribution will follow the same framework as the Initial Distribution.
- **Individual Distributions** – Throughout the FLOW Program, it is expected that new Denver Water households will be added due to move in / move outs, services added to LSI, and other reasons. Also, previously delivered kits may have been missing, lost or damaged. Individual distribution of filter kits, filters or filter cartridges will be mailed within two weeks to the Denver Water household.

C. Alternative Filters - 5400 Series

- **Analysis/Tracking:** Data gathered from the filter kit distribution, door-to-door visits, surveys, and other feedback received will be captured in a centralized database. Data will be further analyzed related to the participant's filter use and requests for alternative filters.
- **Use Survey**
- **Mail Alternative Filter**: If an alternative filter has been requested by the Denver Water household and they have opted for a home-owner-installed alternative filter, the alternative filters will be directly mailed to the Denver Water household. This option is predicted to be used for alternative filters that are easily installed.
- **Install Alternative Filter:** If an alternative filter has been requested by the Denver Water household and they have opted for Denver Water to install, an appointment will be made and the alternative filter will be installed, at no cost to the Denver Water household. Before installing the filter, Denver Water will conduct a visual inspection of the service line as it enters the house. With the aid of the homeowner, the entry point for the service line will be identified. Field staff will carry a Denver Water photo identification for ease of identification.
- **Alternative Survey**

D. Twice a Year Follow-Up – 5500 Series

Upon LRP approval, a twice a year follow-up will commence 6 months after the initial distribution and continue through the end of the FLOW Program in 15 years. The intent is to distribute the next 6 month supply of filter replacement cartridges, further outreach / education material, and survey.

- **Replacement Cartridges:** The next 6 month supply of filter replacement cartridges and outreach / education material will be distributed.

- **Mail**: Pitcher filter replacement cartridges will be directly mailed to the Denver Water household. Also, alternative filter cartridges that are easily installed will be mailed to the Denver Water household.
- **Install:** If an alternative filter is used and they have opted for Denver Water to install, an appointment will be made and the filter replacement cartridge will be installed. Field staff will carry a Denver Water photo identification for ease of identification.

- **Adoption Survey** - once per year
- **On-going Surveys**

E. Transition Off the FLOW Program – 5600 Series

- **Individual:** A Denver Water household will be removed from the FLOW Program, either six months after replacement of the lead service line, or if a non-lead service line is confirmed at the property.
  - Replacement cartridges will be provided for the 6 month period following the lead service line replacement. The Denver Water household will be notified via letter.
  - A Denver Water household will be transitioned off the FLOW Program if a non-lead service line is confirmed at the property in accordance with Appendix III.D.1 Accelerated Lead Service Line Replacement Plan. No additional replacement cartridges will be provided. The Denver Water household will be notified via letter at the end of a 6 month period.
- **FLOW Program Discontinued:** If Denver Water transitions off the FLOW Program, no additional replacement cartridges will be provided. The Denver Water households will be notified via letter.

IV. FILTER USE METRICS

Metrics were developed for use in the FLOW Program and a table of metrics is provided in the Lead Reduction Program Plan (LRP Plan).

V. DEMOGRAPHICS EVALUATION

As part of the use survey, it is important to determine the adoption rate amongst the diverse populations in the Denver Water service area. The American Community Survey (ACS) is part of the U.S. Census Bureau's Decennial Census Program and is designed to provide current social, economic, housing, and demographic estimates throughout the decade. Combining American Census Survey (ACS) data with FLOW data allowed for the estimation of trends between levels of diversity in a neighborhood and filter adoption rates within the FLOW neighborhoods. ACS information at the Block Group Level will be taken from the 2013 to 2017 American Community Survey estimates. The information was adjusted for the Hispanic representation included as a category to reflect additional available diversity information. The information was linked to the Survey Census Block

Groups to develop a geographic component to the data. The survey data was then evaluated by Diversity Categories By Block Group (ACS Data for B02001) as follows:

- Hispanic alone
- White (Non-Hispanic) alone
- Black or African American alone
- American Indian and Alaska Native alone
- Asian alone
- Native Hawaiian and Other Pacific Islander alone
- Some other race alone

As an example, the FLOW Pilot survey results were geolocated based on the address, tap number, or other available spatial information. The geolocation allows the data collected from the FLOW Pilot to be associated to a location and a block group for further analysis of the adoption rates and other survey results compared to the available diverse population statistics for each area. The following evaluations were completed for the Filter Pilot premises:

1. The comparison of the adoption rate noted on completed surveys to the diverse population for each surveyed area.
2. The comparison of areas where surveys where sent but not returned or the adoption rate is low.
3. The identification of specific diverse populations where surveys were sent but not returned or the adoption rate is low.
4. The comparison of the survey results between different areas and diverse groups to establish trends by ethnic population.
5. The populations where filters were sent but surveys not returned.
6. The comparison of adoption rate to the baseline approved adoption metric.

The survey results were then compared to the neighborhood demographics. The COE program can be adjusted if there is a lack of survey results or negative feedback from a certain area are identified. If an area is systemically not participating in FLOW, then the areas' criticality (and thus risk) will be ranked as higher priority in the ALSLR Program.

A summary of the FLOW Pilot demographics evaluation, for three of the seven neighborhoods, is shown in Table III.C.3-5.

Table III.C.3-5 Survey Results by Diversity Analysis (sample results)*

Neighborhood	1	2	3
White Hispanic (%)	62	64	61
White Non-Hispanic (%)	29	16	18.6
Black or African American (%)	3	1	0.1
American Indian and Alaska Native (%)	2	1	0
Asian (%)	0	9	19
Native Hawaiian and Other Pacific Islander (%)	0	0	1
Other (%)	4	9	0.3
Number Using Filter for Drinking	8	4	2
Number Using Filter for Cooking	6	4	2
Initial Survey Completed	7	8	0
Filter Use Survey Completed	9	6	2
Using for Drinking (%)	89	67	100
Using for Cooking (%)	67	67	100
Initial Survey Completed (%)	64	73	0
Filter Use Survey Completed (%)	82	55	9

**The demographic data was developed using limited survey data from August 2, 2019 and available census data. The demographic data is provided as an example and will be further developed with the full-scale filter plan.*

The data indicate that at least 67% of the population surveyed use the filter for drinking and cooking in three (3) of the seven neighborhoods where White Hispanics make up the majority of the population. Other considerations may be affecting neighborhood 3, which shows a markedly lower adoption rate. A geographic strategy analysis will be conducted to determine how the COE plan should be adjusted in neighborhood 3 as opposed to modifying the overall COE efforts specified for the White Hispanic population. Neighborhood 3 has a larger Asian population and this information will be used to provide guidance for increased COE for filter adoption in this neighborhood.

VI. FILTER PLAN 2019/2020 TIMELINE EXAMPLE

Date	Activity	Comments
Based on an October 20, 2019 Variance Approval		
July – October 2019	Develop FLOW Plan	
September 30, 2019	Denver Water contract with • pitcher filter kit content suppliers • pick and pack warehouse • distribution team • program management	
October 21, 2019	Variance Approval Expected	Go / No-Go from Denver Water on FLOW Program
October 23, 2019	Order pitcher filter kit supplies	Confirm pitcher filter supplies and coordinate with suppliers
October 23, 2019	COE	Launch Denver Water internal COE plan
November 11, 2019	Training/Kit Assembly	Training materials and filter kits are ready for distribution
November 13, 2019	Commence Distribution of Batch 1	Coordinate outreach and delivery
November 20, 2019	Commence Distribution of Batch 2	Coordinate outreach and delivery
December 2, 2019	Commence Distribution of Batch 3	Coordinate outreach and delivery
December 9, 2019	Commence Distribution of Batch 4	Coordinate outreach and delivery
December 16, 2019	Commence Distribution of Batch 5	Coordinate outreach and delivery
January 6, 2020	Commence Distribution of Batch 6	Coordinate outreach and delivery
January 13, 2020	Commence Distribution of Batch 7	Coordinate outreach and delivery
January 20, 2020	Commence Distribution of Batch 8	Coordinate outreach and delivery
January 27, 2020	Commence Distribution of Batch 9	Coordinate outreach and delivery
February 3, 2020	Commence Distribution of Batch 10	Coordinate outreach and delivery
February 10, 2020	Commence Distribution of Batch 11	Coordinate outreach and delivery
February 17, 2020	Commence Distribution of Batch 12	Coordinate outreach and delivery

Date	Activity	Comments
March 20, 2020	Confirm pitcher filter distribution to all Denver Water households with known, suspected, and possible lead service lines	
Starting May 2020 & every 6 months	Twice a Year Follow-up following the same batch sequence • Analysis/Tracking • Use Survey • Distribute filter cartridge replacements	• Feedback and collection of data • Determine alternative filter type requested • Follow-up phone calls
Starting May 2020 & every year	• Adoption Survey	• Track Filter Adoption
Starting July 2020	• Mail Alternative Filters • Install Alternative Filters • Alternative Survey	• Order, delivery, and installation of alternative filter equipment • Feedback and collection of data
Starting October 1, 2020.	Analyze surveys on filter usage submitted from approximately 4,267 Denver Water households as part of the ALSLR Program, 1,059 FLOW Program Participants, and others	
December 2020	Progress Meeting	• Feedback and collection of data
June through December every year	Follow-up on Adoption Survey	• COE
Every January	Report Adoption Survey results to CDPHE and EPA	

APPENDIX A – FILTER TYPES

DENVER WATER

Filter Types

Federal regulations do not exist for residential water treatment filters. Voluntary national standards and National Sanitation Foundation (NSF) / American National Standards Institute (ANSI) protocols have been developed to establish minimum requirements for the safety and performance of residential water treatment filters. NSF/ANSI Standards 42 and 53 are applicable for water quality and lead removal, as described, below.

- **NSF/ANSI 42**

  Filters are certified to reduce aesthetic impurities such as chlorine, taste, and odor. Filters can be point-of-use (POU) (faucet filter, water pitcher, etc.) or point-of-entry (POE) (whole house) treatment systems.

- **NSF/ANSI 53**

  Filters are certified to reduce a contaminant with a health effect, such as lead. The standard establishes health effects as regulated by the U.S. Environmental Protection Agency (EPA). Both standards 42 and 53 include adsorption and filtration treatment.

NSF established laboratories that may test and certify filters that meet the NSF protocols for lead removal. The certified laboratories include: NSF International, CSA International, Water Quality Association (WQA), International Association of Plumbing and Mechanical Officials, Underwriters Laboratory, Truesdail, and Intertek.

A summary of filter pitchers, cost estimates, and features is shown in Table A1. A summary of different types of filters, certification laboratory to NSF/ANSI Standards 42 and 53, and associated filter life is shown in Table A2. The general range of filter life for pitcher filters is 1-6 months and the general range of filter life for alternative filters is 1-10 months. Product detail sheets are attached.

DENVER WATER

Table A1: Pitcher Filters									
Brand/Model	**Certification Laboratory**	**Filter Life**	**Percent Lead Reduction at pH 8.5**	**Removes Fluoride**	**Unit Cost - Retail**	**Wholesale Cost**	**Size of Packaging (L X W X H)**	**Weight**	**Inventory and Lead Time**
Brita Monterey (#OB50) 10-cup pitcher with Longlast filter (#OB06)[1]	WQA	6 months	99.6%	No	$34.99[2]	TBD	TBD	TBD	TBD
DuPont 8-cup pitcher (WFPT100) with WFPTC100N filter[3]	WQA	3 months	97.4%	No	$18.71[4]	TBD	7 X 9 ¼ X 9 ½”	1.8 lbs	TBD
DuPont WFTP200 10-cup pitcher with WFPTC100N filter[5]	WQA	3 months	97.4%	No	$24.96[6]	TBD	5 3/8 X 11 ½ X 11 ¼”	2.4 lbs	TBD
ZeroWater 10-cup filter pitcher (ZP-010)[7]	NSF	1 month	99.0%	Yes	$34.99[7]	TBD	12 ¼ X 6 X 11 5/8”	3.75 lbs	TBD

DENVER WATER

Table A1: Pitcher Filters									
Brand/Model	**Certification Laboratory**	**Filter Life**	**Percent Lead Reduction at pH 8.5**	**Removes Fluoride**	**Unit Cost - Retail**	**Wholesale Cost**	**Size of Packaging (L X W X H)**	**Weight**	**Inventory and Lead Time**
Pur Classic 11-cup pitcher (PPT111WV1) with lead reduction filter (PPF951K)[8]	WQA	2 months	97.9%	No	$34.99[8]	TBD	TBD	TBD	TBD

Notes:

1. *https://www.brita.com/water-pitchers/monterey-longlast/?ds_rl=1238837&gclid=Cj0KCQjw9JzoBRDjARIsAGcdIDUi8xyyMENARquLCz_NAqDULqUppLOhn01Pd3XbXRcXZGGWDHWOyLgaAslGEALw_wcB&gclsrc=aw.dshttp://www.protectplus.com/PD-Water-Filtration-82/DuPont-Traditional-Water-Filter-Pitcher-WFPT100-653*
2. *https://www.homedepot.com/p/Brita-Monterey-10-Cup-Water-Filter-Pitcher-in-Blue-with-Longlast-Filter-BPA-Free-6025836304/308802800*
3. *http://www.protectplus.com/PD-Water-Filtration-82/DuPont-Mirage-Water-Filter-Pitcher-WFPT200-652*
4. *https://www.amazon.com/DuPont-WFPT100X-Traditional-Filter-Pitcher/dp/B007VZ2OTM/ref=sr_1_1?keywords=dupont+8-cup+pitcher&qid=1561675034&s=hi&sr=1-1*
5. *http://www.protectplus.com/PD-Water-Filtration-82/DuPont-Mirage-Water-Filter-Pitcher-WFPT200-652*
6. *https://www.amazon.com/DuPont-WFPT200X-Mirage-Filter-Pitcher/dp/B007VZ2OTC*
7. *https://ww.zerowater.com/products-10-Cup-Pitcher?gclid=Cj0KCQjw9JzoBRDjARIsAGcdIDWhrdUxnskz0UuAp4CIuQcDKJ27qwbOVoqxdOPq9XYFa3QJlVwIK2YaAhvzEALw_wcB*
8. *https://www.pur.com/water-filter-pitchers-and-dispensers/pur-ultimate-pitcher-filtration-system-with-lead-reduction*

Table A2: Point-of-Use Filter Types

Filter Type	Brand/Model	Certification Laboratory	Filter Life	Percent Lead Reduction at pH 8.5
Water Dispenser	ZeroWater 20-cup water filter jug (ZD-20RP)[1]	NSF	1 month	99.0%
	ZeroWater 30-cup water filter jug (ZD-30RP)[2]	NSF	1 month	99.0%
	ZeroWater 40-cup water filter jug (ZBD-040)[3]	NSF	1 month	99.0%
Water Dispenser	Brita Ultramax 18-cup Dispenser (#OB24) with Brita Longlast filter (#OB06)[4]	WQA	6 months	99.6%
Faucet-Mount	DuPont WFFM100 Faucet Mount Filter with WFFMC100 or WFFMC300 filter[5]	WQA	5 months	99%
	DuPont WFFM350 with Ultra Protection Filter (WFFMC300)[6]	WQA	10 months	99%
	Brita Faucet Filtration System FF-100 with FR-200 filter[7]	NSF & WQA	5 months	99.3%
	Brita Basic Faucet Filtration System SAFF-100 with FR-200 filter[8]	NSF & WQA	5 months	99.3%
Faucet-Mount	Pur PFM400H Faucet with MineralClear Filter (RF9999)[9]	WQA	3 months	99.9%

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Table A2: Point-of-Use Filter Types

Filter Type	Brand/Model	Certification Laboratory	Filter Life	Percent Lead Reduction at pH 8.5
Refrigerator Filters	Frigidaire PureSource 3 (WF3CB)[11]	NSF	6 months	99.1%
	Maytag Refrigerator Water Filter (UKF8001)[12]	NSF	6 months	99.3%

Notes:

1. *https://www.brita.com/water-pitchers/monterey-longlast/?ds_rl=1238837&gclid=Cj0KCQjw9JzoBRDjARIsAGcdIDUi8xyyMENARguLCz_NAqDULgUppLOhn01Pd3XbXRcXZGGWDHWOyLgaAslGEALw_wcB&gclsrc=aw.dshttp://www.protectplus.com/PD-Water-Filtration-82/DuPont-Traditional-Water-Filter-Pitcher-WFPT100-653*
2. *http://www.protectplus.com/PD-Water-Filtration-82/DuPont-Mirage-Water-Filter-Pitcher-WFPT200-652*
3. *http://www.protectplus.com/PD-Water-Filtration-82/DuPont-Mirage-Water-Filter-Pitcher-WFPT200-652*
4. *https://ww.zerowater.com/products-10-Cup-Pitcher?gclid=Cj0KCQjw9JzoBRDjARIsAGcdIDWhrdUxnskz0UuAp4CIuQcDKJ27qwbOVoqxdOPq9XYFa3QJlVwIK2YaAhvzEALw_wcB*
5. *https://www.pur.com/water-filter-pitchers-and-dispensers/pur-ultimate-pitcher-filtration-system-with-lead-reduction*
6. *https://ww.zerowater.com/products-20-Cup-Ready-Pour*
7. *https://ww.zerowater.com/products-30-Cup-Ready-Pour*
8. *https://ww.zerowater.com/products-40-Cup-Ready-Pour*
9. *https://www.brita.com/water-dispensers/ultramax-longlast/*
10. *http://www.protectplus.com/PD-Water-Filtration-82/DuPont-Premier-Faucet-Mount-Drinking-Water-Filter-WFFM100-647*
11. *http://www.protectplus.com/PD-Water-Filtration-82/DuPont-Deluxe-Faucet-Mount-WFFM350-646*
12. *https://www.brita.com/faucet-systems/complete/*
13. *https://www.brita.com/faucet-systems/basic/*
14. *https://www.pur.com/faucet-filtration-systems/pur-advanced-faucet-filtration-system-with-mineralclear-filter*
15. *https://www.frigidaire.com/Filters--Accessories/Filters/water-filters/WF3CB/?gclid=CjwKCAjwuqfoBRAEEiwAZErCsqQkifIHCX2HhuFjxt_hL213qbrqvzOJ96upk87nk6SIa4b2_4hT2BoCuXYQAvD_BwE&gclsrc=aw.ds*
16. *https://www.homedepot.com/p/Maytag-UKF8001-Refrigerator-Water-Filter-UKF8001/100671093*

APPENDIX B – FILTER KIT CONTENTS

DENVER WATER

Filter Kit Contents

Each participant of the Filter Lead Out of Water (FLOW) Program will receive a filter kit via direct mail or door-to-door hand delivery. Each filter kit includes the following:

Kit Items:

- Frequently Asked Question (FAQ) summary for Lead Service Lines (LSL) and FLOW Program questions
- One (1) water filter pitcher - NSF certified to remove lead
- 6-month supply of replacement filter cartridges
- Pitcher filter instructions and maintenance guidelines in multiple languages
- Initial Survey
- Reusable bag
- Magnet with reminders to use filtered water for infant formula, drinking, and cooking, cartridge date change information, program contact information, website, and telephone number
- Door hanger

The filter pitcher should be used for all infant formula, drinking water, and cooking. The manufacturer's instructions for use and maintenance should be followed and the filter should be replaced in accordance with the manufacturer's guidelines.

APPENDIX C - SURVEY QUESTIONS

DENVER WATER

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FLOW Program Survey Question Matrix

Questions	Initial Survey	Use Survey	Adoption Survey	Alternative Filter Survey	Ongoing Surveys
1. Do you use your filter or bottled water for drinking water? • Yes • No		X	X	X	X
2. Do you use your filter or bottled water for water used for cooking? • Yes • No		X	X	X	X
3. Do you use your filter or bottled water for water used for infant formula preparation? • Yes • No • Not Applicable (no infants)		X	X	X	X
4. Do you have a lead service line? • Yes • No • I do not know	X				
5. What is your household's primary source of drinking water? (Check one) ☐ Unfiltered faucet ☐ Bottled water ☐ Filtered - refrigerated water/ice dispenser ☐ Filtered - pitcher filter ☐ Filtered - under sink filter ☐ Filtered - faucet mounted filter ☐ Filtered - whole house filter ☐ Other (specify)	X				

DENVER WATER

FLOW Program Survey Question Matrix

Questions	Initial Survey	Use Survey	Adoption Survey	Alternative Filter Survey	Ongoing Surveys
6. What is your household's primary source of water used for cooking? (Check one) ☐ Unfiltered faucet ☐ Bottled water ☐ Filtered - refrigerated water/ice dispenser ☐ Filtered - pitcher filter ☐ Filtered - under sink filter ☐ Filtered - faucet mounted filter ☐ Filtered - whole house filter ☐ Other (specify)	X				
7. What is your household's primary source of water used for infant formula preparation? (Check one) ☐ Unfiltered faucet ☐ Bottled water ☐ Filtered - refrigerated water/ice dispenser ☐ Filtered - pitcher filter ☐ Filtered - under sink filter ☐ Filtered - faucet mounted filter ☐ Filtered - whole house filter ☐ Not Applicable ☐ Other (specify)	X				
8. If you have an existing water filter system, what is the make and model number for your filter? (Fill in)	X				
9. Do you currently or do you plan in the future to use filtered or bottled water for infant formula? Yes/No/NA	X	X		X	X
10. If you do not primarily use the water filter provided, what issues are you experiencing? (Check all that apply) ☐ Filter pitcher isn't large enough ☐ Filter pitcher doesn't fit in refrigerator ☐ The filter pitcher takes too much time to fill ☐ It's too much effort to use the filter pitcher ☐ I'm not interested in filtering my drinking water		X			

DENVER WATER

FLOW Program Survey Question Matrix

Questions	Initial Survey	Use Survey	Adoption Survey	Alternative Filter Survey	Ongoing Surveys
☐ Other, please specify: (fill in the blank) ☐ Not Applicable (no issues)					
11. If the water filter provided does not meet your needs, would you be more likely to use an alternative filter? (Check one) ☐ Faucet-mounted filter ☐ Refrigerator filter ☐ Larger pitcher filter ☐ Not Applicable (the water filter meets my needs)		X			X
12. Are you familiar with filter maintenance and cartridge replacement requirements? E.g. replacing the filter cartridge, cleaning the pitcher (if applicable)? Yes/No		X		X	X
13. What questions or comments do you have about the FLOW Program?	X	X		X	X
14. How could we improve the FLOW Program?	X	X		X	X
15. Want to stay informed about the FLOW Program? Provide your email or phone number.	X	X		X	X
16. What is your age? ☐ Under 18 ☐ 18-24 years old ☐ 25-34 years old ☐ 35-44 years old ☐ 45-54 years old ☐ Over 55 ☐ Prefer not to say	X	X		X	X
17. What is your gender? ☐ Male ☐ Female ☐ Other (specify) ☐ Prefer not to say	X	X		X	X
18. Are you Hispanic or Latino? ☐ Yes ☐ No ☐ I do not know					

DENVER WATER

FLOW Program Survey Question Matrix

Questions	Initial Survey	Use Survey	Adoption Survey	Alternative Filter Survey	Ongoing Surveys
☐ Prefer not to say					
19. What is your ethnicity? (Check all that apply) ☐ White (Non-Hispanic) ☐ Black or African American ☐ Native American or Alaska Native ☐ Asian ☐ Native Hawaiian and Other Pacific Islander ☐ Multiple ethnicities ☐ Other (specify) ☐ I do not know ☐ Prefer not to say	X	X		X	X
20. Are you married, widowed, divorced, separated, or never married? ☐ Married ☐ Widowed ☐ Divorced ☐ Separated ☐ Never married ☐ Prefer not to say	X	X		X	X
21. Are you pregnant, nursing, or an expecting family? ☐ Yes ☐ No ☐ Prefer not to say	X	X		X	X
22. What is the primary language you speak? (Check all that apply) ☐ English ☐ Spanish ☐ Other (specify)	X	X		X	X

DENVER WATER

FLOW Program Survey Question Matrix

Questions	Initial Survey	Use Survey	Adoption Survey	Alternative Filter Survey	Ongoing Surveys
23. What is the highest level of school you have completed, or the highest degree you have received? ☐ Less than high school degree ☐ High school degree or equivalent (e.g., GED) ☐ Some college but no degree ☐ Associate degree ☐ Bachelor's degree ☐ Graduate degree ☐ Prefer not to say	X	X		X	X
24. Which of the following categories best describes your employment status? ☐ Employed, working 1-39 hours per week ☐ Employed, working 40 or more hours per week ☐ Not employed, looking for work ☐ Not employed, NOT looking for work ☐ Retired ☐ Disabled, not able to work ☐ Prefer not to say	X	X		X	X
25. How much total combined money did all members of your household earn in 2018? ☐ $0 - $9,999 ☐ $10,000 - $19,999 ☐ $20,000 - 29,999 ☐ $30,000 - 39,999 ☐ $40,000 - 49,999 ☐ $50,000 - 59,999 ☐ $60,000 - 69,999 ☐ $70,000 - 79,999 ☐ $80,000 - 89,999 ☐ $90,000 - 99,999 ☐ $100,000 or more ☐ Prefer not to say	X	X		X	X

APPENDIX D - COE

DENVER WATER

Community Outreach and Education (COE)

The overarching Lead Reduction Program Communication's Strategy, process, procedures, and guidelines will apply to the FLOW Program. The success of the COE will be paramount to provide Denver Water with the necessary data and information to support the variance submittal.

All COE materials will be bilingual for ease of use. The filter kit will include the following COE materials:

Frequently Asked Questions (FAQ)

The FAQ document will provide additional information beyond the press release of the filter program. The FAQ developed specifically for the filter program will have duplicative information from the larger FLOW Program initiative FAQ approved by the EPA and CDPHE, with additional context as to why participants are receiving the filter kit, the length of the program, information about the surveys, and more.

Magnet Reminder Card

A refrigerator magnet will provide a reminder to encourage filter pitcher use for infant formula, drinking, and cooking. The magnet will also remind users to change their filter cartridge regularly. Program contact information will be included on the magnet.

Door-hanger

10% of FLOW Program participants will have door-to-door delivery of their filter kits. A door-hanger will be left on doors with the filter kit to notify Denver Water households of the FLOW Program, inform them of the contents of the filter kit, and provide contact information should the Denver Water household residents not be home during the initial door to door delivery attempt.

Survey Card

An initial survey will be included in the filter kit. FLOW Program participants will be encouraged to complete the initial survey and return their comments to Denver Water within two weeks of receiving their filter kit. Future surveys will be mailed to the FLOW Program participants with incentives such as Amazon gift cards or the chance to be entered into a drawing for a reward offered for the completion of each survey.

APPENDIX III.D.1 - ACCELERATED LEAD SERVICE LINE REPLACEMENT PLAN

September 2019

DENVER WATER

Memo

1600 S Quebec Street
Greenwood Village, CO 80111
aecom.com

Project name: Accelerated Lead Service Line Replacement Plan

Project ref: Denver Water Lead Reduction Plan

To: Denver Water

From: AECOM

CC:

Date:
August 16, 2019

Appendix III.D.1 Accelerated Lead Service Line Replacement Plan

Introduction

Background and Purpose

The Denver Water Lead Reduction Program (LRP) provides a path forward for Denver Water to replace all lead service lines (including galvanized downstream of lead) within its service area (including distributors) over the next 15-years. To support this effort, the enclosed Accelerated Lead Service Line Replacement (ALSLR) Plan describes the general steps and the estimated resources needed to replace approximately 63,955 lead service lines (LSLs) with a 7.0% cumulative program year average replacement rate (or approximately 4,477 lead service lines per program year).

The goal of the ALSLR Plan is to develop an approach that allows for the consistent and reliable replacement of services over the next 15-years. The ALSLR Plan was prepared to develop a contracting and procurement strategy for Denver Water based on lessons learned from other Lead Reduction Programs (LRPs) that have successfully replaced a comparable number of lead services, on the order of a few 1000s per year. The contracting and procurement strategy for the ALSLR Plan is presented in the three construction phases: Pre-Construction Phase, Construction Phase, and Post Construction Phase. The ALSLR Plan describes the close collaboration necessary with the other LRP elements including the Filter Program Plan, Communications, Outreach and Education (COE) Plan, and Lead Service Line Inventory (LSLI – Predicative Model). The reader is directed to Table III.D-1 below, for a list of pertinent Definitions and Acronyms used in this Technical Memorandum as a reference guide.

Table III.D-1. List of Definitions and Acronyms

Definition or Acronym	Descriptions
ALSLR	Accelerated Lead Service Line Replacement
AL	Action Level
CDPHE	Colorado Department of Public Health and Environment
CI	Construction Inspector
CM	Construction Manager
COE	Communications, Outreach, and Education
EJCDC	Engineers Joint Contract Documents Committee
EPA	Environmental Protection Agency
KPI	Key Performance Indicator
LSLI	Lead Service Line Inventory
LRP	Lead Reduction Program
LRP Plan	document submitted to EPA/CDPHE as the technical document that supports Denver Water's variance request.
LSL	Lead Service Line
LSLR	Lead Service Line Replacement
Non-copper	Refers to materials such as lead, galvanized, and polyethylene
Program	Refers to program staff from Denver Water and/or program management firm as appropriate for the task at hand.
POU	Point of Use (as in POU filter)
RFP	Request for Proposal
ROM	Rough Order of Magnitude
TBD	To Be Determined
TM	Technical Memorandum
YoY	Year-Over-Year

References

1. Denver Water Standards / Specifications
2. AWWA/ANSI Standard C810-17
3. Denver Water Procurement Process
4. Predictive Model and Prioritization (Appendix III.B.3)
5. LRP Plan Submissions
6. Filter Adoption (Appendix III.C.1)
7. Filter Pilot (Appendix III.C.2)
8. Filter Program Plan (Appendix III.C.3)
9. Communications, Outreach, and Education Plan (Appendix III.A)

LRP Variance Criteria

Overview

The ALSLR Plan has been developed to meet certain Key Performance Indicators (KPIs) established in the LRP. The success of the ALSLR Plan depends on the success of other LRP elements, namely

the COE Plan and Filter Program Plan, and will undergo continuous improvement through the Learning-by-Doing element. The ALSLR Plan will address the following key LRP variance criteria elements;

- Denver Water will replace all lead services, from the main to the first fitting inside the dwelling. Lead services include galvanized pipe downstream of lead.
- The target of 7.0% cumulative program year replacements is based on a total estimated number of known and suspected lead services of 63,955.
- A LSL replacement for compliance is counted as partially[1] or fully replacing the lead or lead/galvanized service line from the water main to the premise.
- The overall LRP objective of replacing the lead service is to remove the major source of lead from customer's drinking water supply. This implies that all portions of the lead or lead/galvanized service line will be replaced in full – no known lead service line remains. Where a portion was previously replaced - confirmed through LSL investigation activities, the remaining lead or lead/galvanized service line will be replaced. Conditions under which the lead would not be replaced are limited to earning consent from the property owner to replace the service line. If consent is not provided, additional actions are triggered, as discussed in this Plan.

The evaluation criteria and reporting needs are defined in the Terms and Conditions[2].

Annual LSLR Criteria and Resource Requirements

Based on the lessons learned from other LRPs as well as Denver Water's history of LSLRs, a LSLR Resource Summary table was prepared and presents the anticipated range of level of effort (expressed as number of crews) that will be required to meet the 7.0% target for annual replacements based on various assumptions (see Table III.D-2). Denver Water's water main replacement program as well as other similar programs has found that their LSLR crews have consistently replaced from two to four LSLs per day depending upon various circumstances. Based on the LSL inventory of 63,955, Denver Water will need approximately 6 to 11 LSLR external crews, (see Table III.D-2) to achieve an 7.0% cumulative average replacement rate (or approximately 22 LSLRs daily).

Denver Water planned a conservative approach to the Accelerated Lead Service Line Replacement Program by setting the target replacement quantity at 5,250 lead service lines per year. Targeting a higher replacement quantity is more of a safety factor than a number adjustment to achieve compliance of 7.0% cumulative program year average replacement rate. For the LRP and ALSLR Program to be successful, confirming the number of lead service lines and where the lead services are located is paramount. Starting the Program with a 15% safety factor (4,477 vs 5,250 LSLs) for the targeted program year LSLR will provide a compliance buffer of 773 LSLs. This buffer gives the ALSLR Program the ability to manage unforeseen situations that may occur in the first few years without missing the regulatory compliance goal. Additionally, the higher targeted replacement volume will help the Program not rely on other programs to provide support on LSLR and reduce potential effects of other elements (such as inclement weather and foreseen planning issues) to influence the annual replacement totals.

Table III.D-2. 15-Year LSL Replacement Resource Summary

			No. of Crews*

[1] Reference Figure III.D-D. Non-Copper Service Line Replacement Scenarios for examples of acceptable partial LSL replacements.
[2] Reference Appendix IV.A.

Estimated LSL Inventory	Annual Replacement	Total Daily LSLR	LSLR/day per Crew	LSLR/day per Crew	LSLR/day per Crew	LSLR/day per Crew
	7.0%	200 work days	2	2.5	3	4
80,000	5,600	28	14	11	9	7
75,000	5,250	26	13	11	9	7
65,000	4,550	23	11	9	8	6
63,955	4,477	22	11	9	7	6
55,000	3,850	19	10	8	6	5

*Based on experience from Denver Water as well as other jurisdictions, a single crew can replace between 2 and 4 LSLs per day.

In the following sections, the ALSLR Plan will use the annual replacement target of 5,250 as the basis of calculations and resources required to meet the 7.0% cumulative program year average.

Overview of Other LRPs from Other Jurisdictions

Introduction

Denver Water reviewed the experience of other jurisdictions who replaced lead services in their water systems and the associated lessons learned helped guide the development of the proposed ALSLR Plan's contracting and procurement strategy, including the anticipated LSLR rates, delivery delays, and risks.

The previous LRP's experience was gathered from the City of Flint, Pittsburgh Water and Sewerage Authority, and Detroit Water and Sewerage Department based on AECOM's experience working with these water systems as well as information that is publicly available. The City of Flint, under an Emergency Order, replaced approximately 18,000 LSLs from December 2017 to January 2019. The Pittsburgh Water and Sewerage Authority, under an Administrate Order due to multiple Action Level (AL) exceedances, is mandated to replace 7.0% of approximately 14,000 LSLs per year from June 2017 to December 2019. Per the July 2018 Michigan Department of Environment and Quality Lead and Copper Rule, the Detroit Water and Sewerage Department needs to replace more than 125,000 LSLs at a replacement rate of 5.0% per year. Key lessons learned in terms of procurement, describing the scope and responsibilities of all parties to the LRP, and defining the process and steps involved with replacing the LSLs (see Table III.D-3). A preliminary list of potential risks to delivery are summarized in Table III.D-4, based on experience gained from other jurisdictions when replacing lead services on the order of 1000s per year.

Table III.D-3: Lessons Learned from Other Jurisdictions – Procurement, Contracting, and Scoping the Work

Item No.	Description
1	Provide a standard process and expectation related to invoicing when working with multiple contractors (one form for all contracts, offset invoice submittal schedule, enough back up provided with invoice). *Why? This will expedite accurate budget status reporting*

2	Delineate the roles and responsibilities regarding the Contractor and Client Representative communicating any aspect of LSLR work to Residents and ultimately to the regulatory agencies, consistent with the COE Plan. *Why? This will improve the effectiveness of the COE Plan and the overall LRP.*
3	Determine who will perform restoration efforts and describe scope in the Contract Documents accordingly. Consider hiring a separate contractor to be responsible for the restoration work, such that the LSLR crew is not responsible for any external restoration activities such as curb and gutter, landscaping (including turf), hardscaping, or sidewalk modifications, including: (1) filling any excavations on private property with removed soils (2) placing sod, concrete sidewalks and any concrete hardscaping in the public right of way (ROW) (i.e., in small sections of driveway) (3) completing final street paving, sidewalk replacement, and sod after the work order is completed. *Why? This promotes more efficient restoration work process and delegates the task a Contractor more specialized in this type of work. Note that Denver Water's current policy is to provide external restoration only.*
4	Determine the timelines and means and methods to communicate with the Property Owner (and Residents, if not the same) all aspects of the LSLR process. For example, the Client Representative should mail agreement packages to the Property Owners at least 45-days ahead of replacement. Details to be finalized in coordination with the COE Plan. *Why? This will inform the Property Owner of work to come and how they can prepare the property for the work. This will also allow the work to be performed efficiently, avoiding delays to obtain consent on the day of work.*
5	Describe expectations of the Contractor and Client Representative with respect to conducting Property Owner coordination meetings. The purpose of this meeting is to review the work process and potential restoration needs. Details to be finalized in coordination with the COE Plan, *Why? Supports maintaining the customer's trust in Denver Water while allowing the work to proceed efficiently.*
6	Allow one construction inspector (CI) per crew to keep up with reviewing the scope of work being performed, collecting the data necessary, and completing the daily paperwork. Communicate this expectation to the contractors bidding the work. *Why? Having adequate CIs will ensure work is accurately documented and uploaded to the lead service inventory in a timely fashion.*
7	Delineate roles and responsibilities for the Contractor and Construction Manager (CM) in the Contract Documents for who does what with respect to obtaining consent, flushing the service line post LSLR, and distributing filters etc. *Why? This will provide more transparency of expectations and accuracy during the procurement process, while reducing costs, protecting public health, avoiding duplication of effort and improving efficiency and quality of the LRP during execution*
8	Make mandatory the pre-bid conference to prevent excess time spent on RFP questions and unrealistic bids. *Why? Manages effort involved to procure the construction contracts*
9	Define the scope of work to attract companies that have the capability to operate with multiple crews simultaneously *Why? To improve consistency of the work while reducing the level of effort to manage all the Contractors.*
10	Demonstrate that contractors are qualified to perform the work. Contractors should be required to provide examples of projects with similar scale and scope to qualify for bidding. Unqualified contractors have shown that the critical schedules cannot be met, and the quality of work performed is lacking. *Why? To improve the quality of the work, to deliver on KPI expectations particularly related to budget and schedule.*
11	Manage the number of LSLR sites included in a work order (i.e., 200 to 500 addresses). *Why? Optimizing the Contractor's amount of work will lead to better management of their work load and*

	quality of work. This also allows the Program to be responsive to changing field conditions. The range of sites included in a work order will be determined during the annual ALSLR planning exercise.
12	Establish the needs for master plumbers to a) connect the service line to the water main, b) install water meter boxes where needed, and/or c) inspect the meter box installation as part of developing the contract documents. Require bidders to carry to master plumbers. *Why? Inadequate staff of plumbers could delay meter installs and leave Property Owners without water.*
13	Ease the evaluation of contractor bids by assuming that at least two full LSL replacements are completed per day per contractor crew. This is an average used for bidding purposes. If a crew works a 10-hour day, an average value of four LSL replacements will be completed per day. *Why? This will aid in the evaluation of bid pricing, assess level of effort bid, and determine how many crews are needed to meet the targeted rate of annual LSL replacements.*
14	Have Contractors be responsible for documenting conditions at a property before the work commences, using photographs with notes. This will then provide the basis of any customer questions about the work. *Why? This puts the onus of documentation (or proof) on the Contractor and reduces risk to the Owner.*

Table III.D-4: Lessons Learned from Other Jurisdictions – Delivery Risk

Item No.	Description
1	Large programs need protocols for reporting and tracking data in a consistent and timely manner that allows for QA review. Although it is reasonable to expect changes to data handling will occur over the life of the Program, managing these changes to reduce the risk of delays and potential claims is recommended. *Why? To promote quality and timeliness in data handling while providing some degree of consistency to the contractors with respect to executing the scope of the work.*
2	Strategies to promote continuity over the life of the Program should be built into the ALSLR Plan and LRP in general. For example, having a mechanism that promotes for knowledge transfer as staff assigned may change over the 15-year life of the program. *Why? To realize program efficiencies year-over-year and supporting the Learning-by Doing element of the LRP. The intent is to reduce the impact of delays or inefficiencies when transitioning from one year to the next.*
3	Know the stakeholders involved and collaborate work with them to earn support for the LRP in general. Manage stakeholders through the COE Plan. *Why? The LRP will benefit from stakeholder input and proactively managing this will limit the potential for surprises.*
4	The success of the ALSLR Plan depends on participation of the property owner (and resident if not the same person) and as such the number of replacements that can be completed each year depends on earning consent from the property owner as well as the resident performing certain actions. Coordination with the COE Plan and clear protocols for multiple opportunities to communicate with the property owner and residents need to be developed. *Why? Poor participation rates could make it challenging to meet the annual target for LSL replacements.*
5	With multiple capital programs operating in the neighborhoods, coordinating schedules among the various programs for water main, road work, or other infrastructure improvements will reduce the potential inconvenience to residents in addition to realizing schedule and cost savings. Annual planning efforts for the ALSLR Plan would benefit from incorporating schedule considerations from these other infrastructure programs. W*hy? This will demonstrate project organization to the Property Owners and reduce potential Property Owner complaints for extra work being performed.*

The proposed procurement strategy, contract documents to support the ALSLR Plan and the associated procedures that the work will follow are being developed based on the lessons learned from other jurisdictions and feedback received from area contractors at Industry Day and Pre-Qualification meetings.

Finding Lead and the Predictive Model

Introduction and Overview

Planning the annual lead service replacement locations and achieving the annual replacement numbers depends on knowing where lead services are in the system, so that replacement can be planned based upon:

- Individual premises with historic lead levels above 15 ppb and/or demographic risk; and
- Geographic areas with cumulative opportunities to reduce lead exposure.

As Denver Water updates its Lead Service Line Inventory (see section III.B), probability models can be used to predict where lead is likely to be found before proceeding with LSLR at a particular property. As further described in the Appendix III.B.3 (Predictive Model and Prioritization) and briefly described herein, the probability of a service line being constructed of lead will be incorporated into ALSLR planning efforts using the current service line categories as shown in Table III.D-5. To implement the ALSLR Plan, a list of properties on which to act must be extracted from the inventory on a regular basis (annually or more frequently). Actions on properties will be determined based on service line category. The service line categories and action groups in Table III.D-5 are based on the current model predictions.

Under the LRP Phase I inventory model, properties identified to have suspected or possible lead service lines will be enrolled in the Filter Program and provided with filters that are NSF certified for lead removal. Properties within LSLI Groups A and B (known, suspected, or possible lead service line, see Table III.D-5) are the focus of the ALSLR Plan as further described below. The properties with a suspected or possible LSL (Group B) will be subject to additional investigation methods and LSL replacement, if confirmed to be lead. The investigation methods will consist of either water quality sampling and/or potholing as necessary (in that order) to confirm service line material. A desk-top review will be performed along with COE as necessary on select properties unlikely to have a lead service. Frequent reviews of properties in the Predictive Model will be conducted to identify changes in Property's service line assumption category. Desk-top and field methods will be applied to the Group A and Group B properties to determine whether or not a lead service exists, with the intention of either replacing the LSL (if lead is confirmed) or removing the property from the Filter Program (if no lead is confirmed). The phased investigation methods are summarized in Table III.D-6 and were designed to answer the question "does the predictive model make sense" when assigning service line categories to properties. Details will be refined as the predictive model is used with subsequent updates to the LSLI each year.

Table III.D-5. Service Line Category and Actions

Group	Service Line Category	ACTION AND RESPONSES		
		Filter Program	Lead Inventory	ALSLR Program
A	Known lead service line	Provide Filter	Add to lead inventory as confirmed lead	1. Add to list for replacement 2. Remove from inventory / Filter Program through replacement
B**	Suspected and Possible lead service line	Provide Filter	Confirm materials (per Table III.D-6)	1. Add to list for replacement 2. Remove from inventory / Filter Program through replacement
C	Unlikely lead service line	Desk-top review / COE as necessary / Review Predictive Model output regularly for change in service line material assumption		
D	Confirmed to be lead-free	COE		
E***	Other (fire lines, recycled water taps, consecutive system)	No Action / COE		

*Table was developed using information in Appendix III.B.2 (Preliminary Identification of Lead Service Lines) and Appendix III.B.3 (Predictive Model and Prioritization).

(**) Water Quality sampling will be used to confirm the service line material for properties found in Group B.

(***) Inclusion in Group E is based on an application process, not likelihood of lead. Service lines will be maintained in the inventory. Should the application change in the future, COE material will be provided that indicates the water supply is not a suitable source of drinking water.

Table III.D-6. Summary of Phased Investigation Process

Service Line Category (probability value of lead service line)	Sequence of Investigation Method	Comment
Known or Suspected lead service line (≥ 0.8)	Confirm lead as part of replacement planning	For a property with a probability value of 0.8 or higher, the property is treated as if there is a known lead service with an investigation as part of the replacement activities.
Possible lead service line (≥ 0.5 to < 0.8)	These properties will be provided with a filter that is NSF certified for lead removal in year one of the LRP. During year one, Denver Water will perform additional work to update the probability value determination and categorization of the property as having a known lead service line or non-lead service line. o For example, a property with a probability value of 0.7 or higher* will first be subjected to a visual inspection, following by potholing, and if necessary, excavation to confirm the service line material. o For example, a property with a probability value of 0.6 to 0.8*, the data used to determine the p-value will be reviewed, followed with water quality sampling and contact with the property owner to understand the history of upgrades to the property.	Denver Water will focus on investigations independent of lead service line replacements to build back-log for the ALSLR Program in subsequent years and confidence in the Predictive Model.
Unlikely to have a lead service line (< 0.5)	Review historical data used to determine the probability value: does the data make sense and can outliers be explained? o If not, follow-up with water quality sampling to assess likelihood for finding lead o If water quality sampling results are inconclusive, visit the property and conduct visual assessment and contact property owner to understand history of updates to the property, if any If still inconclusive, proceed to more invasive field inspections, starting with potholing.	Where a low probability value is determined for a property that appears to be an anomaly in a street or neighborhood with known lead services, Denver Water will review the factors that contributed to the probability value determination and escalate investigation as needed to confirm the presence of lead or non-lead.

(*) Indicates that the probability values are subject to change as the inventory is better detailed.

Preliminary 2020 ALSLR Plan for Discussion Purposes

The 2020 ALSLR Plan will focus on Groups A and B as outlined in Table III.D-7. Within each of these Groups, Denver Water has categorized three LSLR Groups by various types of LSL properties' conditions (Table III.D-7); Geographic LSLR Area, Individual LSLR, and Investigations of LSL types. The estimated number of LSLRs used in the 2020 ALSLR Plan is 5,250 LSL and is based on the August 2019 estimate of 63,955 LSLs with a 15% safety factor. The LSLR volumes in each category will be further developed as the LRP matures over the next 2 to 4 years and as the predictive model is

better calibrated using the Group B investigation results as well as information from Group A replacements.

Table III.D-7. 2020 ALSLR Plan Summary

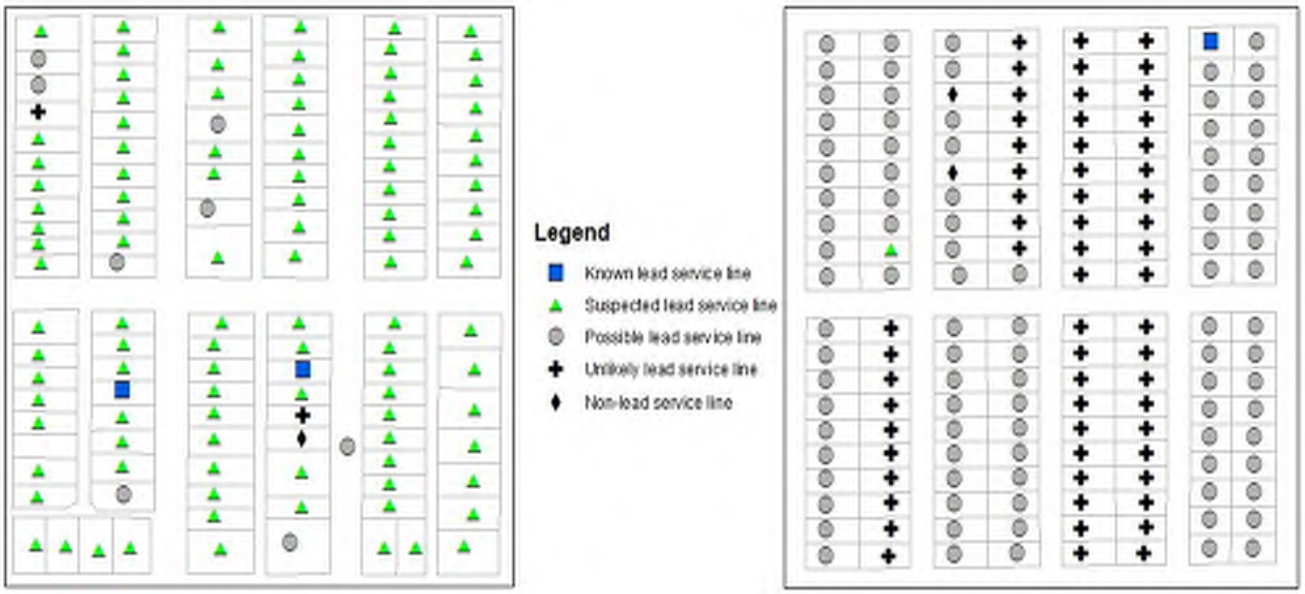
Group/Type		Est. Annual LSLR & LSL Investigation	Group Subtotals for Est. Annual LSLR and LSL Investigation
GROUP A – LSLR by GEOGRAPHIC AREA	Water main Replacement	400	
	Block by Block or Street by Street	3,000*	
	Municipal Pavement and Road Improvement Programs	450*	3,850*
GROUP A – LSLR by INDIVIDUAL	Leaks	300	
	Individual & High Priority LSLR	600*	
	Scrape Off and Redevelopment Properties	500	1,400*
GROUP B - INVESTIGATION	Investigations for areas with suspected and possible LSL	500*	
	Water Quality Testing of areas with expected or somewhat expected to have LSL	1,500*	2,000*

(*) asterisk indicates the values are subject to change.

A geographic depiction of an initial 2020 ALSLR Plan is presented below to provide an example of how the predictive model will be used to help plan the work. The example below incorporates the estimated ALSLR and LSL Investigations in Table III.D-7 (to be updated per the LSLI). In general, the Geographic Area defined by Group A (known lead) is expected to have higher per day of LSLR rates resulting from reduced effort for mobilization/demobilization while Individual LSLRs will have a lower LSL replacement rate as the result of greater efforts needed for mobilization/demobilization across an expanded geographic area. The ALSLR Plan will incorporate individual LSLRs within the Geographic Areas when located near each other and it is practical to do so.

The Geographic Area map of Figure III.D-A integrates various prioritization and risk parameters to allow the criticality of geographic areas to be ranked; this in turn is used to determine the highest priority areas to plan for a given program year's ALSLR inventory to be addressed.

Figure III.D-A. Geographic Area (left) and Individual (right) Map Visual Representation



An example of Geographic Area LSLRs (left-side) from Group A (known lead) are shown above in Figure III.D-A. As an example, the blue (square), green (triangle), and grey (circle)colors (symbols) reflect known lead, suspect lead, and possible lead service lines, respectively. The properties, shown on the right-side map, are individual LSL properties identified in a predominately non-lead area. The properties were recognized as a high risk based on prioritization parameters that use a consequence risk analysis. Individual properties may not be in highly concentrated areas like in the geographic areas. A separate ALSLR strategy is developed for Denver Water to mobilize LSL replacement crews to address these high-risk individual properties since the level of effort will not be comparable to LSLRs in the Geographic Area model. However, the impact of replacing these Individual LSLs is just as important in terms of public health.

Properties types targeted for Individual LSLRs include:

- multi-family units,
- daycare centers,
- private schools*, and
- health facilities.

These property types have a broader impact on Denver Water's customer base because their service lines provide clean drinking water to more than a single-family or customer.

*Service lines at all Denver public schools have been replaced.

A prioritization parameter, for both Groups A and B, is municipal (infrastructure) project data (i.e., planned project locations and times) which is used to aid in determining key areas to perform work, whether it's pavement restoration or water main replacement. Incorporating these municipal projects into the ALSLR work is key because of the ability to reduce disturbances to Property Owner's, reduce project costs, and facilitate service line material investigations.

Accelerated Lead Service Line Replacement Plan

Denver Water Lead Service Line Standards

Denver Water has years of experience executing LSLRs both as part of water main replacement projects as well as at individual properties. Denver Water plans to utilize their existing lead service line replacement design standards to act as a guideline for LSL replacement process completed under the ALSLR Plan. The Denver Water LSL standards state that lead service lines shall be replaced with copper service lines, provided that Denver Water is given consent by property owners. Denver Water's

goal under the ALSLR Plan is to replace all non-copper (lead or galvanized downstream of lead) service lines from the water main to the first fitting inside the residents dwelling. The ALSLR Plan goal is to replace LSLs at a cumulative program year average replacement rate of 7.0% throughout the 15-year program.

To achieve this goal, the ALSLR Plan will require close coordination among the Filter Program, Approvals/Permits, COE Plan activities, LSLI and predictive modeling tasks, and the various stakeholders during the full life-cycle of the LSLR process. Denver Water's continued proactive approach to LSLR will require activities to be closely coordinated during three phases of the LSLR: Pre-Construction Phase, Construction Phase, and Post-Construction Phase.

ALSLR Pre-Construction Phase

The Pre-Construction Phase uses the predictive model's biannual identification of Group A and B LSL replacements and investigation of properties (see Table III.D-8), based on the hierarchical approach described earlier. These properties classified in Group A and B categories will be the focus of the ALSLR. The properties included in Group A are to be replaced in the given year based on a geographic or individual approach. The Group B properties are scheduled for investigation of the service line material type in a given year. The investigation process will require potholing and/or water sampling to determine the expected material type of the service line. If any part of the service line material is verified as lead, the properties service line information will be updated in the LSLI. The properties will be allocated to the appropriate ALSLR Group for replacement in the future. If the service line material is verified as copper, then the service line information will be updated in the LSLI, and the properties will be removed from the LSLR list. The property information will be used by Denver Water to obtain the necessary permits and approvals from the respective agencies to conduct LSL replacements. The COE Plan describes how to inform property owner (and residents, if different) of the upcoming LSL replacement. Concurrently, the Filter Program will coordinate with the resident(s) to ensure the filter devices are made available and being used.

Denver Water's current LSLR program has a standard communication timeline. The Denver Water timeline illustrates the responsible parties and specific times before, during, and after construction when Denver Water staff must contact Property Owners. The Denver Water communications outline for LSL replacement (see Figure III.D-C) will act as the foundation with updates as necessary for the larger Denver Water ALSLR Pre-/Post-Construction Property Owner Communication Timeline.

Trained program staff will distribute and collect signed Resident Consent forms to perform LSL replacement, and conduct with consenting residents a detailed explanation of the work to be performed and address any questions residents may have. A LSLR Contractor will then proceed to verify the service line material prior to starting LSLR work. Pre-Construction activities are designed to enhance the LSLR rates through earlier identification of lead services at properties with unknown service materials. Furthermore, Denver Water will document pre-construction conditions (exterior and interior) for all properties consenting to LSL replacement.
In summary, this delivery process with the associated plans overview, objectives, and metrics being measured are described in Table III.D-9 and are intended to lay the ground work for successful LSL replacement through close collaborations with all LRP elements.

Table III.D-8. LSLR Contracting Groups Summary

LSLR Groups	Descriptions
Group A (Known Lead) - Geographic LSL Replacement Area	**Water main Replacement -** Confirm service line material and replace LSLs concurrently with water main replacement projects.
	Block by Block or Street by Street - Confirm service line material and replacement of LSLs on Blocks or Streets. These are LSL replacements that are confirmed to have a partial- or full-lead. High priority properties will be integrated via the prioritization model. For more details, see the Appendix III.B.3 *Predictive Model and Prioritization*.
	Municipal/Transportation/Pavement Improvements - Confirm service line material and replace LSLs in coordination with Municipal, Transportation, and/or Pavement improvement projects.
Group A (Known Lead) - Individual LSL Replacement	**Individual and High Priority** - Confirm service line material and replace LSLs for properties providing water to day-cares, schools, nursing, jails, dialysis and critical customer facilities. Properties are known to have high lead concentrations (> 15 ppb) and consequence (depending on risk factors).
	Redevelopment and Scrape Offs - Confirm service line material and remove existing LSLs. Developer to install new service line and tap.
	Leaks - Confirm service line material and replace LSLs jointly with Denver Water's service leak repair projects.
Group B (Suspected or Possible Lead) - LSL Investigation	**Investigation** – Potholing and/or water sampling LSL inventory with a relatively high probability of lead classification (possible or suspected, $p \geq 0.5$). Work is to be performed separately from LSL replacement contracts. Intent is to verify if service lines are lead or non-lead.
	Declined Consent Investigation – If Resident Consent is declined, the service line material to be verified will be listed in the LSLI as not verified and placed on a list of non-consenters and supplied to Denver Water legal department. (TBD per Approved Non-Consenter Policy)

Figure III.D-C. Denver Water's Communications Outline for LSL Replacement

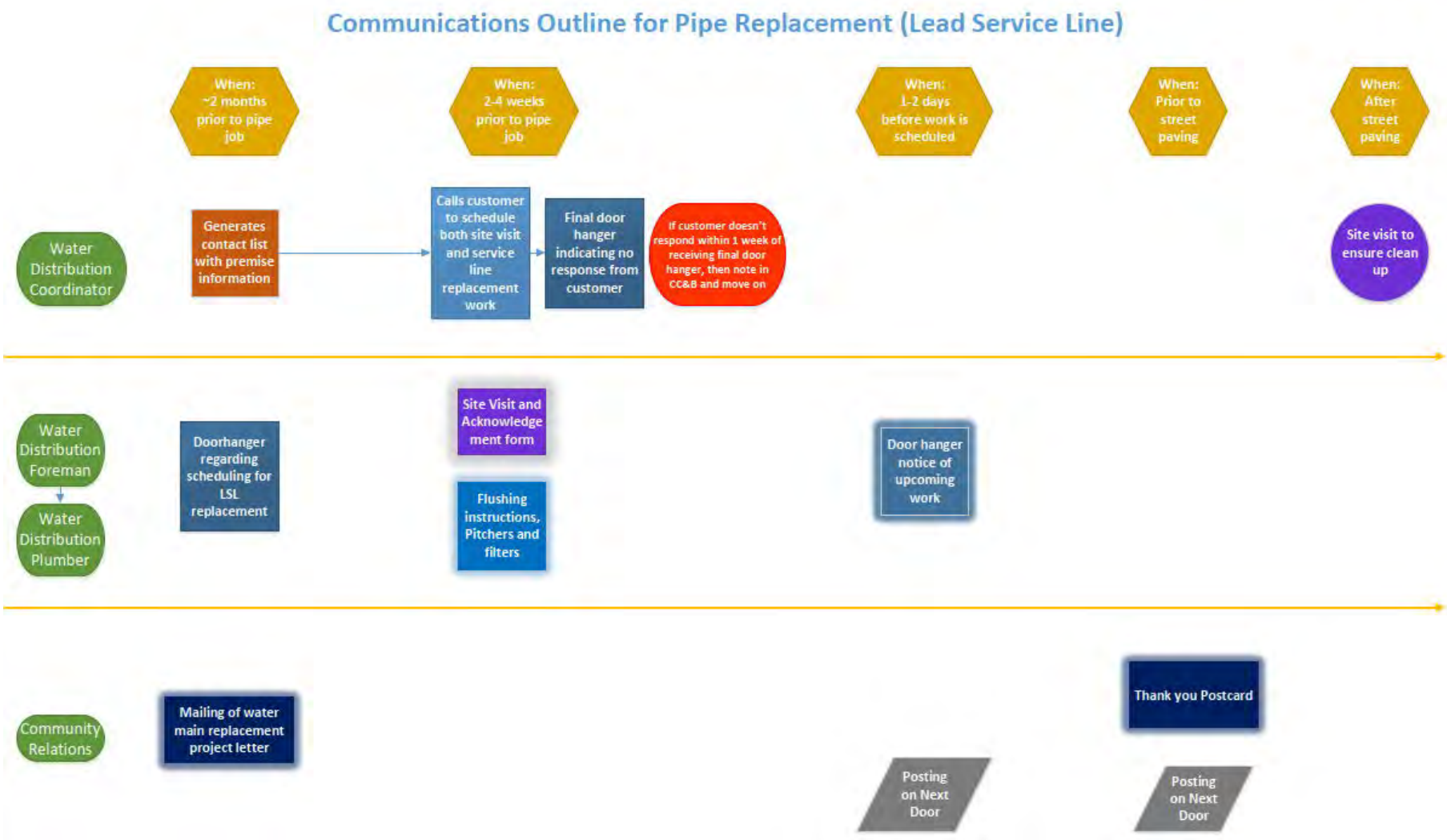


Table III.D-9. LSLR Pre-Construction Components

PREDICTIVE MODEL	APPROVALS / PERMITS	COE ALSLR PLAN
OVERVIEW		
The predictive model uses the lead service line inventory to annually plan the works schedule for Group A (Geographic and Individual LSLRs) and Group B (LSL Investigations) using a hierarchical approach as described above in Table III.D-8. The Group B properties will consider field investigation results.	Obtain the necessary approvals, permits, and documentation prior to ALSLR work, including local governments, property owners and residents with a known, suspected, or possible LSL. The Resident Consent Form is an important approval and the protocol to engage the property owner and resident is described in the COE Plan.	The COE ALSLR Plan will engage public stakeholders and residents in seeking customer/resident approvals to move forward with LSLR. Program representatives will work closely with all public stakeholders and residents/customers to perform the necessary COE activities. The COE Plan describes up to three touch points with residents to confirm and obtain Resident Consent Form Approval. Efforts will be coordinated with the COE team.
OBJECTIVES		
• Define annual ALSLR Plan. • Categorize replacements into ALSLR work groups: Investigation (green), Per Area (blue), and Individual (orange) • ALSLR work groups will act as the basis for Contracts o *Per Geographic Area* will be completed in a Block by Block or Street by Street manner. o *Individual* will include single LSLs in non-concentrated area and locations at properties determined to be of high lead potential and consequence. o *Investigation* will classify services based on likelihood (suspected or possible) that line is lead that requires confirmation. • Improve calibration of the predictive model as service line materials are confirmed; update predictive model twice a year. • Maintain independent LSL Investigation Contracts to support year-over-year planning by eliminating uncertainty of lead service line materials. o If service line is verified (potholed) to be lead, after Property Owner consent is received, it will be re-allocated to the appropriate ALSLR work group. o If Property Owner consent for investigation is declined, the service line material to be verified will be listed in the LSLI as not verified and placed on a list of non-consenters and supplied to Denver Water legal department. ((TBD per Approved Non-Consenter Policy)	• 8 Weeks Prior to Construction (timing to be confirmed): o Apply for necessary permits (CC&B, Municipality Traffic Control Plan, Tree Protection, Stormwater Permit, Stormwater Management Plan, Dewatering Permit, Sewer Discharge Permit, Street Restoration Plan, Street/Occupancy Permit, and Regional Building Permit). ***Note:*** *Estimate of the permits needed, will vary by geographic location of service line replacements.* • 6 Weeks Prior to Construction: o Program schedules a coordination meeting with property owners and answers any questions. • 4-5 Weeks Prior to Construction: o Program holds a coordination meeting with property owners, performs a pre-construction site inspection, and determines the tie-in location of service line. • 2-3 Weeks Prior to Construction: o Contractor will contact Denver Water Sales Administrators to schedule a water main tap and survey the property for utilities. o Contract must verify any conflicts noted during utility survey prior to LSLR. • 2 Weeks Prior to Construction: o Program will follow-up with any non-responsive property owners to obtain consent to perform the LSLR. o If consent is declined by property owner, Denver Water will follow non-consent procedure.	• 45-Days Prior to ALSLR Construction: o Mail LSL replacement project letters and consent form to the property owners (in their first language). • 4-5 Weeks Prior to Construction: o Program places signage in the geographic area for reminder of LSLR work to be performed. • 2-3 Weeks/Days Prior to Construction: o Program distributes informational door hangers. o Follow-up with property owners to address any uncertainty about the upcoming work and confirm they have signed the Resident Consent Form. • 1 Day Prior to Construction: o Provide 24-hour water outage notice in advance of LSL replacement.
METRICS		
The metric to assess performance is outlined in Appendix IV.A.	The metric is to obtain Approvals and Permits to achieve a confirmed ALSLR with a backlog of 4 Weeks of approved Resident Consent Forms.	The metric to assess performance is detailed further in Appendix IV.A.

TABLE III.D-9. LSLR Pre-Construction Components (Continued)

FILTER PROGRAM	ALSLR PLAN
OVERVIEW	
Customers with known, suspected, possible lead service lines will be automatically enrolled into the Filter Program and supplied with a filter kit and educational materials regarding use of the filter.	Activities will include confirmation that the Contractor has obtained the necessary approvals and permits, has all equipment and materials mobilized to the site, and is ready to commence with the ALSLR.
OBJECTIVES	
• 4-5 Weeks/Days Prior to Replacement: o Denver Water distributes additional NSF certified filters to remove lead, if required, during the property owner coordination meeting. • Denver Water to reinforce the message of continued use of the filters that are NSF certified to remove lead through six (6) months following LSLR.	• Contractor mobilization is complete and necessary plans, permits, and approvals are in place. • Safety Plans are in-place and Crews are briefed. • COE and Filter Plans have been reviewed. • Proactively obtain Resident Consent forms. • Contractor staff trained on how to engage with the public, who to contact for help, how to safely enter a property, etc. • For properties where consent for the LSLR is not earned, the property will be placed on a list for follow-up and CDPHE notified.
METRICS	
The metric to assess performance is detailed further in Appendix IV.A.	The metric to assess performance is detailed further in Appendix IV.A.

ALSLR Construction Phase

Once the Pre-Construction Phase activities have been addressed, the ALSLR Contractor will proceed to replace LSLs per the contracting model (see Table III.D-8). The Construction Phase focus is to replace lead service lines that are known or have gone through an investigation process that has confirmed the presence of lead service lines and/or galvanized downstream of lead. The investigation process is conducted using the progressively calibrated predicative model. Based on the determination, the Program will actively work with property owners to replace the lead service based on Property Owner/Customer approval of the Resident Consent Form. The different possible insitu lead service line configurations are shown in Figure III.D-D.

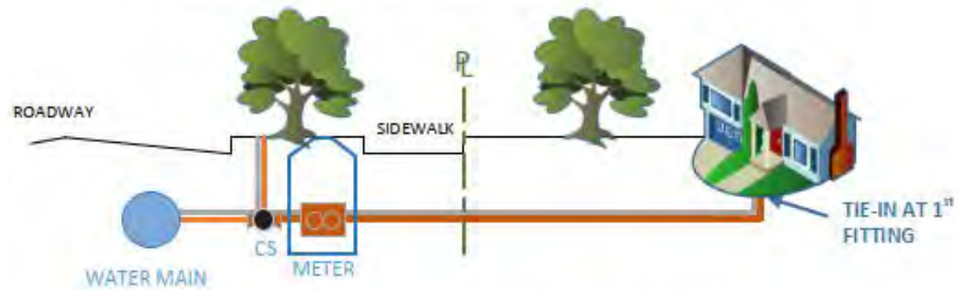
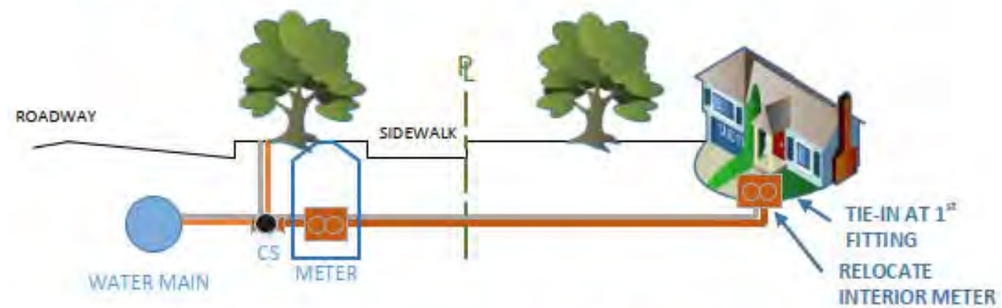
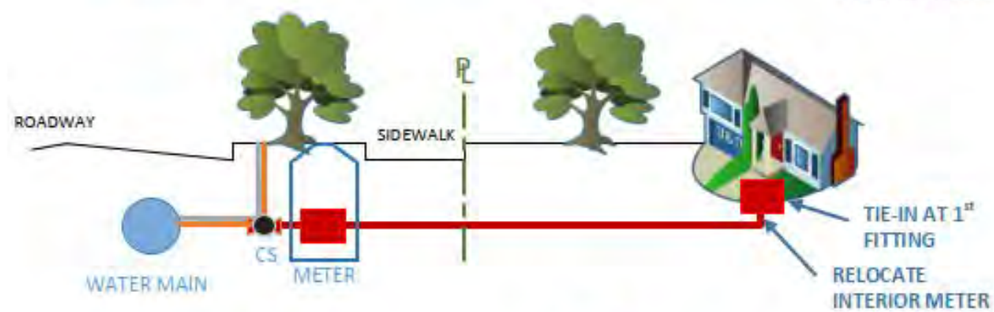
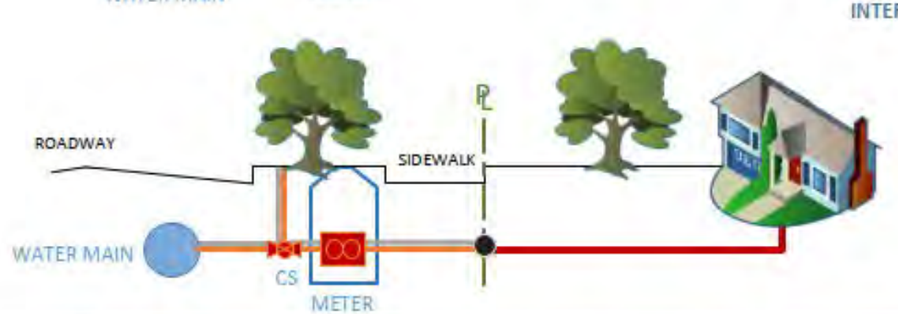
Denver Water will use the configurations of Figure III.D-D to document the level of LSLR and report the LSLR credit toward the total number of replacements completed each program year. In addition to the full replacements illustrated in Figure III.D-D, Denver Water may have a unique scenario that requires only partial LSLR. When Denver Water replaces water mains, the existing service line will need to be transferred from the old water main to the new water main. This LSLR activity provides Denver Water the opportunity to replace Property Owners service lines. If the existing service line at the water main is identified as lead, Denver Water will request resident consent to investigate the service line's material up to the first fitting inside the dwelling. However, if the property owner does not consent to having their lead service line replaced, Denver Water will only replace the LSL up to the meter regardless of the service line material from the meter to the first fitting inside the dwelling. This will not be considered a partial replacement, and it will not contribute to the cumulative program year average 7.0% LSLR.

During construction, Denver Water's Construction Inspectors (CIs) will provide field quality assurance and quality control (QA/QC) oversight for the work being performed by contractors to ensure compliance with the Contract Documents and Specifications. LSL replacement work will be overseen in the field by CIs; and the Project Engineers will review the LSL replacement data submitted, by the CI or Contractor, based on the work completed in the field. The Project Engineers will review the LSL replacement data or any reports, to ensure it is correct, before including it into the LSLI database for use by the Predictive Model.

ALSLR Post Construction Phase

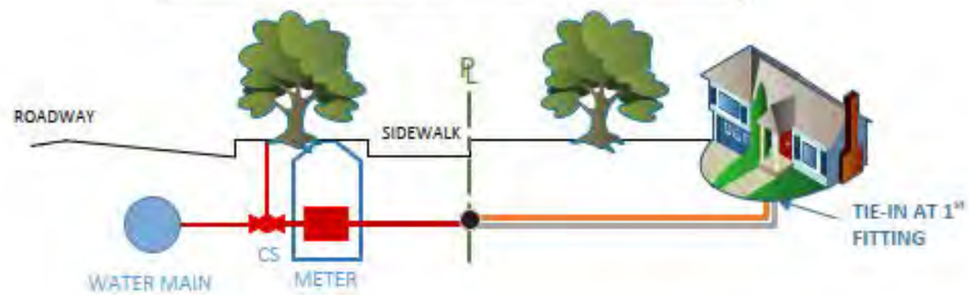
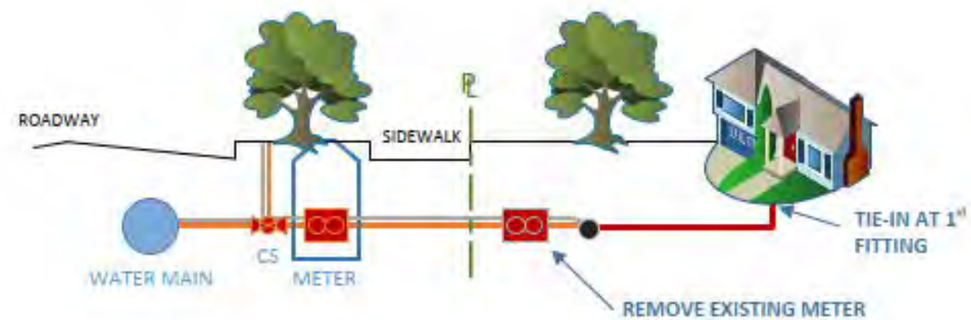
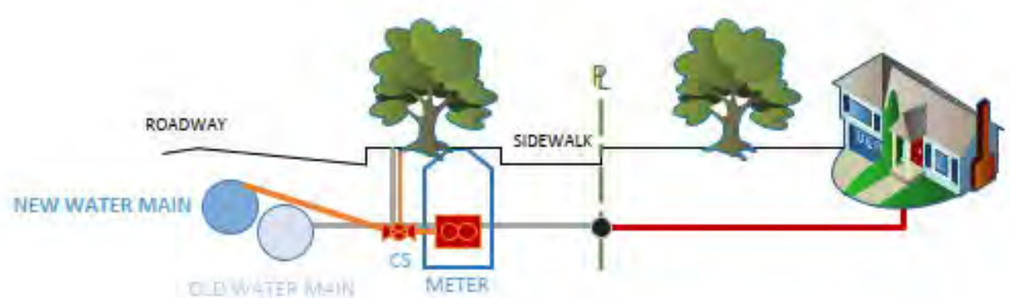
Once the LSLR has been completed through the Construction Phase, the ALSLR will move forward to the Post-Construction activities to ensure the new copper service line is ready for use per AWWA/ANSI Standard C810-17 (Standard C810-17) for Replacement and Flushing of Lead Service Lines. Upon completion of the flushing procedures and water quality testing, the property's results of LSL replacement will be recorded and stored in the appropriate data management system. The Post-Construction Phase activities are further highlighted in Table III.D-10 for each component of the LRP.

Figure III.D-D. Non-Copper Service Line Replacement Scenarios

SCENARIO TYPES	SCENARIO ILLUSTRATIONS	SCENARIO DESCRIPTIONS
Full LSLR with Exterior Meter		1. Replace lead service line (LSL) from the water main to the 1st fitting inside the building with copper. 2. Install new tap on water main. 3. Install a new meter and meter box in the Public Right Of Way (ROW). 4. Remove and install new curb stop (CS).
Full LSLR with Interior Meter		1. Replace lead service line (LSL) from the water main to the 1st fitting inside the building with copper. 2. Install new tap on water main. 3. Relocate the existing meter from inside the building. Install a new meter and meter box in the Public Right Of Way (ROW). 4. Remove and install new curb stop (CS).
LSLR at Curb Stop with Interior Meter Relocation		1. Replace lead service line (LSL) from the water main to the curb stop. 2. Install new tap on water main. 3. Relocate the existing meter from inside the building. Install a new meter and meter box in the Public Right Of Way (ROW). 4. Remove and install new curb stop (CS).
LSLR in Public ROW with Exterior Meter		1. Replace LSL from the water main to the property line with copper. 2. Install new tap on water main. 3. Remove and install a new meter and meter box in the Public ROW. 4. Remove and install new CS

LEGEND: EXTENT OF EXISTING LEAD OR GALVANIZED DOWNSTREAM OF LEAD — EXTENT OF EXISTING COPPER — EXTENT OF REPLACED COPPER — TIE-IN TO NON-COPPER EXISTING SERVICE

Figure III.D-D. Non-Copper Service Line Replacement Scenarios (Continued)

SCENARIO TYPES	SCENARIO ILLUSTRATIONS	SCENARIO DESCRIPTIONS
LSLR with Lead Service on Private Property		1. Remove LSL from the property line to the 1st fitting inside the building with copper. 2. Tie-in new copper service on private property to the copper service on the public property.
LSLR on Public and Private Property with Exterior Meter Relocation		1. Replace LSL from the water main to the 1st fitting inside the building with copper. 2. Install new tap on water main. 3. Remove and install a new meter and meter box in the Public ROW. 4. Remove and install new CS.
Water Main Replacement without Consent		**Consent not given by Property Owner to replace LSL during Water main Replacement Project:** 1. Replace LSL from old water main to the meter. 2. Install tap on new water main. 3. Remove meter and install new meter with copper service line. 4. Remove and install new CS. 5. Inform Property Owner that non-consent will result in a Lien on the Property's Title.

LEGEND: EXTENT OF EXISTING LEAD OR GALVANIZED DOWNSTREAM OF LEAD — EXTENT OF EXISTING COPPER — EXTENT OF REPLACED COPPER — TIE-IN TO NON-COPPER EXISTING SERVICE

Table III.D-10. ALSLR Post-Construction Components

PREDICTIVE MODEL	APPROVALS / PERMITS	COE PLAN	FILTER PROGRAM	ALSLR PLAN
OVERVIEW				
The LSLI will be updated with ALSLR information to reflect progress to refine the Predictive Model.	The approvals and permits must be closed out, once Group A - Geographic Area is complete.	Program team will notify the property owner of the water quality sample results and provide additional support as needed after the LSL replacement.	The Filter Program does not end with LSL replacement, Denver Water will deliver to the Property Owners the necessary information and materials to conduct a property plumbing flush and how to obtain a water quality sample.	Property Owners (Residents) will receive a new copper service line and restoration is completed.
OBJECTIVES				
• The LSLI database will be updated through ongoing reporting and provide the Predictive Model the necessary information to develop the annual LSLR program. • The LSLR crew rates will be documented to demonstrate the replacement rate of crews in the periodic LSLR progress reports. • Current year LSL replacements will be monitored to confirm Denver Water is meeting the cumulative program year average replacement rate 7.0% target.	• Once water service has been returned to the property owner, the Program will schedule restoration work to be completed on the property. • Provide list of properties where consent is denied to Denver Water legal department and CDPHE for follow-up. • Place/designate non-consent residents into Denver Water LSL inventory as noted for future follow-up.	• Program team to provide education materials to describe how and when to flush the home by the resident. • Program team to distribute water quality sampling kit, four (4) months after the LSL replacement. • Program team will inform the property owners of the water quality sample results for the four (4) month post replacement sample. • If water quality sample test result reveals lead level is high, the Program team will reach out to the property owner to provide additional education materials on how to identify potential sources of lead within the dwelling (plumbing), provide information on additional mitigation measures, and contact information for Community Organizations.	• Program team will communicate with the property owner with handouts to ensure the property owner understands the flushing and sampling programs that will be required post-construction. • Program team will continue to supply filter cartridges that are NSF certified to remove lead, as needed, up through six-months following the LSLR.	• Program team to perform 15-minute service line flush immediately after replacement. • Contractor commences restoration of the Resident's property to its pre-construction condition, which will be based on documentation obtained prior to construction. • Any non-salvageable materials generated from construction will be disposed of in accordance with the local regulations. • CI completes post-construction documentation (videos/photographs) of all areas restored.
METRICS				
The metric to assess performance is detailed further in Appendix IV.A.	• No outstanding Permits with municipalities. • Inspection approvals are received.	The metric to assess performance is detailed further in Appendix IV.A.	The metric to assess performance is detailed further in Appendix IV.A.	The metric to assess performance is detailed further in Appendix IV.A.

ALSLR Contracting Strategy

Introduction

Denver Water and other third parties have been replacing approximately 1,200 LSLs over the last few years. To meet the 7.0% program year ALSLR rate, Denver Water will contract with outside resources for the additional LSLR crews as discussed above. The proposed contracting strategy is to seek qualified local contractors to support Denver Water LSLR crews to meet the 7.0% program year ALSLR rate. The procurement strategy must consider approaches to the three LSLR groups discussed in Table III.D-8: geographic area, individual LSL, and LSL investigations. Denver Water will strive through planned Industry Day events to inform the Denver Metro contracting community of the LRP's goals, objectives, and resource needs. Through Industry Days and a qualification-based selection process, Denver Water will proactively identify a shortlist of qualified ALSLR Contractors and the number of LSLR crews needed to meet the planned replacement rate. Denver Water will use a pre-qualification approach to select qualifying contractors from the qualified contractors list, request price bids that will be used in selecting the most responsive and lowest cost contractors that can either individually or collectively provide the needed ALSLR crews to support in accomplishing the 7.0% ALSLR rate.

Overview LSLR Contract Types and Goals

The different LSLR groups and contract types from Tables III.D-7 and III.D-8 will be categorized through the Predictive Model to guide the Program in the ALSLR planning and contracting strategy. Based on these LSLR groups and contract types, a rough order of magnitude (ROM) estimate was developed for the annual LSLR volume for each of the main LSLR Groups supported by each sub-group category as shown in Table III.D-11. The estimated annual LSLR targets were defined using present Denver Water replacement rates and those from other jurisdictions. The 2 LSLR crew replacement rate selected ensures Denver Water will achieve the goal of 5,250 LSLRs per program year. Group A utilizes this replacement rate. Estimated annual LSLR volumes (with an asterisk) are determined from historical data, while LSLR volumes (with no asterisk) are estimated values assigned to each group type to meet the 7.0% cumulative average LSLR. The annual work days of 200 is used to determine the total number of annual LSLRs per group type. To maintain consistency with Table III.D-2, the estimated replacements per group type is set at 2 LSLRs per crew. The replacement rate used in the calculated volumes and rates consider production differences between LSLR crews per each group type due to the nature of the work. The difference in group type production efficiency is what attributes to the number of LSLRs per day minor differences. In summary, Denver Water will need approximately 13 ALSLR crews to achieve the 7.0% LSLR cumulative average. Scrape offs/Redevelopment Properties will be performed by their respective developers and hence, Denver Water will not be providing LSLR crews for this work. However, Denver Water through the collaboration with the City and County of Denver will define a SOP to work closely to monitor these activities and account for LSL being replaced.

Table III.D-11. ROM of Annual LSLR Volume Summary

LSLR Group Type		Est. Annual LSLR Completed	Est. LSLR/Day	Est. LSLR Crews	Pre-Const. Scope	Construction Scope	Post-Const. Scope
GROUP A - GEOGRAPHIC AREA	Water main Replacement	400	-	-	Coordinate, schedule w/ Denver Water, COE	Verify and Replace LSL	Filter, Flushing and Restoration Work
	Block by Block or Street by Street	3,000*	15.0	5	Permitting, COE	Verify and replace LSL	Flushing, Restoration Work
	Municipal Pavement and Road Improvement Programs	450*	2.25	1	Permitting, COE	Verify and Replace LSL	Filter, Flushing and Sampling, Restoration Work
	Subtotal	3,850*	17.25	6			
GROUP A - INDIVIDUAL	Service Line Leaks	300	-	-	Permitting, Notifications	Leak Repair Verify and Replace LSL	Flushing, Restoration Work
	Individual & High Priority LSLR	600*	3.0	2	Permitting, Notifications	Verify and Replace LSL	Flushing, Restoration Work
	Scrape Offs and Redevelopment Properties	500	-	-	Permitting, Coordinate with Property	Replace or Remove LSL Based on New Use	Filter, Flushing and Sampling, Restoration Work
	Subtotal	1,400*	3.0	2			
	Combined Total	5,250*	20.75	8			
GROUP B -INVESTIGATION	Field Investigations for areas expected or somewhat expected to have LSL	500*	5.0	1	Permitting, Notifications	Field Verify LSL	Restoration Work and Report Findings
	Water Quality Testing of areas expected or somewhat expected to have LSL	1,500*	-	-	Notifications	Obtain Water Quality of Property	Report Findings
	Total	2,000*	5.0	1 - 2			

(*) asterisk indicates the values are provisional and subject to change.
(-) hyphen indicates that these group types will be completed by internal Denver Water crews.

As shown above, Denver Water's Preliminary 2020 ALSLR Plan estimates approximately 5,250 planned LSLRs and does not include the Group B investigation category since no LSLR will be conducted as part of these investigations. Denver Water will use external contracted crews to staff up

to 13 ALSLR crews to meet the 7.0% cumulative program year average replacement goal. The Group B, Investigation category has not been included in the total due to the difficulty determining the number of non-lead service lines that will be encountered. However, the investigation category has been established to assist Denver Water in better understanding the LSL inventory that has been identified, via water quality testing or investigation activities, in areas of their system that are defined in Group B – suspected and possible to contain LSL. As discussed in the LRP, where contractors are conducting investigations only, if copper service lines are found, the lead service line inventory will be updated to reflect the copper service and be incorporated into the 7.0% compliance count. Residents in the Filter Program, found to have a non-lead service line, will be removed from the Filter Program.

Contractor Performance

In late 2019, Denver Water plans to solicit and shortlist qualified Contractors to support the ALSLR Plan. Denver Water will be seeking to identify a minimum of 16 LSLR crews or more as needed to conduct the ALSLR work in 2020. Denver Water reviewed two types of ALSLR contracting strategies;

- **Option 1 - On a single-year basis** - request price bids from the shortlist of qualified contractors to obtain the necessary qualified crews prior to the following program year (2020) ALSLR work. By awarding a finite quantity for each work type over a defined period, contractor performance can be monitored and if necessary, determine paths for improvement. This will allow Denver Water to reward the outperforming contractors with additional work during the contract period based on adjustments to their bid quantities and if necessary, unit price adjustments. The annual single year contract award will keep bid quantities and associated prices to a defined and manageable amount and scope. This will allow Denver Water the ability to manage the various aspects of the LSLRs and ensure the specific areas and needs are completed in a timely manner prior to moving to another location. This contracting process would repeat each program year by soliciting price bids from the qualified shortlist. Under the multi-year contract, task orders would be issued to the selected contracts for approximately 200 properties to help in managing the annual ALSLR program and if needed, to make adjustment during the program year.

- **Option 2 - On a multi-year basis** - request bids from the shortlist of qualified contractors to obtain the necessary qualified crews prior to the following program year (2020) ALSLR work. Denver Water will award the first-year (2020) contract to the most responsive and low-price contractor(s). The multi-year contract would have a two or three-year extension clause that would allow for annual unit quantities and price adjustments. The option for the subsequent program year's ALSLR work will be based on contractor performance: If ALSLR targets are not being met, the Contractor will be removed from the LRP. if it is determined that ALSLR targets are met, Contractors will be given the option to extend their contract for the next program years' work after successful negotiations on their unit prices. The multi-year contracts will continue with maintaining/updating bid quantities and associated prices to a defined and manageable amount and scope. This will allow Denver Water the ability to manage the various aspects of the ALSLRs and ensure the geographic and individual LSLR areas and needs are being addressed in a timely manner prior to moving to another location. Under the multi-year contract, task orders would be issued to the selected contracts for approximately 200 properties to help in managing the annual ALSLR program and if needed, to make adjustment during the year.

Denver Water favors Option 2 because of the flexibility in contracting and reduction in administrative costs to repeat the annual contracting and bidding process if not warranted. In addition, this will allow Denver Water the opportunity to adjust bid schedule unit prices (increasing or decreasing) which reflect competitively priced field tasks. In addition, this option will incentivize Contractors to perform at a higher-level of production and quality while meeting the overall LSLR goals. The incentive clause will consider three primary objectives; safety, quality, and replacement rates. Furthermore, within the first 90 days, Denver Water will use lessons learned for improvement and adjustment to the overall ALSLR

process. This multi-year approach will allow Denver Water the opportunity to make Contract Document adjusts prior to subsequent program years' work extensions or during the recomplete of new contracts.

Learning by Doing

Denver Water's business practice is founded on the philosophy of continual improvement and development as an organization. To that end, Denver Water will instill this philosophy through the Learning by Doing element of the LRP into the ALSLR Plan and the associated construction contracts. Bi-annually, the Learning by Doing approach will include Roundtable Partnership Meetings that will be conducted with ALSLR contractors to discuss and articulate lessons learned to promote greater safety, quality, LSLR crew efficiencies, and opportunities for improvement in all areas of the ALSLR Plan including being good neighbors in the community. The Learning by Doing approach will provide a sounding board for contractors to discuss opportunities for improvements that will help meet ALSLR objectives and provide a better understanding of issues that have arose during the program year (see Table III.D-12 for proposed discussion topics).

Table III.D-12. Learning by Doing Meeting Schedule and Proposed Topics

Meeting Type (Month)	Key Topics Discussion Items
2nd Quarter Review	Safety Review, Communications (between Contractor-Denver Water and Contractor-Property Owner), Delays (Field Issues), Risks, Data Management (Submittal of information), LSLR Process (Best Practices), Other
4th Quarter Annual Review	Safety Review, Communication, approvals/permits, filter, Contracting (Resources), Procurement (Unit Pricing), Replacement Rates vs. Target, Improvements to Contract & Specifications, Restoration, Data Management, Risks Review, Other Risks and Items not previously identified, Other

ALSLR Regulatory Performance Criteria

The LRP Plan is required to meet the basis of regulatory compliance by meeting the 7.0% cumulative program year average rate of replacement such that all known lead service lines are replaced within 15 years, For details please refer to Appendix IV.A, Proposed Terms and Conditions.

To evaluate the sensitivity of the calculation used to determine the cumulative rate of replacement for each program year, sample calculations were prepared Several scenarios were developed and analyzed to understand how different assumptions affect compliance and the performance of the 15 year Program, including:

- Maintaining baseline compliance replacement rates of 7.0% (baseline condition).
- Starting the Program above 7.0% replacement rates over the first half of the Program and decreasing the rate of replacement in later years of the Program (fast start, slow end).
- Completing the Program early by maintaining high replacement rates through a majority of the Programs life (early completion).
- Recovering the (cumulative program year average after with one year of poor performance (baseline plus one year poor performance).

- Starting the Program slowly with a 6.0% replacement rate in program year 1 and 6.5% replacement rate in program year 2, then maintaining the 7.0% replacement rate from program year 3 until the end of the Program (slow start).
- Poor performance (below 7.0% replacement rate) on multiple occasions in the first half of the Program to determine if it is possible to recover the cumulative program year average (failure condition).

It is evident from the results (shown in Table III.D-13) of the six scenarios that it is paramount that the Program maintain or exceed the 7.0% replacement rate. It is possible to recover from one poor performing year by exceeding the 7.0% goal for several years thereafter, but recovery after more than one year of poor performance is unlikely. Therefore, Denver Water will closely monitor ALSLR crews' performance throughout the life of the LRP and if necessary, make adjustments to address factors that hinder performance. It is anticipated that the Group A targeted rough order of magnitude LSLR volume for each type of group (Geographic and Individual) and number of crew estimates will evolve over the life of the LRP such that all known LSLs are replaced within 15 years.

Table III.D-13. Sensitivity Analysis ALSLR Performance Scenarios

Program Year	BASELINE CONDITION			FAST START/SLOW END			EARLY COMPLETION			BASELINE CONDITON + 1 YEAR POOR PERFORMANCE			SLOW START (YEAR 1 AND 2 MINIMUM) + BASELINE CONDITION			FAILURE SCENARIO		
	LSLR per Year	Average	Cumulative Average	LSLR per Year	Average	Cumulative Average	LSLR per Year	Average	Cumulative Average	LSLR per Year	Average	Cumulative Average	LSLR per Year	Average	Cumulative Average	LSLR per Year	Average	Cumulative Average
1	4477	7.0%	7.0%	5250	8.2%	8.2%	5600	8.8%	8.8%	4477	7.0%	7.0%	3837	6.0%	6.0%	3200	5.0%	5.0%
2	4477	7.0%	7.0%	5000	7.8%	8.0%	5600	8.8%	8.8%	4477	7.0%	7.0%	4157	6.5%	6.2%	3400	5.3%	5.2%
3	4477	7.0%	7.0%	5000	7.8%	7.9%	5600	8.8%	8.8%	4477	7.0%	7.0%	4477	7.0%	6.5%	4477	7.0%	5.8%
4	4477	7.0%	7.0%	4800	7.5%	7.8%	5600	8.8%	8.8%	4477	7.0%	7.0%	4477	7.0%	6.6%	3200	5.0%	5.6%
5	4477	7.0%	7.0%	4800	7.5%	7.8%	5600	8.8%	8.8%	4477	7.0%	7.0%	4477	7.0%	6.7%	4477	7.0%	5.9%
6	4477	7.0%	7.0%	4700	7.3%	7.7%	5250	8.2%	8.7%	4477	7.0%	7.0%	4477	7.0%	6.8%	4477	7.0%	6.1%
7	4477	7.0%	7.0%	4500	7.0%	7.6%	5250	8.2%	8.6%	1000	1.6%	6.2%	4477	7.0%	6.8%	4750	7.4%	6.3%
8	4477	7.0%	7.0%	4500	7.0%	7.5%	5250	8.2%	8.6%	6000	9.4%	6.6%	4477	7.0%	6.8%	4750	7.4%	6.4%
9	4477	7.0%	7.0%	4500	7.0%	7.4%	5250	8.2%	8.4%	5250	8.2%	6.9%	4477	7.0%	6.9%	500	0.8%	6.2%
10	4477	7.0%	7.0%	4400	6.9%	7.4%	5250	8.2%	8.5%	5250	8.2%	6.9%	4477	7.0%	6.9%	5724	9.0%	6.1%
11	4477	7.0%	7.0%	4300	6.7%	7.4%	5000	7.8%	8.4%	4477	7.0%	6.9%	4477	7.0%	6.9%	5000	7.8%	6.2%
12	4477	7.0%	7.0%	4250	6.6%	7.3%	4705	7.4%	8.3%	4477	7.0%	6.9%	4477	7.0%	6.9%	5000	7.8%	6.4%
13	4477	7.0%	7.0%	3300	5.2%	7.1%	-	-	-	4477	7.0%	7.0%	4477	7.0%	6.9%	5000	7.8%	6.5%
14	4477	7.0%	7.0%	3255	5.1%	7.0%	-	-	-	4477	7.0%	7.0%	4477	7.0%	6.9%	5000	7.8%	6.6%
15	1277	2.0%	6.7%	1400	2.2%	6.7%	-	-	-	4477	7.0%	7.0%	2237	3.5%	6.7%	5000	7.8%	6.7%

(-) Dash denotes no further work to be performed.

Average – Means the program year replacement rate.

Procurement Strategy

Introduction

The ALSLR Plan contracting strategy will use Denver Water's procurement office to establish a standardized procurement process to notify and solicit qualifications and bids from outside contractors. To support this procurement process, Denver Water will provide an ALSLR Contract Document that includes standard front-end contract documents supported by technical specifications, supplemental specifications, and standard drawings for all components of the ALSLR work. The LSLR Contract Manual will contain the necessary bid forms that will govern the work to be conducted and payment for this work on a unit price basis. Denver Water will use three bid schedules based on the type of Groups identified above; Geographic, Individual, and Investigation.

Denver Water Purchasing utilizes the Rocky Mountain E-Purchasing System that helps to provide greater visibility to the contracting industry. The Rocky Mountain E-Purchasing System will be utilized as well as other notifications process for Industry Day, the subsequent Request for Qualifications (RFQ).

Denver Water promotes inclusiveness in their procurement process based on setting goals for Minority, Women, and Veterans owned businesses or Special Business Enterprise (SBE) and Minority Business Enterprises (MBE). To continue with best practices in the community and construction industry and to foster inclusion of qualified SBE's/MBE's, Denver Water will establish minimum goals for participation as a percent of construction dollars for construction contracts under the LRP.

ALSLR Contractor Procurement

Qualified Contractors who have been determined as most responsive and lowest price will be selected based on a task order format to focus on three LSLR Group areas: Geographic Area, Individual, and Investigations as further described below. The Plan may adjust the contracting and procurement strategy for this work as the ALSLR work evolves and specific or specialty work items are better identified that would warrant individualizing a specific scope of work outside of those already planned.

Lead Service Line Replacement Contractors will have a task order that defines scope of work (upwards of 200 properties) to replace lead service lines from the main to the first fitting within the dwelling and conduct restoration of disturbed areas. The LSL replacements scope will include from connection to the water main, meter box replacement (if not already located outside the property), curb stop replacement, and plumbing connections inside the resident home. ALSLR contractors will be expected to have excavation, boring, and plumbing capabilities to complete the replacements. Contractors will mobilize to one geographic area to replace multiple services in a given block, while others will replace individual lead service lines in high priority locations. Construction Liaisons will be present during construction to manage communications with Property Owners and Contractors. The Contractor will not be expected to interface or coordinate with the Property Owners.

Investigation Contractors will have a task order scope of work to verify whether a lead service line exists ahead of the replacement crews. These contractors will be expected to use different methods of excavation, hand digging, potholing, meter box viewing, and interior dwelling investigation. Their productivity and ability to verify the presence of a LSL will help in better updating the LSLI and calibration of the predictive model. By improving the LSLI database, the predictive model will help in

assuring task orders for various LSLR groups will assist in keeping the replacement contractors on schedule and achieve the annual ALSLR target. Construction Inspectors will report their findings to the Program team so that the LSLI can be updated, the prioritization model can be adjusted, and planning for replacement can be performed. Construction Liaisons will be present during construction to manage communications with Property Owners and Contractors. The Contractor will not be expected to interface or coordinate with the Property Owners.

Scheduling and Coordination

To promote the LRP, ready the contracting community for ALSLR work, and gauge the interest of the contracting community, an open house (referred to as an Industry Day) will be planned for early August 2019. During the Industry Day, contractors will learn more about the LRP goals and expectations and Denver Water can also use this event as a forum to receive Construction Industry feedback. This will benefit not only potential bidders, but also the Program team in finalizing the contracting and procurement strategies. The dialogue from the Industry Day will be used to discuss unit price bidding options, clarify specifications, and aid in assigning risks within the construction contract document. The event will be advertised through the Rocky Mountain System BidNet, the Colorado Contractors Association, Denver Water's Public Information, and other appropriate channels. This event will be in advance of the formal qualification process so that the information gathered and shared can be used by Denver Water to develop the qualification package and contract documents.

A Request for Qualifications Process will follow the Industry Day to solicit specific information on relevant work experience, bonding, insurance, key staff, and overall capacity and approach. The qualifications packages will be evaluated, and a short list of contractors will be developed. If needed, interviews can be conducted during this stage. Once the short list of contractors is developed, these contractors will be invited to a price bid on three bid forms; Group A – geographic, Group A – individual, and Group B - Investigations.

All Contractor Procurement Contract Documents are expected to be finalized by October 15, 2019 and to allow the bid process to move forward once the LRP variance is approved. The current timeline and milestones for the Procurement and Contracting of the ALSLR Plan are illustrated below in Table III.D-14.

Table III.D-14. Timeline and Milestones for Procurement and Contracting, Example

Description	Estimated Timeframe
Request for Qualifications (RFQ) Notification	August 2019
Receive RFQ	Mid-September 2019
Shortlist Qualified Contractors	Early October 2019
Finalize Accelerated Lead Service Line Contractor Contract Documents	October 15, 2019
Finalize ALSLR 2020 Work Plan	Mid October
Request for Unit Bid Price Proposals (RFP)	Mid October
Pre-Bid Meeting	TBD
Bid Opening	Early November
Bid Awards	Mid November
Notification of Selected ALSLR Contractors (Multiple)	TBD
Issue Task Orders	TBD
ALSLR Notice to Proceed	January 2020

Summary

Denver Water through a proven process will procure the needed qualified contractors for successful implementation and completion of the annual ALSLR Program. Denver Water is committed to providing the necessary resources to meet the ALSLR cumulative program year replacement rate goal of 7.0%.

APPENDIX III.E.1 - LEAD SEQUENTIAL SAMPLING STUDY

September 2019

DENVER WATER

Appendix III.E.1

Lead Sequential Sampling Study

Background

The purpose of this study is to gain a better understanding of the comparative influence of existing lead service lines (LSLs) and copper with lead solder (Cu w/ Pb) in addition to galvanized (GAL) plumbing downstream of an existing or replaced lead service line on lead levels at customers' taps.

Sequential sampling of individual homes was used to capture water quality samples representing various plumbing material types within a single premise to understand the amount of lead released from those materials.

Sequential sampling entails taking multiple water quality samples from a customer's tap, one after another, to discern how water quality changes throughout the premise plumbing and service line. Three categories of homes were sought to take part in the study: 1) homes a with lead service lines (LSL), 2) homes with copper with lead solder (Cu w/ Pb) and 3) homes with galvanized (GAL) plumbing downstream of an existing or replaced lead service line. To date, thirty-two Denver Water customers' homes have been potholed in search of homes that meet the criteria of the study. This report highlights the results of the three rounds of quarterly sampling that took place in Q4 of 2018 as well as Q1 and Q2 of 2019.

Study Design

- The sampling methods used for this study were informed by the work of Michael Schock et. al as outlined in the presentation, "Lead Tap Sampling Approached: What Do They Tell You".
- Lead concentration were measured via the EPA method 200.8 and are presented as dissolved lead in this report.
- The sequential sample volumes outlined below were collected after a minimum 6-hour stagnation time from the cold-water kitchen or bathroom faucet.
    - 125mL, 125mL, 250mL, 250mL, 250mL, 500mL (as many 500mL samples as necessary to capture service line volume back to the main based on a calculated volume of the plumbing system).
    - Five additional 1000mL samples were collected at the end of the sequence after the 1st round of sampling to ensure that final sample represented water originating from the main and not sitting in the service line during stagnation.
- A volume weighted lead concentration of the first 5 samples (1000mL cumulative) was calculated to determine the "Calculated 1st Draw" lead concentration. This concentration represents the expected concentration of an LCR compliant first draw sample.

First Round Sampling Results

- Lead Service Line Homes
    - Seven of the identified homes were confirmed by potholing to have lead service lines.
        - All results for the first-round sampling of LSL homes are shown in Figure 1 below.
        - The average "Calculated 1st Draw" lead concentration was 6.1 ppb.

        - The average of the highest measured lead concentration from all LSL homes was 13.9 ppb. The maximum lead concentration for any LSL home was 23.4 ppb.

- Copper with Lead Solder Homes
    - Seven of the identified homes were confirmed by potholing and internal plumbing inspection to have copper with lead solder.
        - All results for the first-round sampling of Cu w/ Pb homes are shown in Figure 2 below.
        - The "Calculated 1st Draw" lead concentration for all Cu w/ Pb homes except one was below the minimum reporting limit (MRL) of 1 ppb.
            - The one exception (Garrison St.) had a "Calculated 1st Draw" lead concentration of 4.9 ppb and a maximum lead concentration of 8.6 ppb. It was hypothesized that the results from this home were artificially high due to particulate that was observed in the samples and believed to be caused by closing the hot water shut off valve for the "first time in 20 years", according to the customer.
            - Re-sampling was performed at this home the following month and lead concentrations of all samples were below 1.7 ppb with a "Calculated 1st Draw" lead concentration of 1.2ppb. The re-sampling results are labeled "S Garrison RS" in the Figure 2 below.
        - None of the Cu w/ Pb homes had a single sample with a lead concentration of 1.8 ppb or greater (initial Garrison results excluded).
        - The average of the highest measured lead concentration from all copper with lead solder homes was 1.1 ppb (2.2 ppb when including the initial Garrison results).

- Galvanized Plumbing Downstream of a Replaced Lead Service Line
    - During the first round of sampling, no homes were identified to have galvanized plumbing downstream of an existing or previously replaced lead service line.

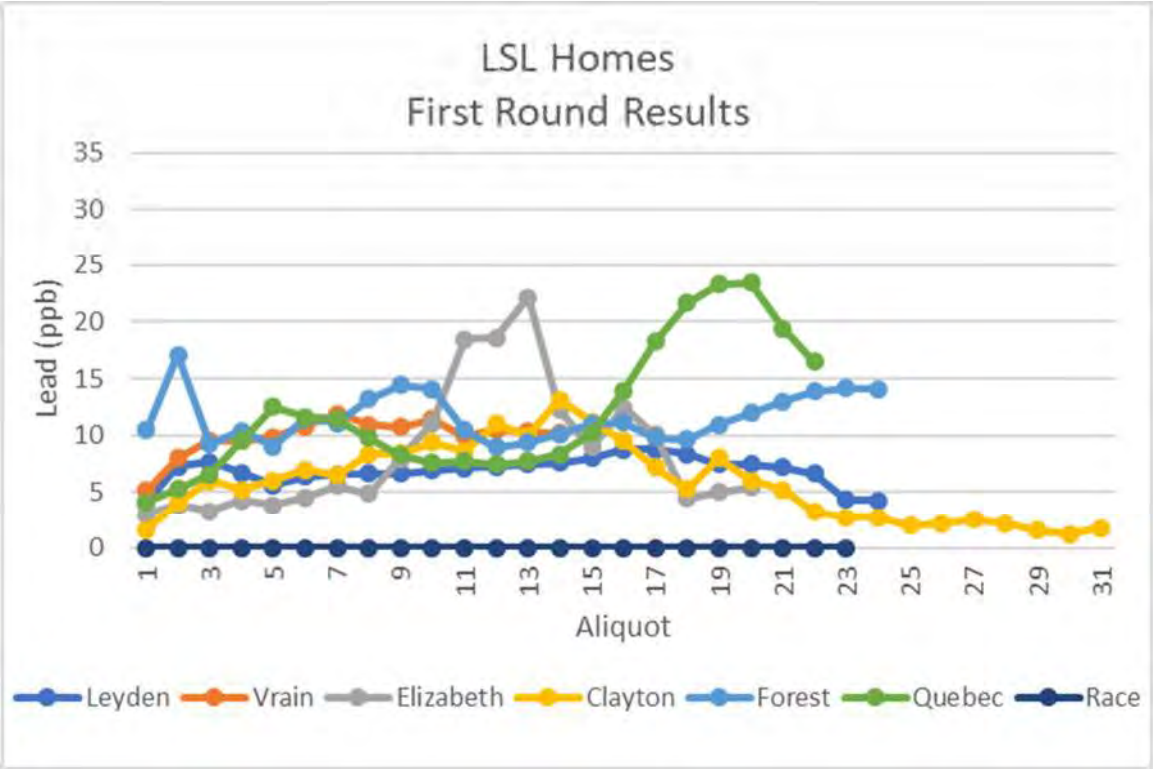


Figure 1 – First Round LSL Homes Results

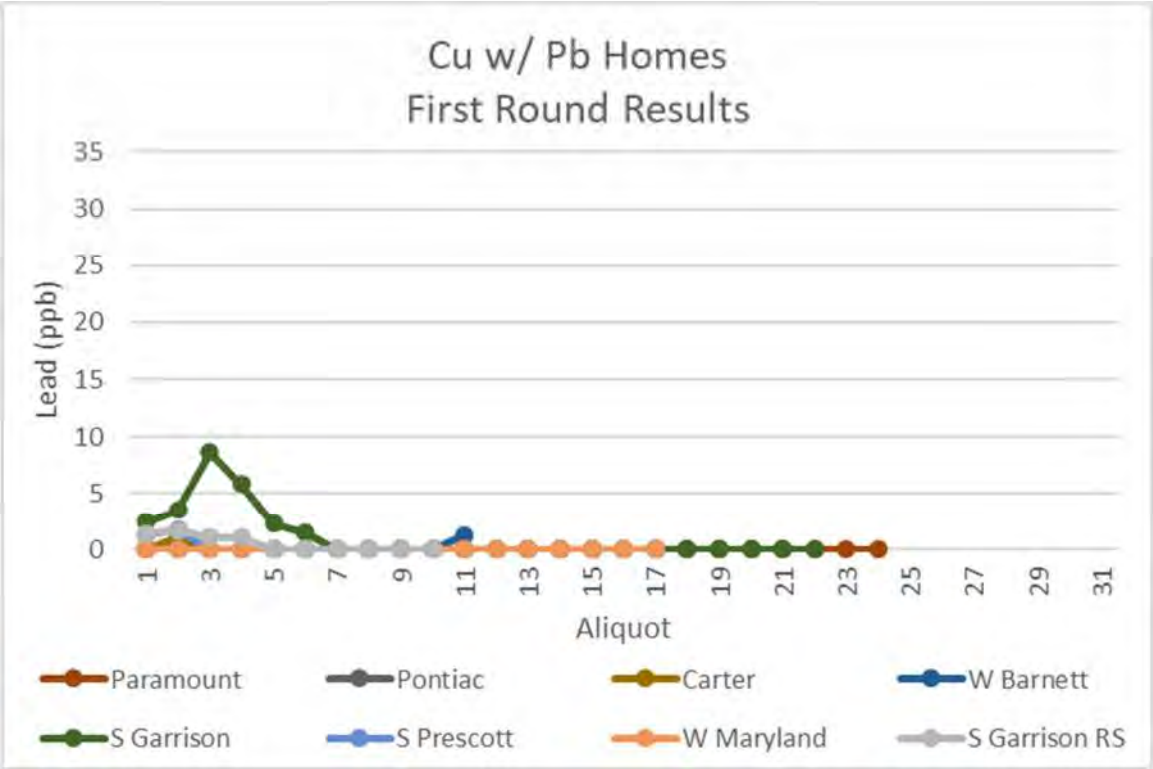


Figure 2 – First Round Cu w/ Pb Homes Results

Second Round Sampling Results

- Lead Service Line Homes
    - The same seven lead service lines homes from the first round of sampling were sampled again 2-3 months later. Two additional lead service line homes were identified to represent portions of the distribution system not captured in the initial round of sampling for a total of 9 homes sampled.
        - All results for the second-round sampling of LSL and GAL homes are shown in Figure 3 below.
        - The Race St. home was confirmed to have a lead service line despite all samples measuring below the MRL.
        - The average "Calculated 1st Draw" lead concentration for LSL homes was 4.6 ppb.
        - The average of the highest measured lead concentration from all LSL homes was 15.9 ppb. The maximum lead concentration for any LSL home was 33.6 ppb.

- Copper with Lead Solder Homes
    - Six of the copper with lead solder homes sampled in the first round of sampling were sampled again 2-3 months later. One of the homes dropped out of the study.
        - All results for the second-round sampling of Cu w/ Pb homes are shown in Figure 4 below.
        - The average "Calculated 1st Draw" lead concentration for Cu w/ Pb homes was below the MRL.
        - The average of the highest measured lead concentration from all copper with lead solder homes was 1.5 ppb.
        - No sample from any of the Cu w/ Pb homes in the second round of sampling had a lead concentration greater than 4.3 ppb.

- Galvanized Plumbing Downstream of a Replaced Lead Service Line
    - All results for the second-round sampling of GAL home are shown in Figure 3 below.
    - Only one home with galvanized plumbing downstream of a replaced lead service line was identified for the second round of sampling. This home is identified as Mariposa in Figure 3.
    - Of all the 15 homes sampled, the galvanized home had the 3rd highest "Calculated 1st Draw" lead concentration at 8.6 ppb. The galvanized home also had the 3rd highest maximum lead concentration at 25.8 ppb.
    - The lead levels released from the galvanized home were similar to the lead service line homes.
    - It is of interest to note that lead levels spike earlier in the sampling sequence for the GAL line compared to LSLs. This is indicative of galvanized internal plumbing acting as a source of lead.

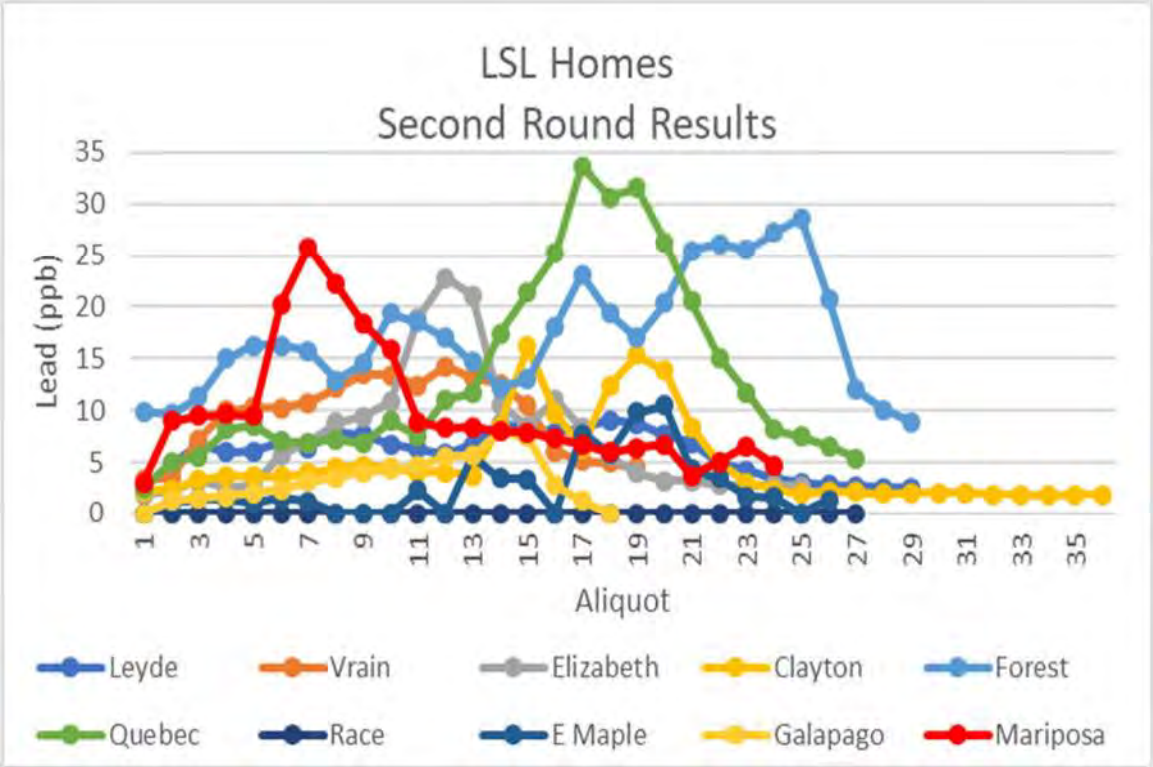


Figure 3 – Second Round LSL and GAL Homes Results

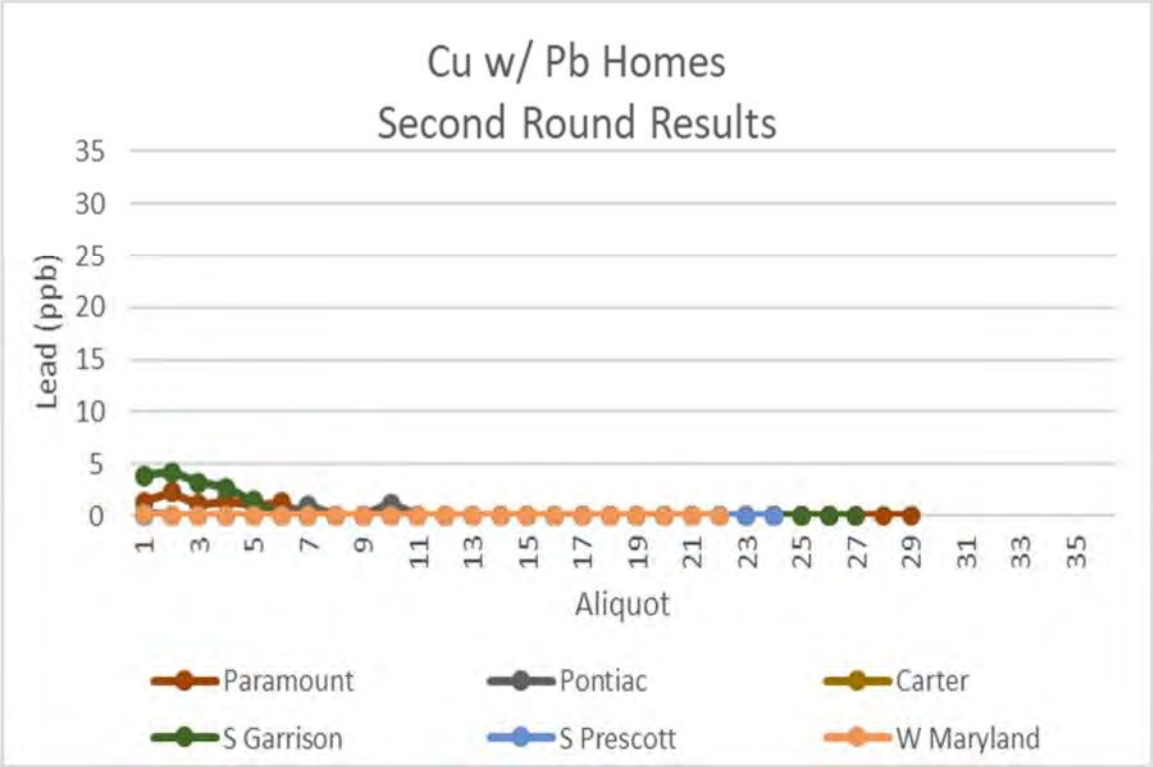


Figure 4 – Second Round Cu w/ Pb Homes Results

Third Round Sampling Results

- Lead Service Line Homes
    - For the third round of sequential sampling, one of the original homes (Forest St) dropped out of the program. Eight LSL homes remained in the study for the 3rd round.
        - All results for the second-round sampling of LSL and GAL homes are shown in Figure 5 below.
        - Overall, lead levels in all samples were significantly lower for the 3rd round of sampling. The highest measured lead value from any LSL home sample was only 10.4 ppb.
        - The average "Calculated 1st Draw" lead concentration for LSL homes was 1.8 ppb.
        - The average of the highest measured lead concentration from all LSL homes was 7.2 ppb.

- Copper with Lead Solder Homes
    - The six homes from the second round of sampling were sampled again for round three.
        - All results for the second-round sampling of Cu w/ Pb homes are shown in Figure 6 below.
        - Lead levels from Cu w/ Pb homes were significantly lower for the 3rd round of sampling. Only two samples from any of the Cu w/ Pb homes in the third round had a lead concentration above the MRL, both of which came from the Garrison St. home.
        - The average "Calculated 1st Draw" lead concentration for Cu w/ Pb homes was below the MRL.

- Galvanized Plumbing Downstream of a Replaced Lead Service Line
    - Despite multiple attempts to contact the owner of the GAL home, samples were not collected for the third round.
    - One other home has been identified that potentially meets the requirements of the study. At the time of writing this report, sample collection is being scheduled with the homeowner.

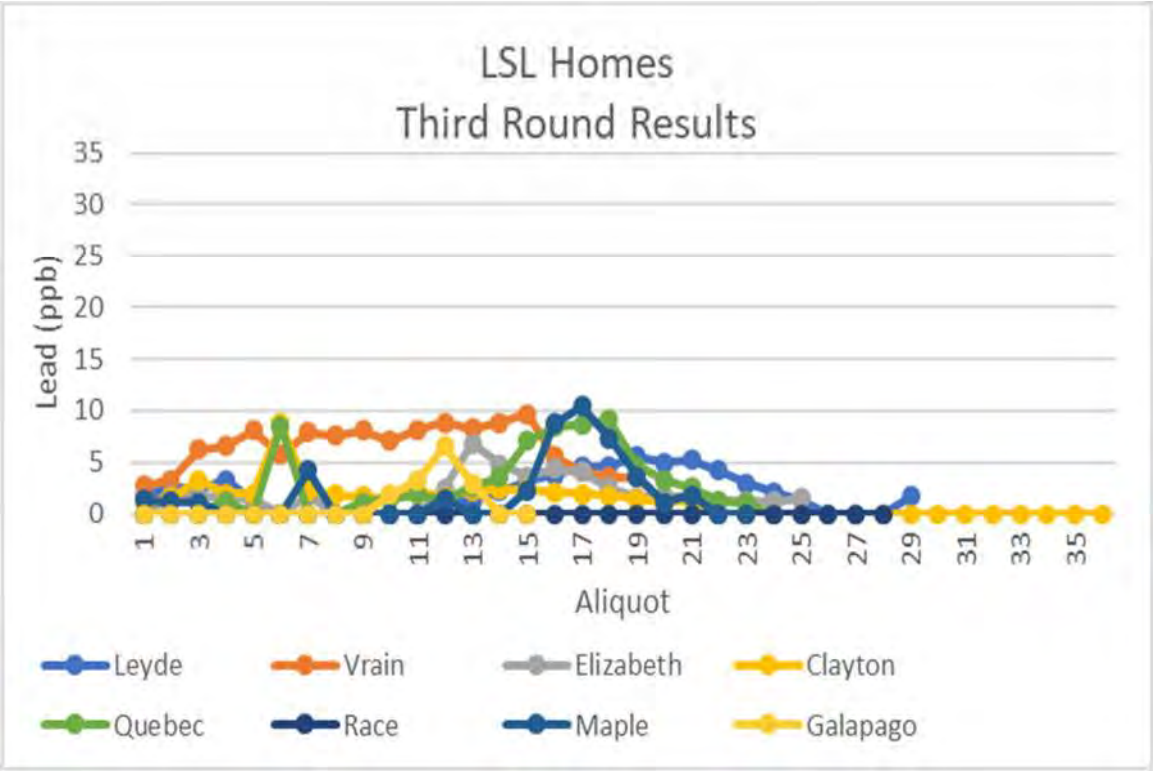


Figure 5 – Third Round LSL Homes Results

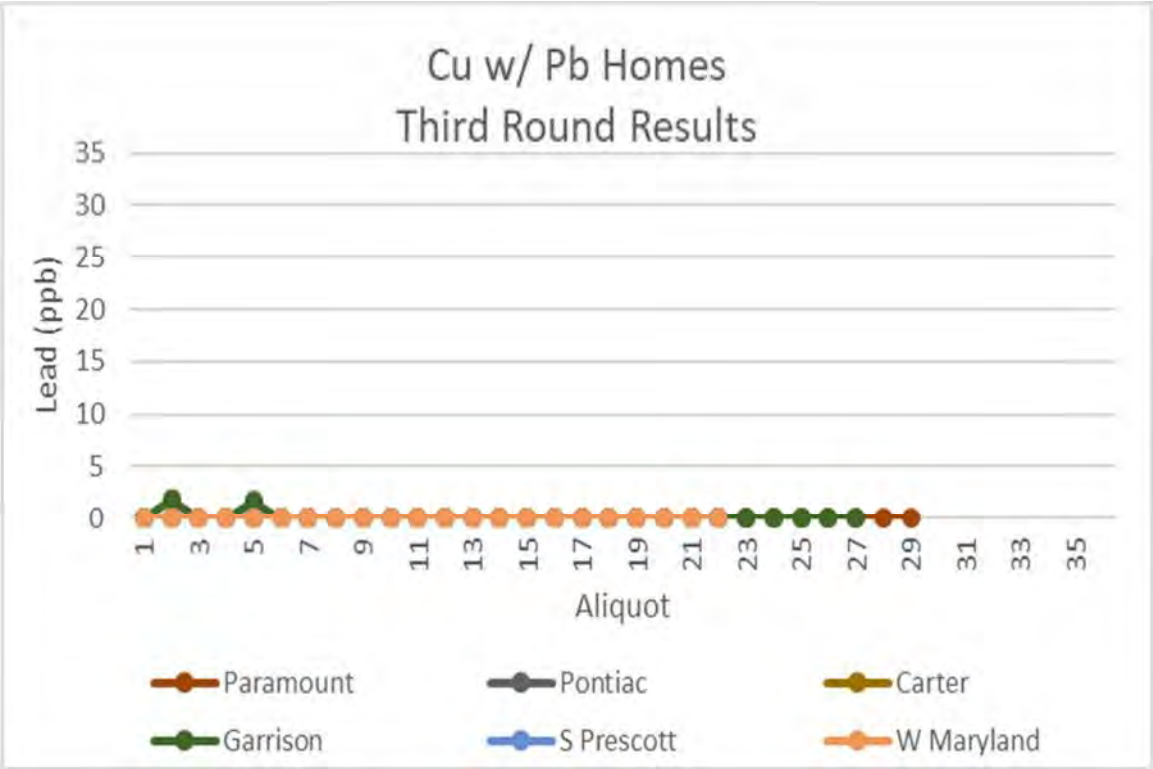


Figure 6 – Third Round Cu w/ Pb Homes Results

Conclusions

- Of the homes sampled in sequential sampling study, lead service lines overwhelmingly represented the greatest source of lead when compared to copper with lead solder.
    - Not including the first-round initial sampling at S Garrison as explained above, all samples events at copper with lead solder (Cu w/ Pb) homes yielded maximum lead concentrations below 5 ppb.
    - Conversely, all sampling events at lead service line (LSL) homes yielded maximum lead concentration greater than 5 ppb. The maximum Pb concentration measured from any LSL home was 33.6 ppb.
- The first liter of water from the tap, represented by the first 5 sample aliquots in this study and used to derive the "Calculated 1st Draw" lead concentration, contained nearly all the lead released from a copper with lead solder home in this study.
    - Only 3 samples from Cu w/ Pb homes had a lead concentration greater than the MRL after the 5th aliquot (representing a 1-liter first draw). These three samples were all less than 1.4 ppb.
    - These results are consistent with those found in the customer requested sampling program.
        - Table 1 below highlights the similarity of results from the customer requested sampling program (1196 sampling events over 3 years) compared to the sequential sampling study (20 sampling events over 9 months) for Cu w/ Pb homes.
        - First, second, and third draw equivalent samples were calculated based on the sampling procedure described below to make the comparison between the two different data sets.
- The "Calculated 1st Draw" concentrations for lead service lines are lower than subsequent aliquots and therefore under-represents the amount of lead released from a lead service line home.
    - Only one LSL home during one sampling round had a maximum lead concentration occur in the first five aliquots.
- The single galvanized home participating in the study yielded lead levels similar to LSL homes. However, the peak lead level in the GAL home occurred in an earlier sample in the sampling sequence compared to LSL homes.
    - Caution must be used when viewing the results from the GAL home. The results from the single GAL home sampled in this study may not be representative of other galvanized homes within the distribution system.
    - The lead results from GAL home are consistent with the hypothesis that galvanized pipe acts as a lead sink while downstream of a lead source (i.e. lead service line) and then acts as a lead source once the original source of lead has been removed.

Figures 6-10 summarize the lead results from the three rounds of sequential sampling. Lead concentrations below the reporting limit of 1 ppb are reported as 0 ppb.

Table 1 – Comparison Between Customer Requested Sampling and Sequential Sampling Results

	Decade of Home Construction	Average Lead (ppb)			50th Percentile Lead (ppb)			90th Percentile Lead (ppb)		
		1st Draw	2nd Draw	3rd Draw	1st Draw	2nd Draw	3rd Draw	1st Draw	2nd Draw	3rd Draw
Customer Requested Sampling Results	1952-1959	1.13	0.62	0.7	0.5	0.5	0.5	2	0.5	0.5
	1960-1969	1.18	0.85	0.72	0.5	0.5	0.5	3	0.5	0.5
	1970-1979	2	0.69	1.14	0.5	0.5	0.5	3	1.5	0.5
	1980-1982	1.19	0.67	0.5	0.5	0.5	0.5	2	1.16	0.5
	1983-1987	1.01	0.48	0.48	0.5	0.5	0.5	2	0.5	0.5
Sequential Sampling Study Results	Copper with Lead Solder Homes	0.8	0.1	0.1	0.0	0.0	0.0	2.9	0.0	0.0

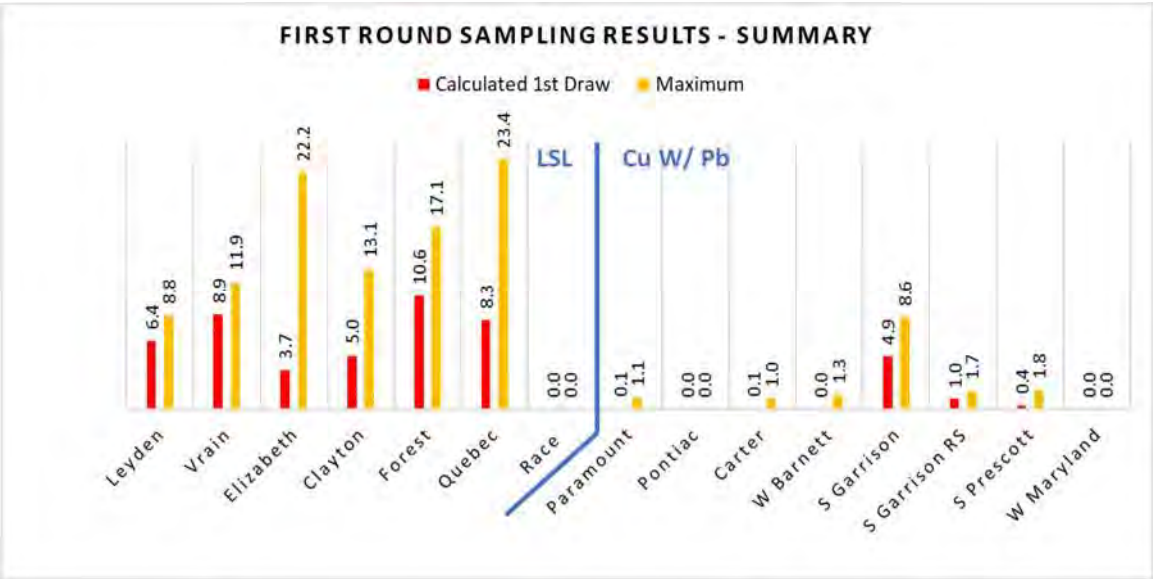


Figure 7 – First Round Sampling Lead Results as ppb

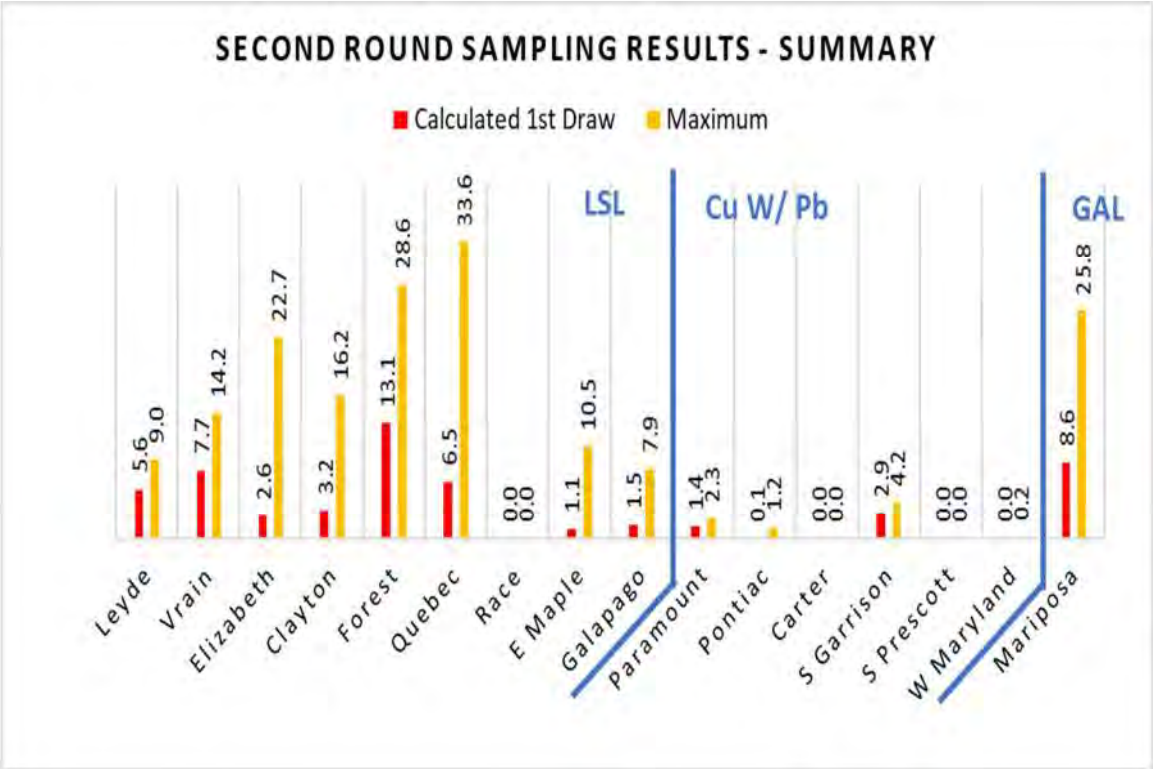


Figure 8 – Second Round Sampling Lead Results as ppb

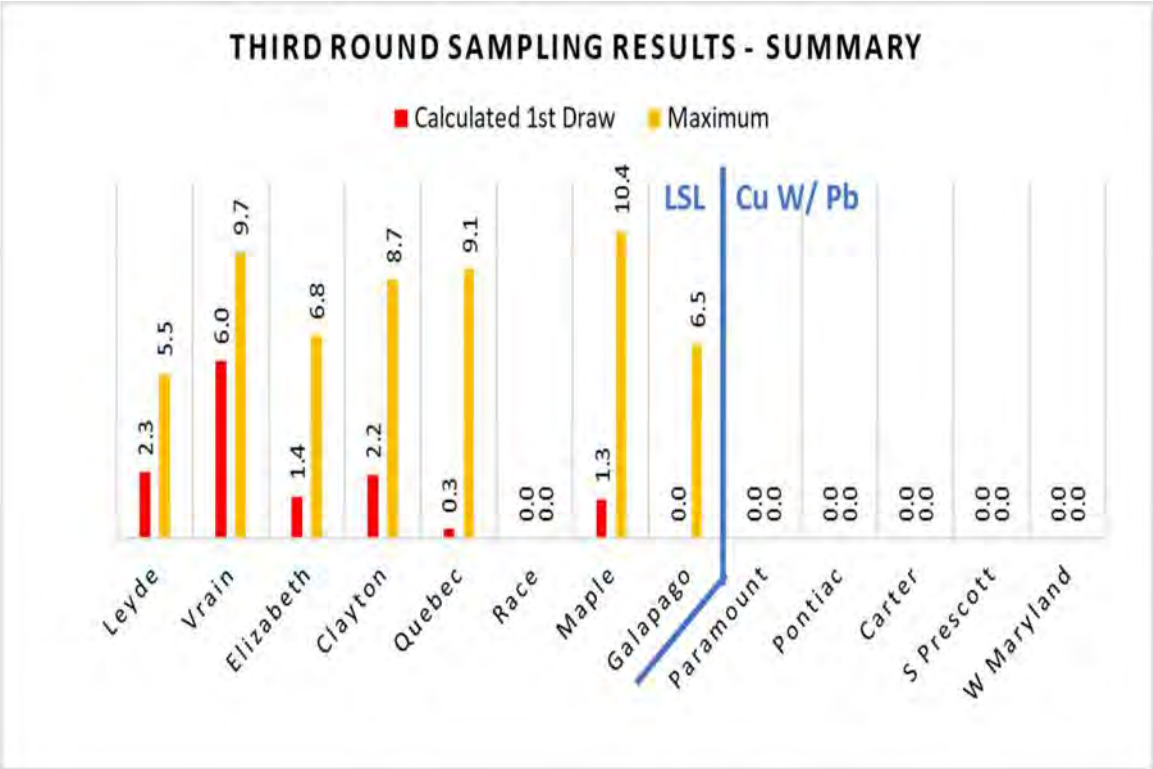


Figure 9 – Third Round Sampling Lead Results as ppb

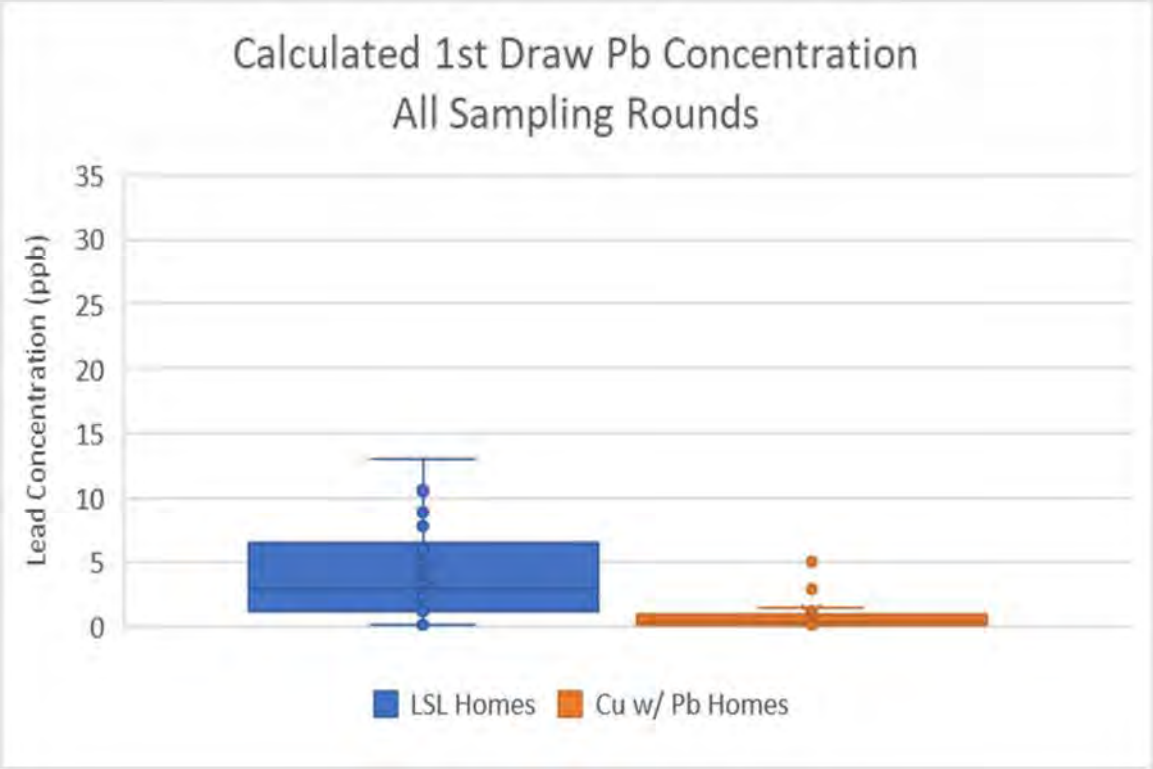


Figure 10 – All Results for Calculated 1st Draw Lead Concentration from Each Home Sampled

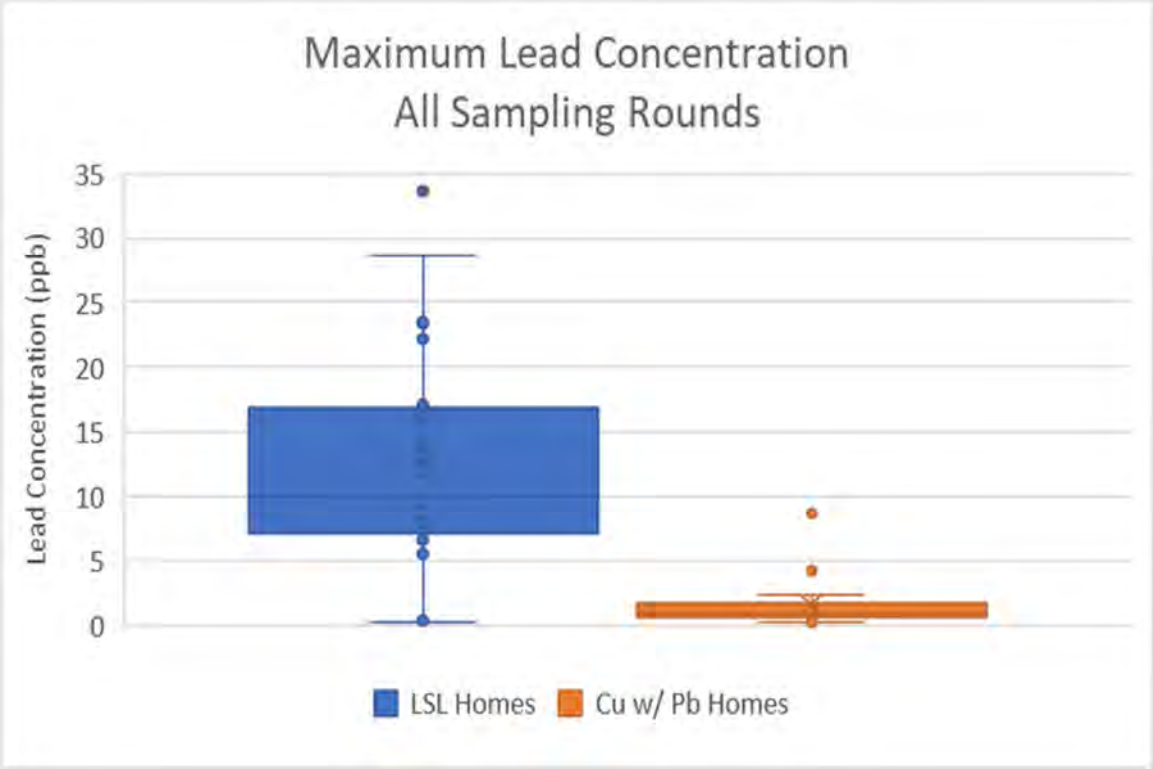


Figure 11 – All Results for Maximum Lead Concentration from Each Home Sampled

Sampling Method Comparison

Denver Water's Customer Requested Lead Sampling program asks customers to collect three 1-liter samples following at least 6 hours of stagnation. The first 1-liter sample is collected immediately following stagnation before any water has passed through the premise. After the first sample is collected, customers are asked to flush for 25 seconds without shutting off the faucet. A second 1-liter sample is then collected. After the second sample is collected, the customer is asked to flush for an additional 25 seconds before collecting the third and final 1-liter sample. Denver Water has measured sampling flow rates when collecting lead samples and has found that flows typically range between 2-4 liters per minute. It is assumed that the flushing rate during the 3-Draw sampling is within this range.

The first 1-liter sample represents the same volume of water that is collected during LCR compliance sampling. This sample is thought to be most influenced by the sampling fixture and internal plumbing nearest to the fixture. The second sample is collected with the intent to capture the lead from internal plumbing without significant influence from the sampling fixture or the service line. The third sample is intended to represent the water stagnating in the service line.

Figure 11 and 12 show the lead concentrations from three homes sampled during the 2nd round of sequential sampling. The three homes include a lead service line home (Quebec), a copper with lead solder home (Paramount) and a home with galvanized plumbing downstream of a replaced lead service line (Mariposa). Overlaid on these figures are the theorical sample and flushing volumes corresponding to the 3-Draw sampling protocol described above. Note that the horizontal axis represents the aliquot or sample bottle with volumes detailed in the Study Design section above.

The homes selected are not intended to represent all homes of certain plumbing type. They were merely selected as an example. It is impossible to select a "representative home" because of the innumerable variables associated with lead sampling. For example, when looking at the aliquot in which the maximum lead concentration occurred in LSL homes, it varies from aliquot 13-27. This means that for lead service line homes, the maximum lead concentration could occur between the fifth and twelfth liter when sampling.

Given the number of variables that impact lead concentration captured during a sampling event (faucet flow, internal plumbing and service line length, stagnation time, flushing prior to stagnation, etc) and the resources required to process and analyze samples, Denver Water has concluded that the existing 3-draw sampling protocol is the most appropriate method to obtain consistent and reliable data on lead concentrations from homes when sampling lead is requested by customers.

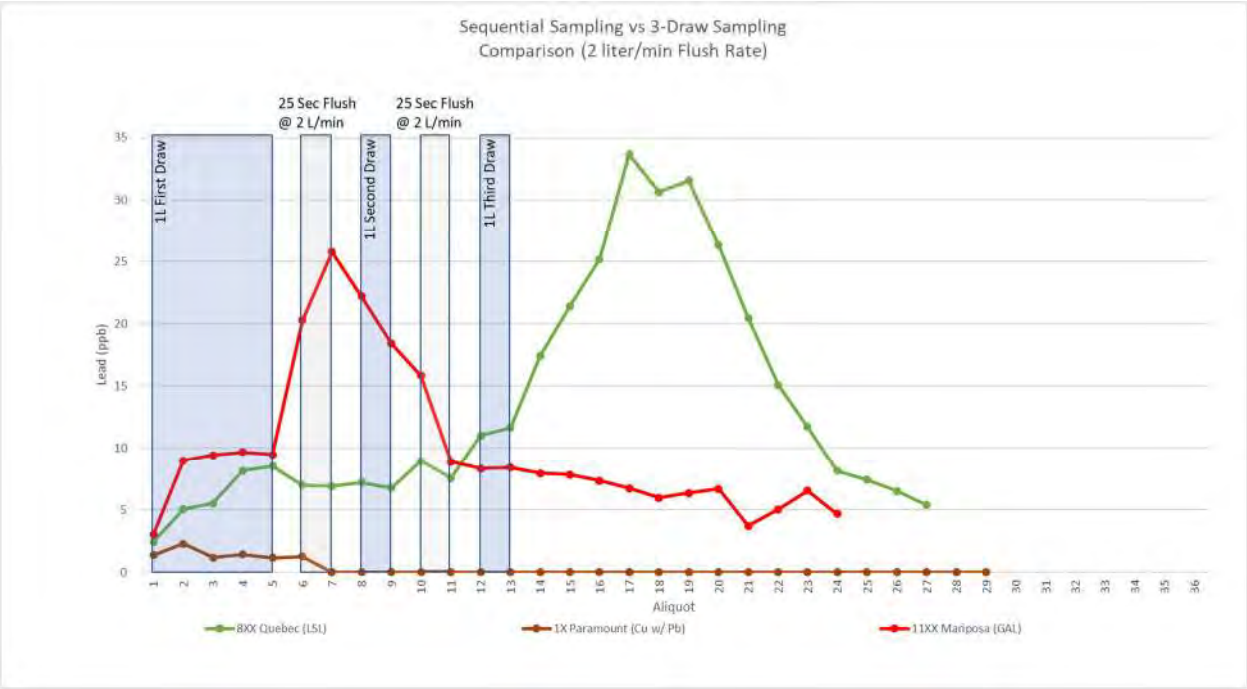


Figure 11 – 3-Draw Sample Volumes at 2 L/min Flushing Compared to Sequential Sampling Results

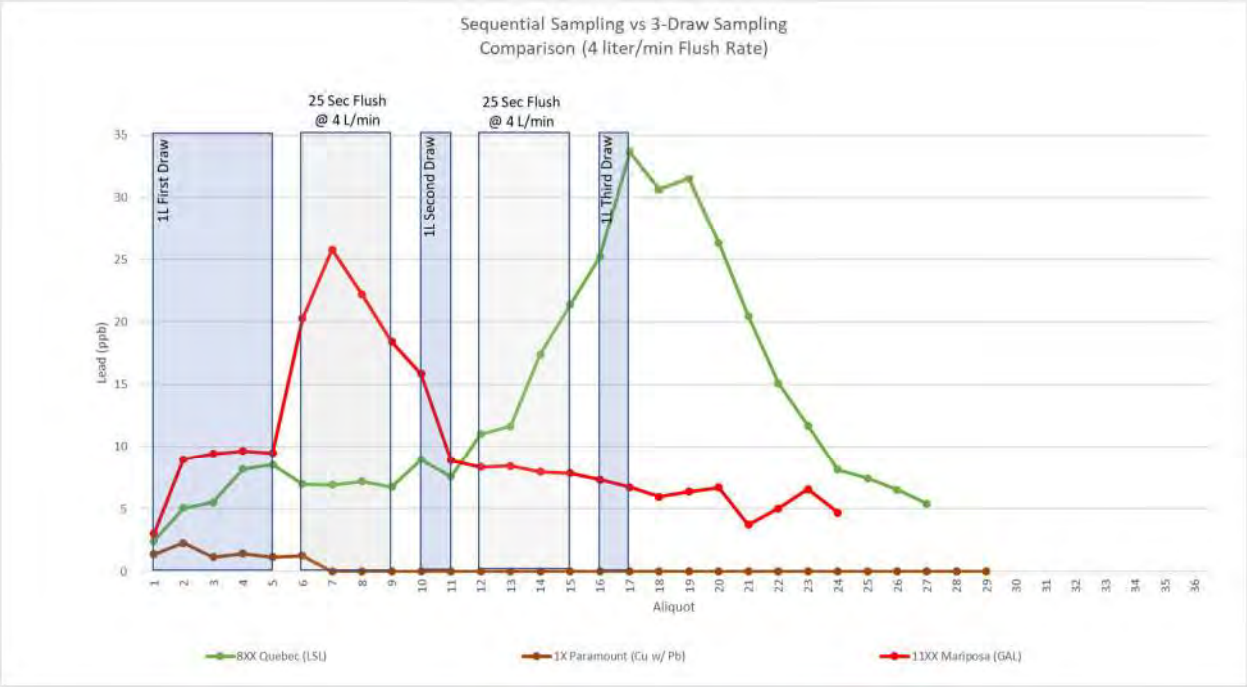


Figure 12 – 3-Draw Sample Volumes at 4 L/min Flushing Compared to Sequential Sampling Results

APPENDIX III.E.2 - LEAD FROM SOLDER

September 2019

DENVER WATER

Appendix III.E.2

Immersion Study Comparing 2 mg/L of Orthophosphate and pH 8.8 for Controlling Lead Release from Solder

Date: August 16, 2019

To: Denver Water

From: Corona Environmental Consulting, LLC

Research Question

Does 2 mg/L of orthophosphate as PO_4 and pH 8.8 result in equivalent lead reduction from copper with lead solder coupons?

Introduction

Copper service lines joined by leaded solder are known to exist in many homes in the United States, including homes within Denver Water's service area. Copper lines with lead solder will become a dominant source of lead once the lead service lines are removed. The purpose of this Appendix is to summarize the findings of a 17-week immersion study comparing the performance between high pH with alkalinity adjustment and orthophosphate for control lead release from copper with lead solder.

In developed countries the solder used to join copper pipes has historically been lead-tin solder. In the United States, 50/50 lead/tin solder was common (MWH, 2005). Lead bearing solder has been banned from use in drinking water plumbing and 95 percent tin and 5 percent antimony is now more commonly used in the US. As part of the LCR materials survey Denver Water found copper joined by lead solder to be common in homes constructed between 1983 and 1988. The 90th percentile lead levels from Tier 1 homes with copper with lead solder has been consistently below 10 ppb, as shown in Figure 1.

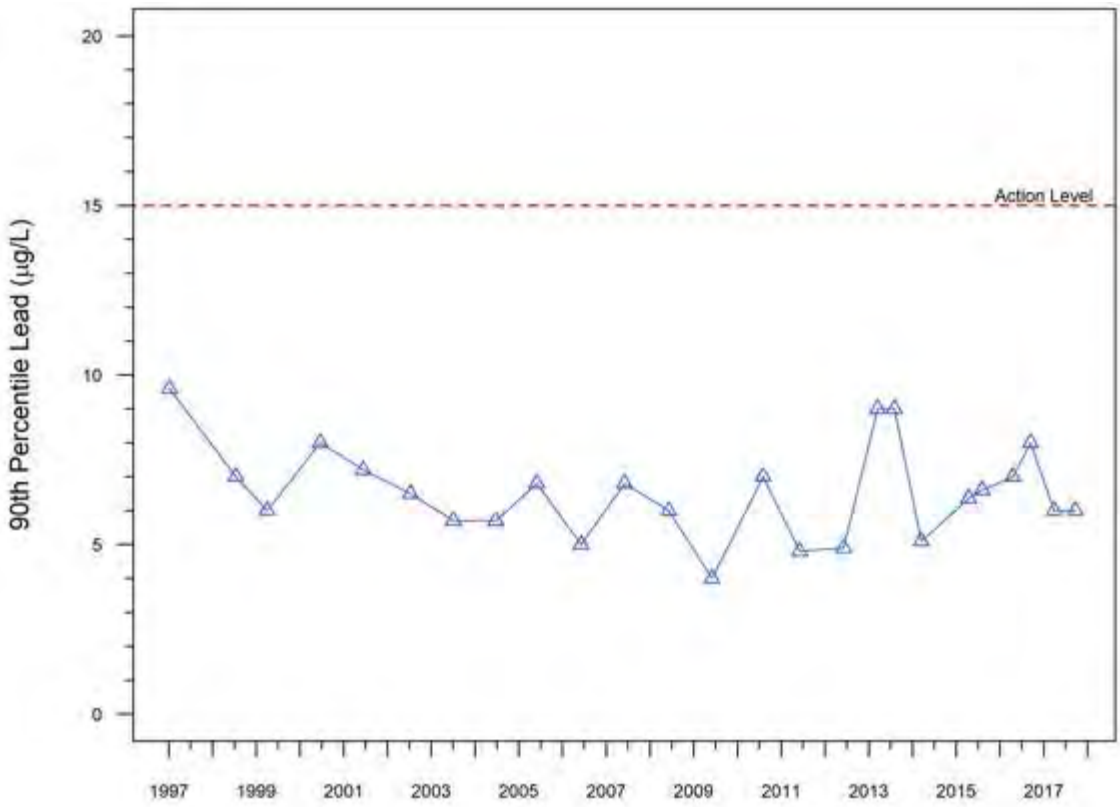


Figure 1. Denver Water's 90th percentile lead levels for Tier 1 homes with copper with lead solder

Similar to lead service lines, the corrosion of copper with lead solder can be reduced by pH/alkalinity adjustment or the addition of a corrosion inhibitor (e.g., orthophosphate). However, the corrosion of lead solder is different from lead pipe because the corrosion of solder is driven by the galvanic cell. Lead release from solder is variable over time and across different sites in a distribution system with similar age and construction (Schock and Lytle, 2011). This is partly due to random particulate lead release (Lytle et al., 1993). Lead release from solder is significantly influenced by the joint's geometry and the workmanship (Lyon and Lenihan, 1977).

In general, only a small amount of solder is exposed to the water and since lead/tin solders are anodic to copper the small anode-large cathode surface area effects apply. In this circumstance the larger the cathode compared to the anode results in greater galvanic current and solder corrosion.

Water parameters found to increase the corrosion of solder are lower pH and higher chloride and nitrate concentrations (Oliphant, 1983). Sulfate in sufficient concentration can mitigate the effect of chloride and the ratio of these predictors (i.e., chloride to sulfate mass ratio or CSMR) have been used as a measure of the potential for galvanic corrosion of copper with lead solder (Oliphant, 1983; Gregory, 1990; Nguyen et al., 2011). Sulfate works by changing the corrosion product to crystalline plates that are more protective. If a utility has a CSMR increase above 0.5 and an alkalinity less than 50 mg/L as $CaCO_3$ then the utility could potentially have serious lead problems following treatment changes that increase the CSMR (Nguyen et al., 2010). Low pH occurs at the solder metal surface due to corrosion reactions, but alkalinity provides buffering to mitigate the pH decrease and dissolution of lead into the water. For example, in bench scale studies with copper with lead solder Nguyen et al. (2010) found that lead release at an alkalinity of 25 mg/L as $CaCO_3$ was ~ 2.5 times higher than lead release at 100 mg/L as $CaCO_3$. The finished water CSMR

at the Marston and Moffat water treatment plants is shown in Figure 2. In general, the CSMR at Marston tends to be higher than at Moffat. Most times the CSMR is below the 0.5 threshold; however, there are several occasions where this is exceeded. The fluctuation in CSMR is likely due to changes in the ionic composition of the source water. Neither addition of caustic soda (NaOH) or orthophosphate as phosphoric acid (H_3PO_4) for corrosion control will affect the CSMR.

Denver Water is converting their ammonia source from aqueous ammonia to liquid ammonia sulfate (LAS) at Marston (~early 2020) and Foothills (late 2020 or early 2021). Longer term, Denver Water is also converting from chlorine gas to bulk hypochlorite at Marston (~2025) and Foothills (~2028). Both of these changes will have a small positive impact on CSMR as detailed in the 2017 OCCT Study (Denver Water, 2017). Specifically, conversion from aqueous ammonia to LAS will result in a net increase in sulfate ions in the finished water, and thus a reduction in CSMR. On average, the three drinking water plants dose 0.63 mg/L as N to form total chlorine for residual maintenance. Converting to LAS, this dose is 2.97 mg/L as LAS and 2.16 mg/L as sulfate. Converting to LAS would result in an average net increase of 2.16 mg/L of sulfate in finished water. Conversion to bulk hypochlorite will reduce the chloride concentration by 0.5 mg/L per mg/L as Cl_2. This will reduce the chloride in the water by about 1.5 mg/L. Taken together, these long-term changes will reduce the CSMR in the Marston water from an average of 0.5 to about 0.4 (-20%). In the Moffat water the predicted change is from an average of 0.3 to 0.2 (-33%).

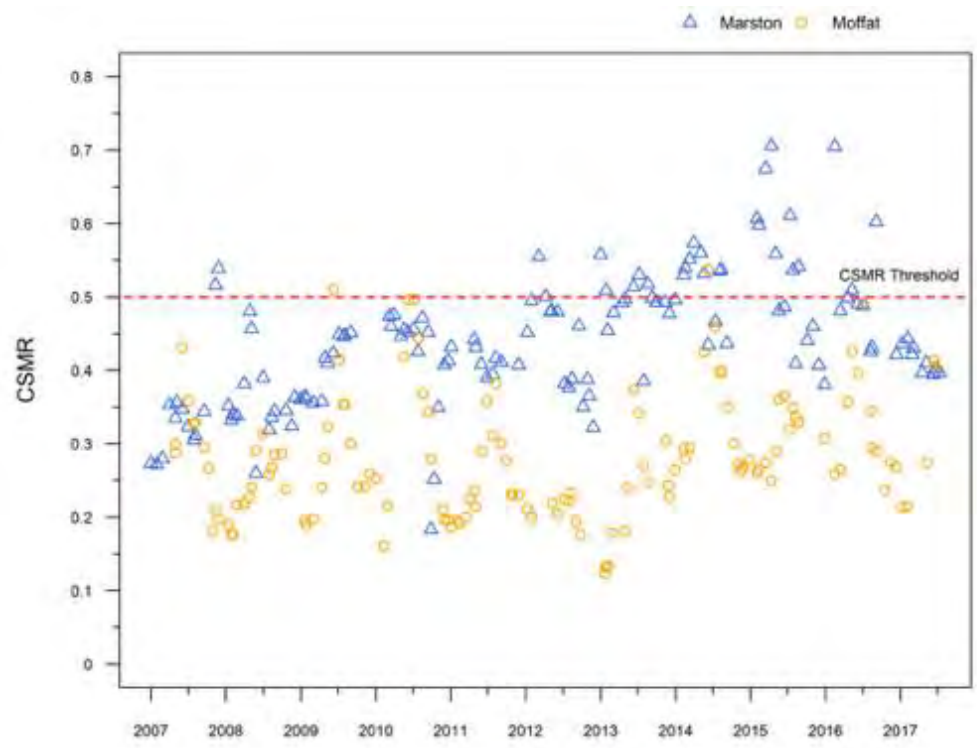


Figure 2. CSMR in the Marston and Moffat finished water

Immersion Study

Past and recent studies of systems similar to Denver Water suggest that it is possible that pH/alkalinity can reduce lead level from solder similar or better than orthophosphate treatment (Boffardi and Sherbondy, 1991; MacQuarrie et al., 1997; Confluence Engineering Group, 2018). Denver Water conducted testing on copper with lead solder coupons in both source waters at bench-scale. The immersion study tested 2 mg/L of orthophosphate and pH adjustment to 8.8 for controlling lead release

from new copper with lead solder. The experimental matrix is presented in Table 1 below. The experiment was designed following the CDPHE document "Lead and Copper Corrosion Bench-Scale Testing Guidance Manual" prepared by Hazen and Sawyer (2019). Each condition was tested in triplicate. Glass jars (250 mL) were cleaned by filling them with 0.1 M hydrochloric acid and allowing to sit for 24 hours. Each test jar was labeled with a unique identifier including the test water ID, test material, and replicate number. Copper with lead-tin solder coupons were prepared by melting a 1-inch long piece of lead solder into a 1-inch long ½'' diameter new copper coupling. All coupons were cleaned by immersing them in 0.1 M hydrochloric acid for 30 seconds, rinsing them with deionized water and the allowing them to air dry. Each coupon was suspended in a glass jar using a zip tie attached to the cap and the cap was epoxied to reduce reactions with the atmosphere outside the jars (Figure 3).

Table 1. Testing Matrix for Lead Release from Copper with Lead Solder.

Test Water	**pH**	**Orthophosphate Dose (mg/L as PO_4)**	**Number of Cu/Pb Solder Coupons**
Marston/Moffat	7.8	0 (Control)	3/3
Marston/Moffat	7.8	2.0	3/3
Marston/Moffat	8.8	0	3/3

55-gallon samples of combined filter effluent were collected from Marston and Moffat treatment plants. A six-week conditioning phase was followed by a nine-week treatment phase. The jars were filled so that they were headspace free. Chloramination and corrosion control (pH adjustment or orthophosphate addition) were performed just before filling. Sample water is collected three times per week with a composite sample being analyzed at the end of each week. The vessels were stored in the dark on a temperature-controlled orbital shaker. Water characterization of the influent waters is presented in Table 2.

Figure 3. Sample immersion vessel

Table 2. Collected combined filter effluent water characterization for immersion testing.

Parameter	Marston Influent	Moffat Influent
pH	7.8	7.8
Alkalinity (mg/L as $CaCO_3$)	61.2	39.9
Calcium (mg/L)	34.5	17.8
Magnesium (mg/L)	8.6	2.0
Chloride (mg/L)	26.4	3.7
Sulfate (mg/L)	65.0	17.9
Sodium (mg/L)	17.0	2.8
Conductivity (µS/cm)	362	139
CSMR	0.41	0.21

Lead, pH, and Orthophosphate Data for Immersion Study Conditions

The descriptive statistics and illustrations included below compare lead release data from copper with lead solder immersion studies using Marston and Moffat Plant influent water under conditions of an orthophosphate dose of 2 mg/L (as PO_4), pH adjustment to 8.8 and a control (no treatment). Only data from the last 7 weeks of the treatment are used in the calculations to avoid conditioning effects.

Lead Summary Statistics

Lead concentration data for the three treatment conditions are summarized in Table 3 which shows that the median lead concentrations were lower for both pH adjustment and orthophosphate compared to the control regardless of the source water. However, for the Marston coupons the mean lead concentration for orthophosphate was more than three times higher than the control and eight time higher than the pH condition. This was due to lead spikes that occurred in the last three weeks of the study in one of the Marston orthophosphate replicates. For this reason, we rely on the median and percentile statistics for comparison. For Moffat coupons, the mean followed the same pattern as the median lead release where both orthophosphate and pH adjustment resulted in lower lead levels compared to the control. However, orthophosphate resulted in slightly lower lead release.

Table 3 Summary of lead concentration data for immersion study (Week 11-17)

	Marston			Moffat		
Condition	Control	pH	Orthophosphate	Control	pH	Orthophosphate
Mean (ppb)	45.7	22.4	134.2	19.3	8.7	4.7
Variance (ppb^2)	1759.6	56.1	130579.4	138.8	9.0	1.4
Standard Deviation (ppb)	41.9	7.5	361.4	11.8	3.0	1.2
Minimum (ppb)	21.1	14.0	7.4	7.3	5.1	2.9
1st Quartile (ppb)	28.7	17.0	8.8	10.2	7.1	4.0
Median (ppb)	32.7	19.4	9.8	13.6	7.8	4.4
3rd Quartile (ppb)	46.0	29.2	37.9	33.1	9.9	5.4
Maximum (ppb)	221.9	39.5	1590.0	42.0	17.7	7.9
Count	21	21	21	21	21	21

pH Summary Statistics

Between weeks 11-17 the pH before and after the water change was monitored. The time series pH results are shown in Figure 15 in the Appendix. The target mean pH for the control and orthophosphate conditions was 7.8 ± 0.2 and 8.8 ± 0.2 for the pH adjustment condition. Table 4 and Table 5 show that mean pH before and after the water change was within the target pH range for both the Marston and Moffat coupons.

Table 4 Summary of pH data for Marston coupons before and after water change (Week 11-17)

	Control		**pH**		**Orthophosphate**	
	Before	**After**	**Before**	**After**	**Before**	**After**
Mean	7.78	7.79	8.72	8.56	7.69	7.62
Variance	0.01	0.01	0.00	0.01	0.00	0.02
Standard Deviation	0.11	0.15	0.05	0.10	0.06	0.15
Minimum	7.62	7.57	8.62	8.34	7.60	7.41
1st Quartile	7.68	7.73	8.69	8.50	7.65	7.52
Median	7.82	7.81	8.71	8.58	7.68	7.59
3rd Quartile	7.86	7.85	8.75	8.62	7.73	7.68
Maximum	7.95	7.99	8.82	8.72	7.80	8.21

Table 5 Summary of pH data for Moffat coupons before and after water change (Week 11-17)

	Control (pH 7.8)		**pH (pH 8.8)**		**Orthophosphate (pH 7.8)**	
	Before	**After**	**Before**	**After**	**Before**	**After**
Mean	7.85	7.80	8.84	8.68	7.75	7.65
Variance	0.01	0.01	0.00	0.01	0.00	0.02
Standard Deviation	0.11	0.15	0.05	0.10	0.06	0.15
Minimum	7.63	7.49	8.67	8.40	7.60	7.44
1st Quartile	7.72	7.72	8.71	8.51	7.64	7.56
Median	7.90	7.81	8.87	8.71	7.71	7.65
3rd Quartile	7.94	7.87	8.96	8.82	7.87	7.76
Maximum	8.00	8.19	8.99	8.96	7.98	7.87

Orthophosphate Summary Statistics

For the orthophosphate conditions the target was a mean concentration of 2 ± 0.3 mg/L as PO_4. Table 6 shows that the means for the Marston and Moffat coupons were within the target mean. While these results were on the low side, this can be explained from the consumption of orthophosphate by the coupons during the testing period.

Table 6 Summary of 2 mg/L target orthophosphate data after treatment addition (Week 11-17)

	Marston	**Moffat**
Mean (mg/L)	1.8	1.7
Variance ($(mg/L)^2$)	0.0	0.0
Standard Deviation (mg/L)	0.2	0.1
Minimum (mg/L)	1.2	1.6
1st Quartile (mg/L)	1.7	1.7
Median (mg/L)	1.8	1.7
3rd Quartile (mg/L)	1.9	1.8
Maximum (mg/L)	2.2	1.8

Lead Illustrations

Lead concentration data for the Marston coupons and the Moffat coupons over time are shown in Figure 4 and Figure 5, respectively. Data above 500 ppb are not shown in Figure 4 and Figure 5 and all the data during the study are shown in Figure 16 and Figure 17 in the Appendix. Control charting for the lead data are discussed in the Appendix. Figure 4 and Figure 5 identify the pre-treatment before pH adjustment or orthophosphate addition. The respective target pH or orthophosphate level over time is also shown. These time series figures provide visual information on how lead release from each coupon behaved over time and show that in general the experiment did not exhibit a high level of variability except for a few occasions. It is of note that during the conditioning phase, all the vessels experienced exactly the same conditions except source water. It can be observed that lead concentrations stabilize over time and essentially are unchanged between weeks 5 and 6 meaning conditioning is complete. While there is some replicate-to-replicate variability, most of the lead release has stabilized to about 50 ppb prior to the beginning of treatment.

The lead concentration data for the Marston and Moffat coupons are also shown as boxplots grouped based on the condition for the last 7 weeks of the study (Figure 6 and Figure 7). The boxplot figures allow for comparing lead release under the different treatment conditions, and similar to the time series figures, they also illustrate the variability in lead release. The boxplots have been prepared with the box ranging from the 25th to the 75th percentile with the median shown as a line through the box. The diamond indicates the average value. The whiskers extend from the 5th the 95th percentile. Values outside the 5th and 95th percentiles are shown as dots and the number below the box indicates the number of data points use in the construction of the boxplot.

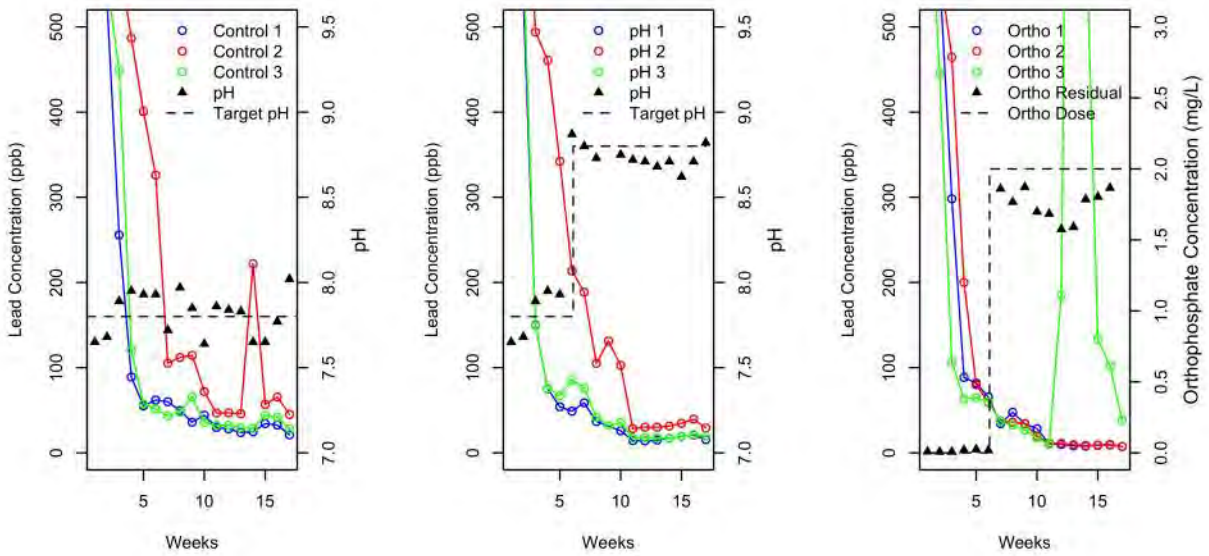


Figure 4. Time series of lead concentration data from lead solder coupons in Marston Water

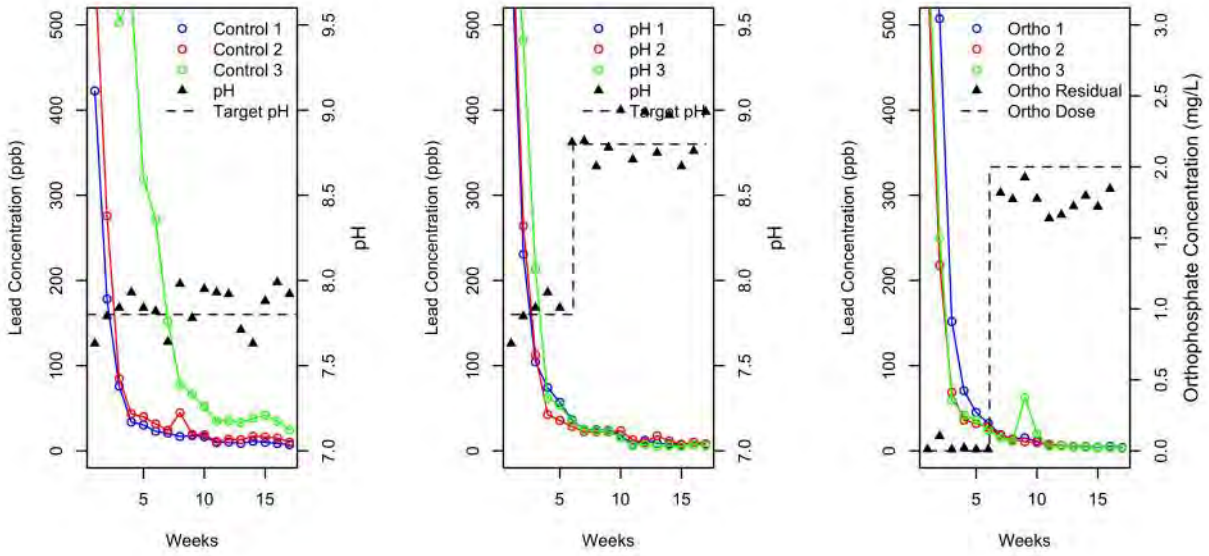


Figure 5. Time series of lead concentration data from lead solder coupons in Moffat Water

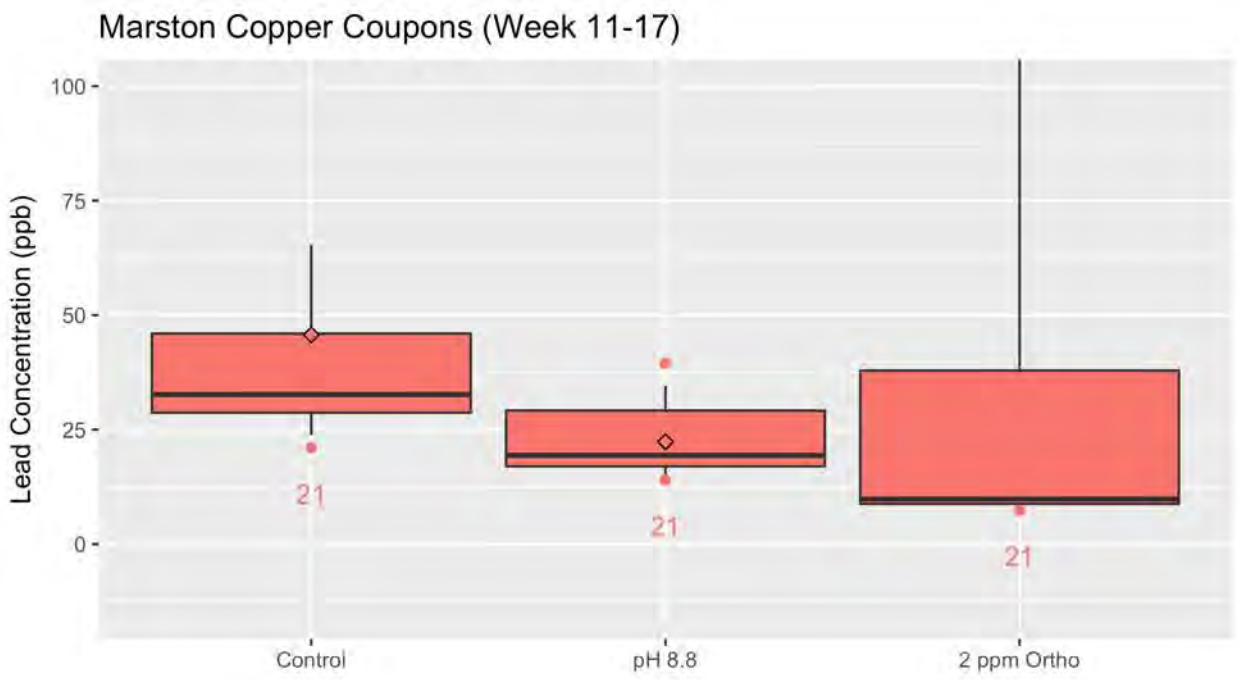


Figure 6 Boxplots of lead concentration data from lead solder coupons in Marston Water

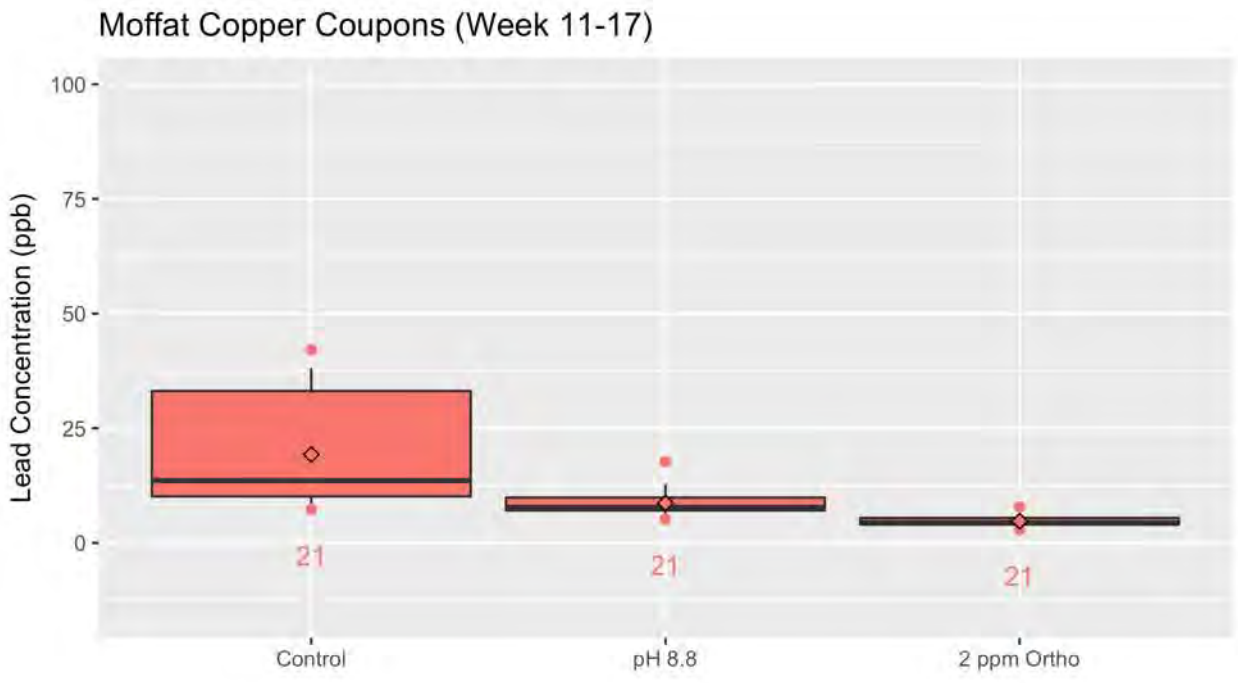


Figure 7 Boxplots of lead concentration data from lead solder coupons in Moffat Water.

The distribution of lead reductions between the control and the treatments was calculated using all the possible combinations of the data without duplication for Marston and Moffat coupons. The distributions of lead reductions are also shown as histograms in Figure 10. The results of the reduction calculations are summarized in Table 7. For both Marston and Moffat, the median lead reduction is greater for the orthophosphate treatment compared to the pH treatment. In other words, the orthophosphate treatment results in greater lead reduction compared to the pH adjustment.

Because negative removals are not expected as a result of the treatment conditions (but instead of variability that is independent of the treatment condition), we recalculated the statistics with all reductions below zero excluded from the analysis (Table 8). Box plots of these data are presented in Figure 8 and Figure 9. Distributions of lead reductions are also shown as histograms in Figure 10 after a 5,000 sample bootstrap.

Table 7 Summary of lead reduction data comparing to control to the treatment conditions

	Marston		**Moffat**	
	pH 8.8	2 ppm Ortho	pH 8.8	2 ppm Ortho
Mean (%)	37	-280	38	66
Variance ($\%^2$)	960	11387	1425	350
Standard Deviation (%)	31	1067	38	19
Minimum (%)	-88	-7449	-142	-8
1st Quartile (%)	22	-17	18	53
Median (%)	40	68	44	68
3rd Quartile (%)	58	78	70	84
Maximum (%)	94	97	88	93

Table 8 Summary of lead reduction data comparing to control to the treatment conditions

	Marston		**Moffat**	
	pH 8.8	2 ppm Ortho	pH 8.8	2 ppm Ortho
Mean (%)	46	72	49	67
Variance ($\%^2$)	434	183	593	342
Standard Deviation (%)	21	14	24	19
Minimum (%)	0	10	1	9
1st Quartile (%)	32	66	29	54
Median (%)	46	74	50	68
3rd Quartile (%)	61	80	71	84
Maximum (%)	94	97	88	93

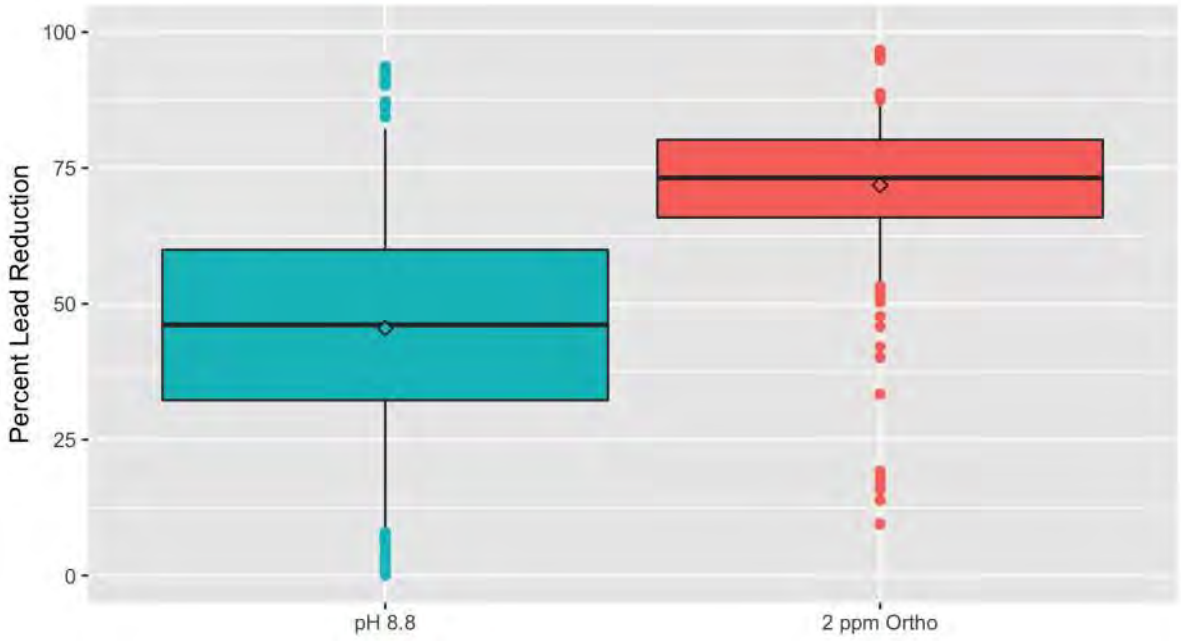


Figure 8 Distribution of percent reduction comparing the control condition to the treatment conditions at Marston

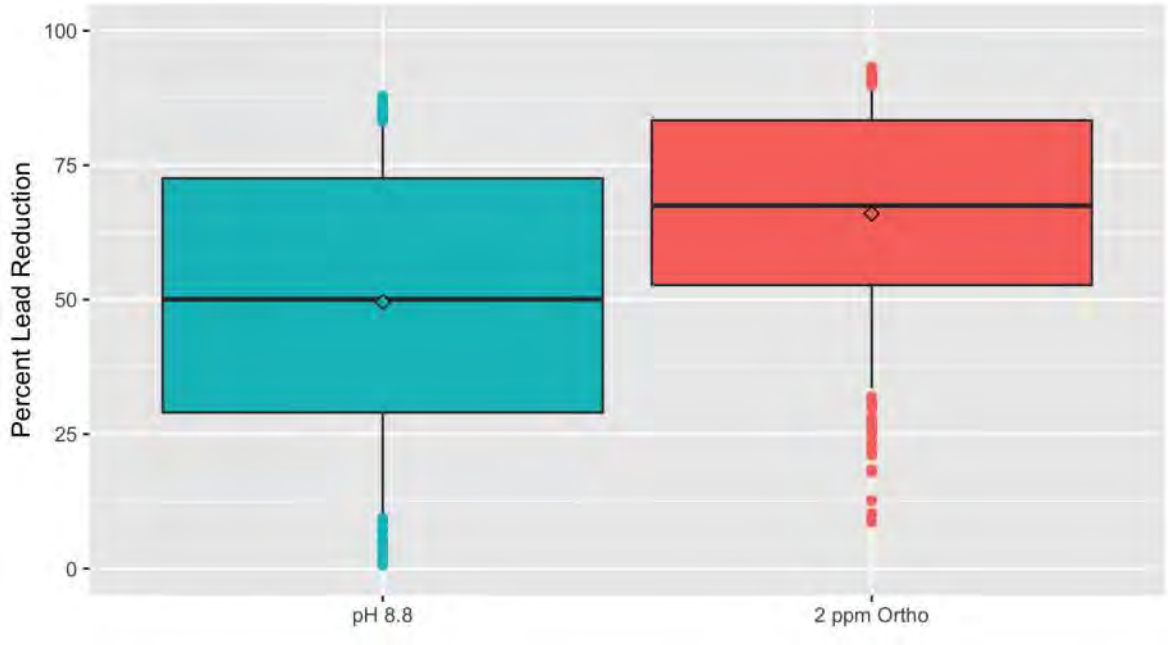


Figure 9 Distribution of percent reduction comparing the control condition to the treatment conditions at Moffat

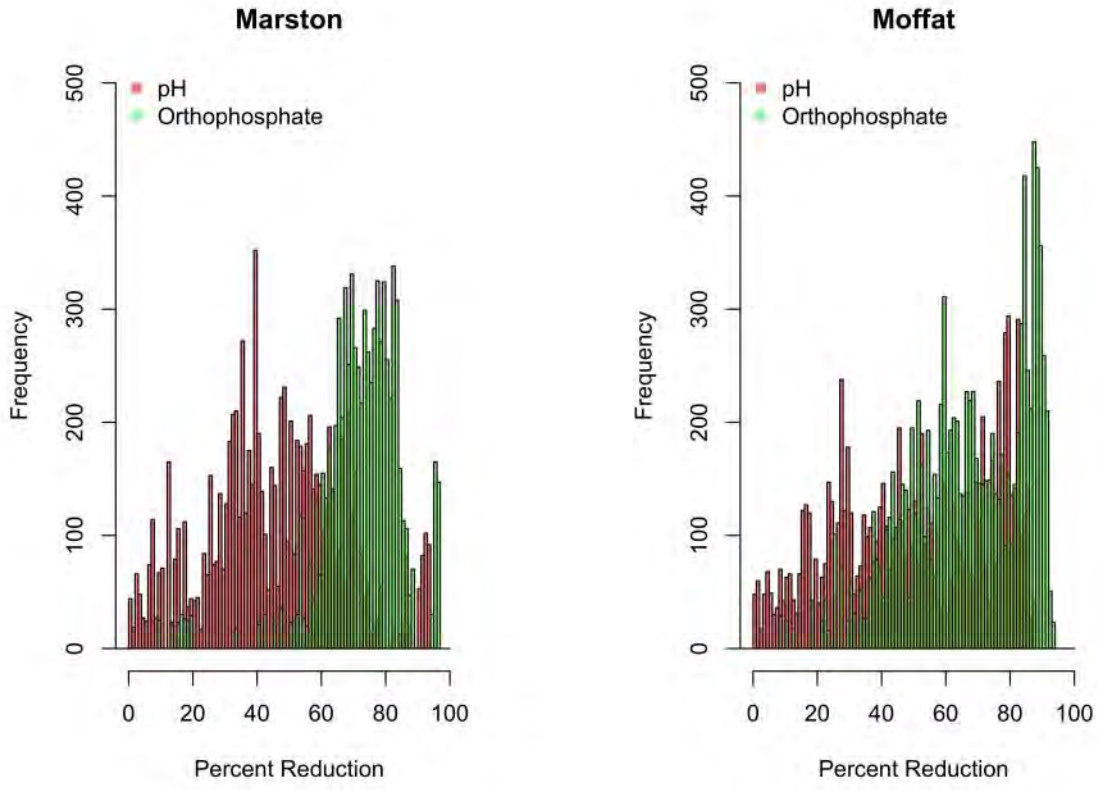


Figure 10 Distributions of lead reduction comparing the control to the treatments in Marston and Moffat coupons

Copper Data for Immersion Study Conditions

The descriptive statistics and illustrations included below compare copper release data from copper with lead solder immersion studies using Marston and Moffat Plant influent water under conditions of an orthophosphate dose of 2 mg/L, pH adjustment to 8.8 and a control. Only data from the last 7 weeks of the treatment are used in the calculations. Copper concentration data for the three treatment conditions are summarized in Table 9.

Table 9 shows that the median and median copper concentrations were lower for both pH adjustment and orthophosphate compared to the control regardless of the source water. For the Marston coupons the mean and median copper concentration for orthophosphate slightly lower than the pH treatment. For the Moffat coupons, the mean and median copper concentration was slightly lower for pH treatment compared to orthophosphate addition.

Table 9 Summary of copper concentration data for immersion study (Week 11-17)

	Marston			Moffat		
Condition	Control	pH	Orthophosphate	Control	pH	Orthophosphate
Mean (ppb)	406.7	185.4	154.5	371.8	134.9	142.1
Variance (ppb ^{2})	1758.5	550.8	10.74.1	4053.4	357.5	219.3
Standard Deviation (ppb)	41.9	23.5	32.8	63.7	18.9	14.8
Minimum (ppb)	344.9	154.1	50.3	250.7	101.9	118.8
1st Quartile (ppb)	380.6	167.1	146.0	323.4	121.5	133.3
Median (ppb)	394.6	180.7	165.4	360.9	136.5	138.9
3rd Quartile (ppb)	447.3	201.2	171.8	416.8	142.8	145.0
Maximum (ppb)	514.6	239.4	201.1	481.6	173.1	187.0

Copper Illustrations

Copper concentration data for the Marston coupons and the Moffat coupons over time are shown in Figure 11 and Figure 12, respectively. For the Marston and Moffat coupons copper release increased during the conditioning phase. After the treatment changes were made copper continued to increase in the control condition but decreased in the two conditions where treatment was added.

The copper concentration data for the Marston and Moffat coupons are also shown as boxplots grouped based on the condition for the last 7 weeks of the study (Figure 13 and Figure 14). The boxplots show that copper release in the control conditions was more variability compared to the treatment conditions. Similar to the lead data, control charts were developed for the copper release data for the three conditions tested in Marston and Moffat Water Racks (Figure 24 and Figure 29) in Appendix.

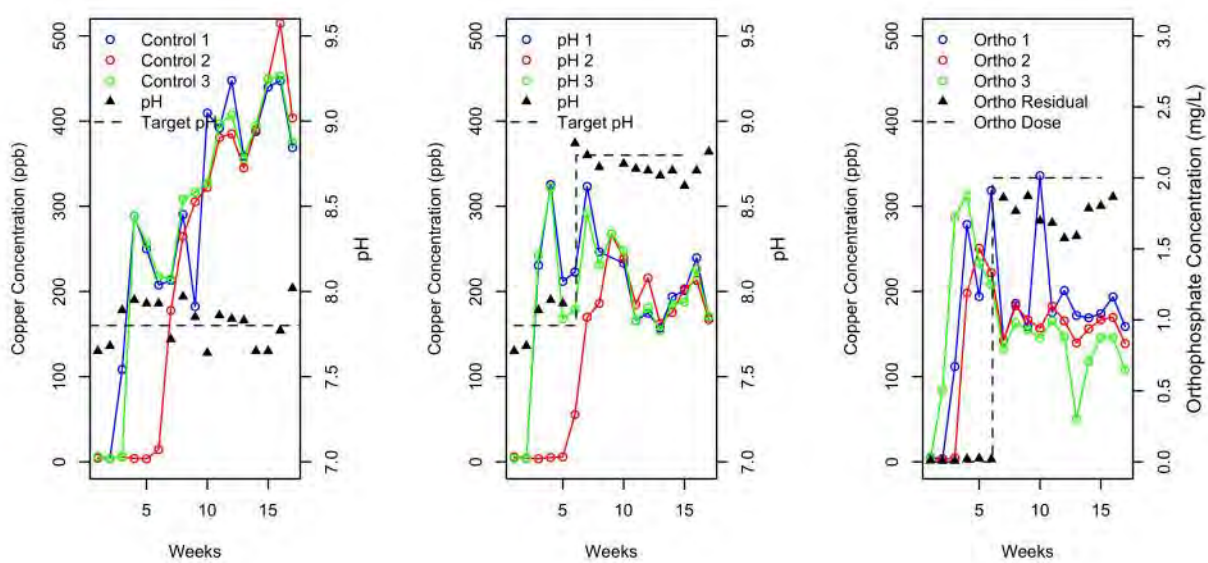


Figure 11. Time series of copper concentration data from lead solder coupons in Marston Water.

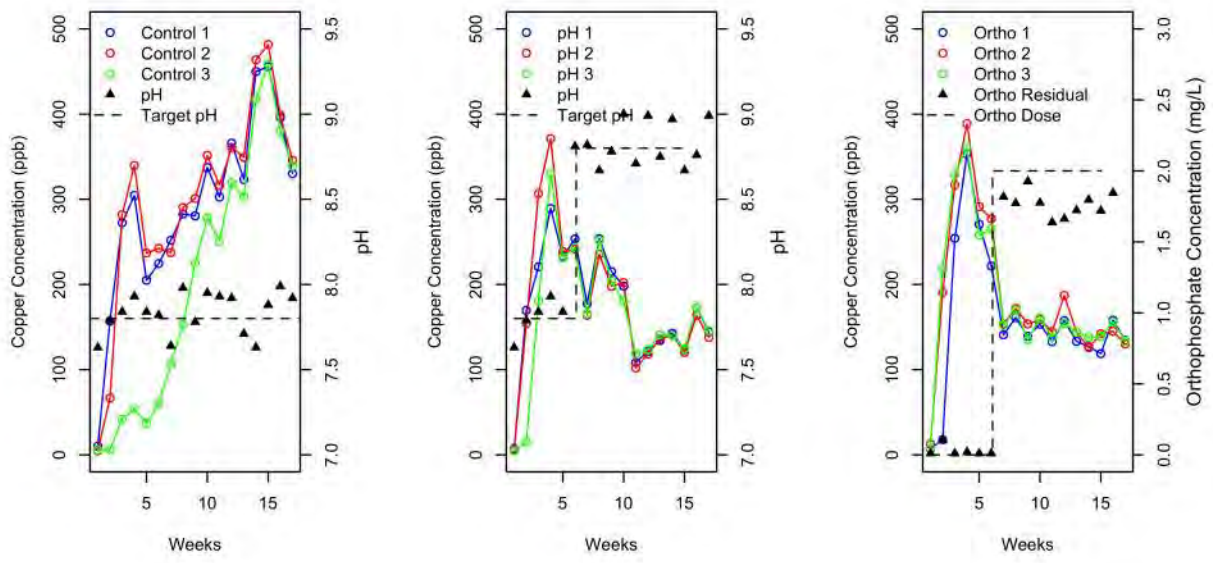


Figure 12. Time series of copper concentration data from lead solder coupons in Moffat Water.

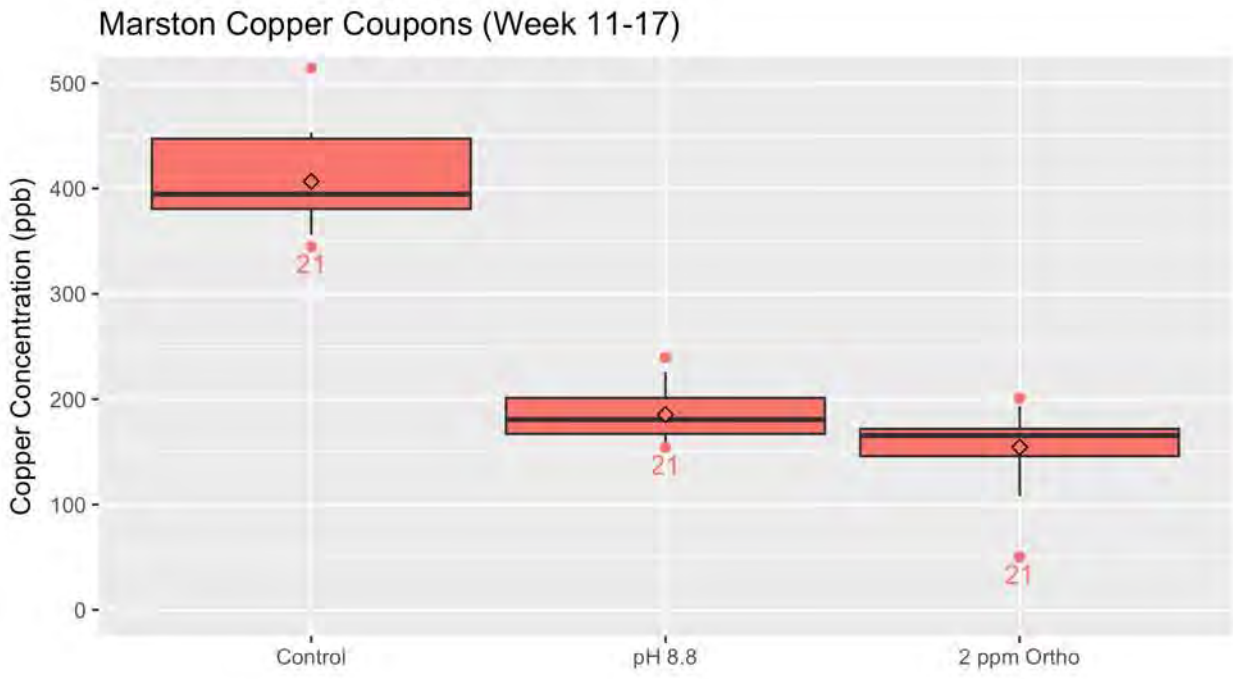


Figure 13 Boxplots of copper concentration data from lead solder coupons in Marston Water

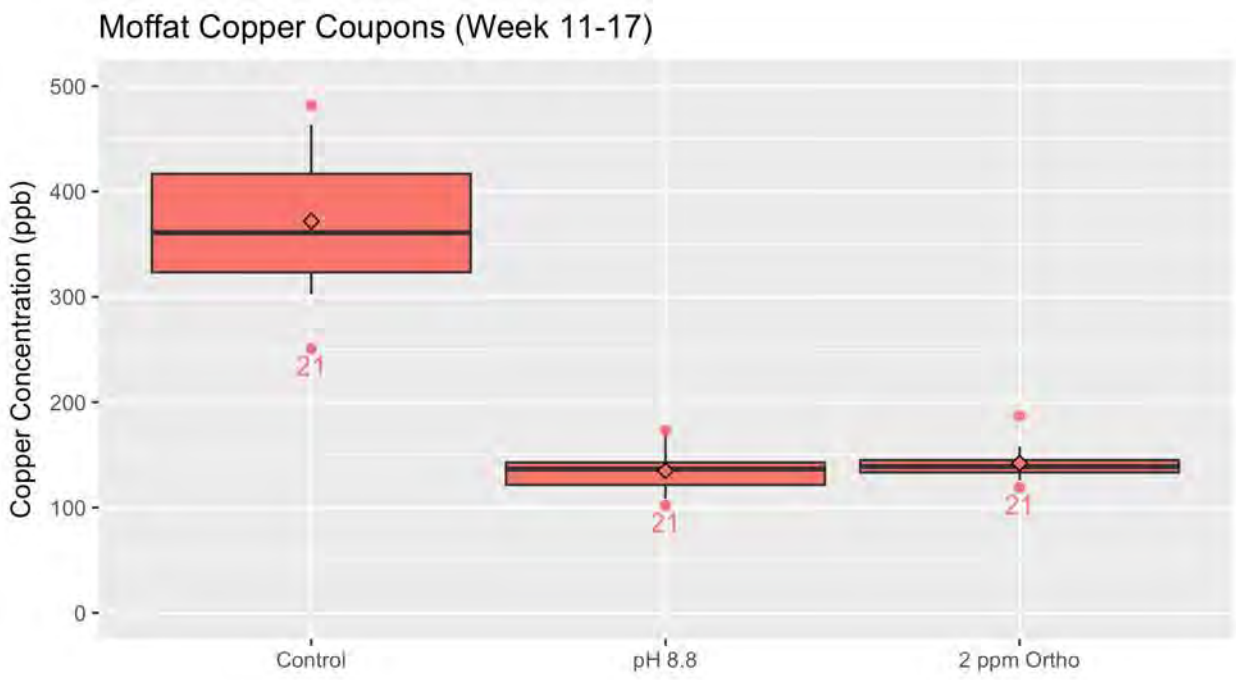
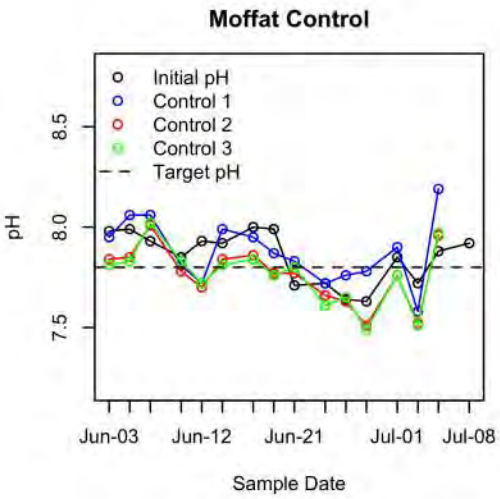


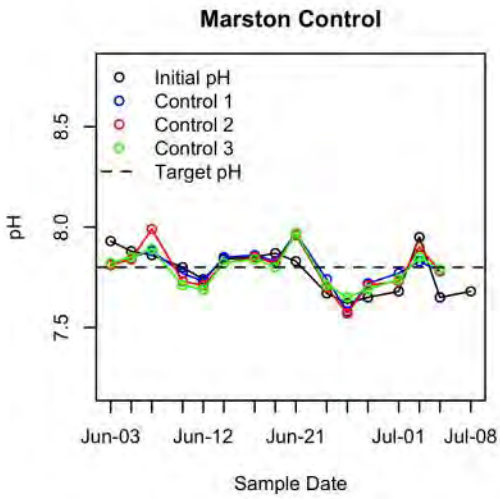
Figure 14 Boxplots of copper concentration data from lead solder coupons in Moffat Water

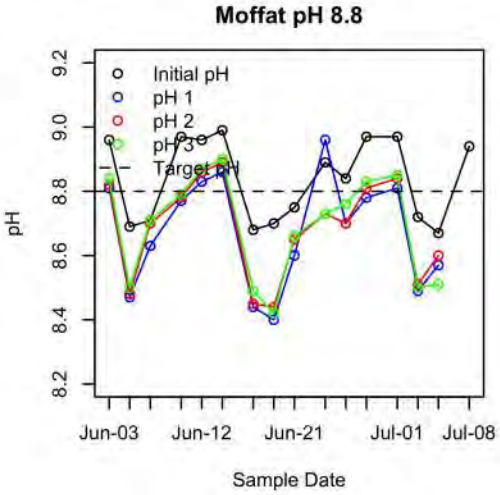
Summary & Conclusions

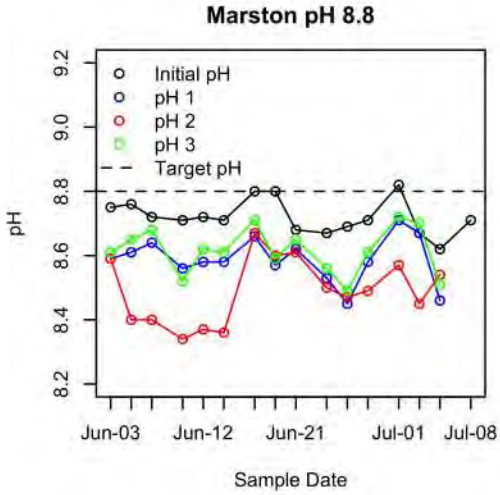
We conclude that the median lead release from copper with lead solder was lower for orthophosphate treatment compared to pH adjustment for both Moffat and Marston waters. The median lead reductions from 2 mg/L as PO_4 were 74% and 68% from Marston and Moffat, respectively. For pH control at pH of 8.8, the median lead reductions were 46% and 50% from Marston and Moffat, respectively.

Appendix


Moffat Control
Initial pH
Control 1
Control 2
Control 3
Target pH
pH
7.5
8.0
8.5
Jun-03
Jun-12
Jun-21
Jul-01
Jul-08
Sample Date


Marston Control
Initial pH
Control 1
Control 2
Control 3
Target pH
pH
7.5
8.0
8.5
Jun-03
Jun-12
Jun-21
Jul-01
Jul-08
Sample Date


Moffat pH 8.8
Initial pH
pH 1
pH 2
pH 3
Target pH
pH
8.2
8.4
8.6
8.8
9.0
9.2
Jun-03
Jun-12
Jun-21
Jul-01
Jul-08
Sample Date


Marston pH 8.8
Initial pH
pH 1
pH 2
pH 3
Target pH
pH
8.2
8.4
8.6
8.8
9.0
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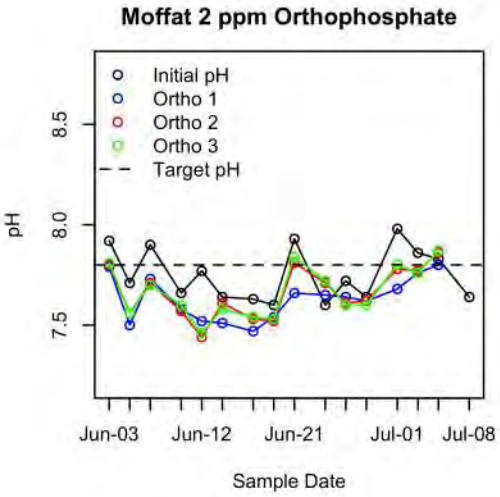
Jun-03
Jun-12
Jun-21
Jul-01
Jul-08
Sample Date


Moffat 2 ppm Orthophosphate
Initial pH
Ortho 1
Ortho 2
Ortho 3
Target pH
pH
7.5
8.0
8.5
Jun-03
Jun-12
Jun-21
Jul-01
Jul-08
Sample Date

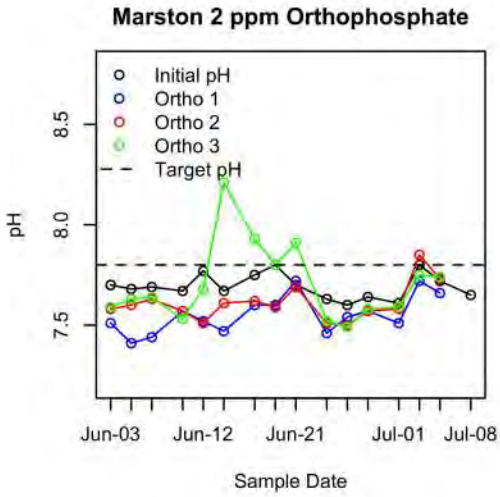

Marston 2 ppm Orthophosphate
Initial pH
Ortho 1
Ortho 2
Ortho 3
Target pH
pH
7.5
8.0
8.5
Jun-03
Jun-12
Jun-21
Jul-01
Jul-08
Sample Date

Figure 15. pH in the glass reactors before and after water change

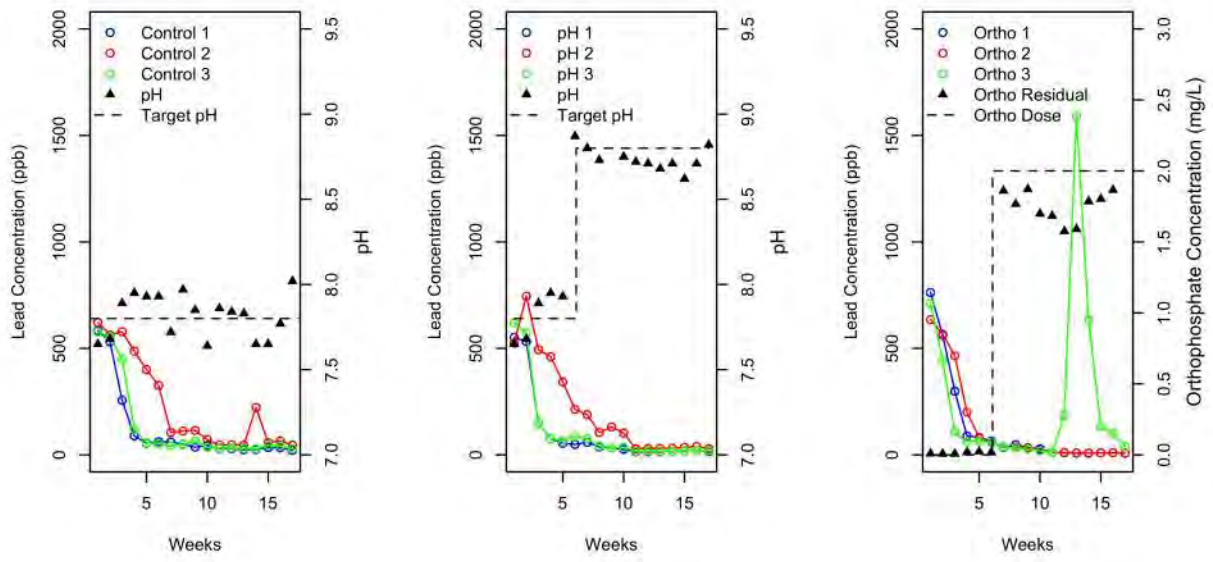


Figure 16. Time series of lead concentration data from lead solder coupons in Marston Water

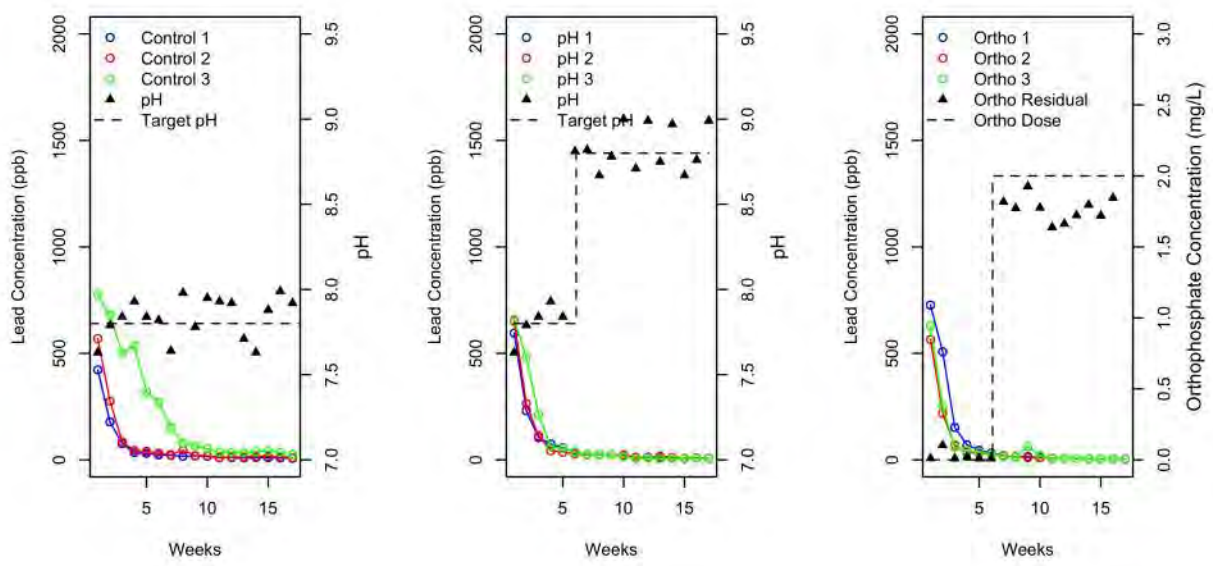


Figure 17. Time series of lead concentration data from lead solder coupons in Moffat Water

Lead Control Charts

Control charts were developed for the lead release data for the three conditions tested in Marston and Moffat Water Racks for data used in the analysis. The control charts display a series of mean day lead

concentrations throughout the experimental period. The center line is equal to the mean of all samples collected and the upper and lower control limits indicate the threshold at which the process output is considered statistically out of control and are drawn at three standard deviations from the center line. The data identified in red indicate data out of control while data identified in yellow indicate when the mean lead concentration for at least seven consecutive weeks with data available fall on one side of the center line. The control chart refers to these points as "violating runs."

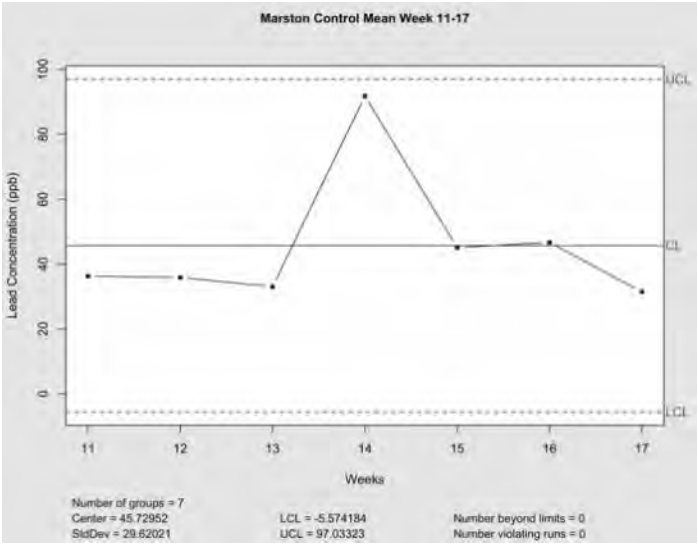


Figure 18 Control charts for pooled lead concentration data from the Marston control coupons

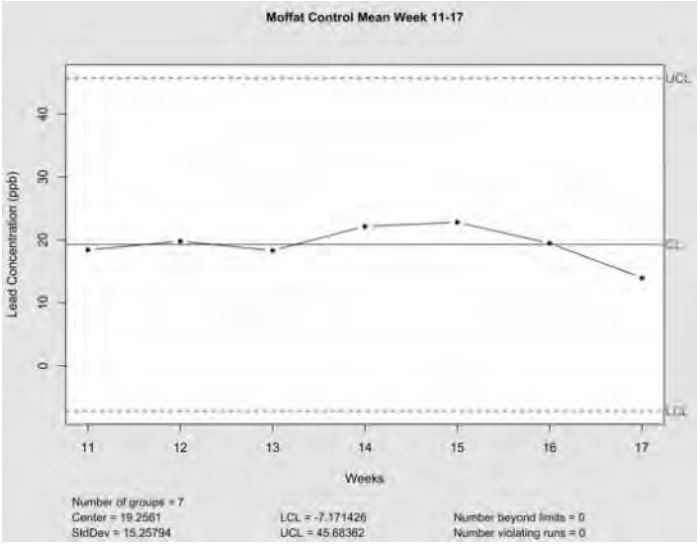


Figure 19 Control charts for pooled lead concentration data from the Moffat control coupons

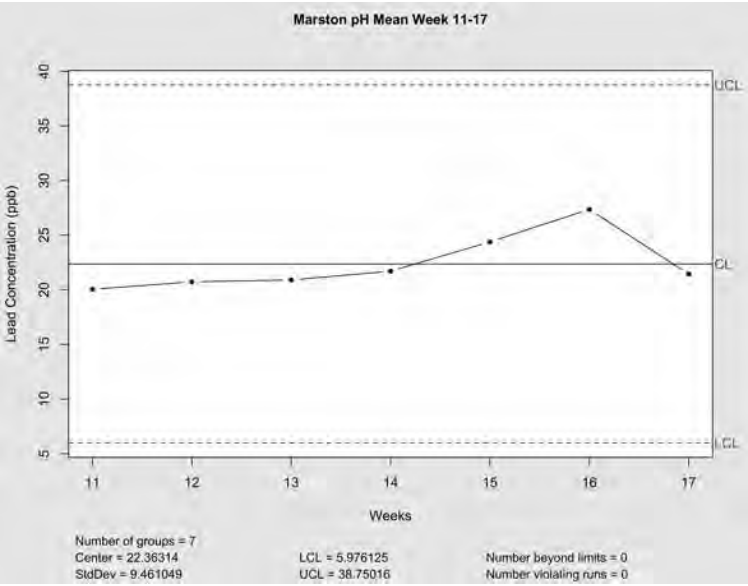


Figure 20 Control charts for pooled lead concentration data from the Marston pH coupons

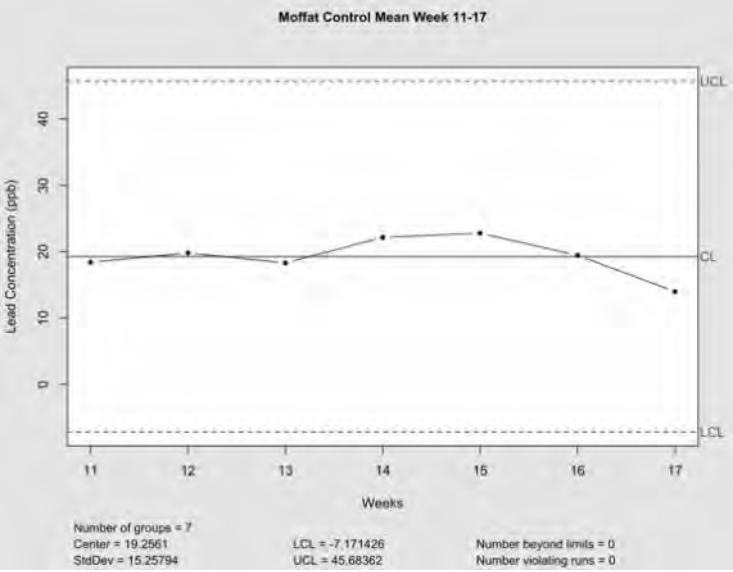


Figure 21 Control charts for pooled lead concentration data from the Moffat pH coupons

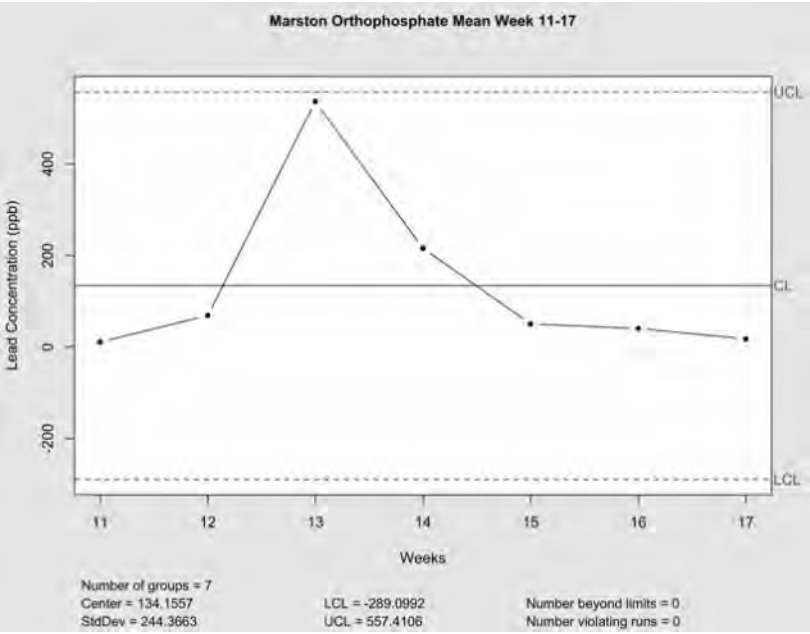


Figure 22 Control charts for pooled lead concentration data from the Marston orthophosphate coupons

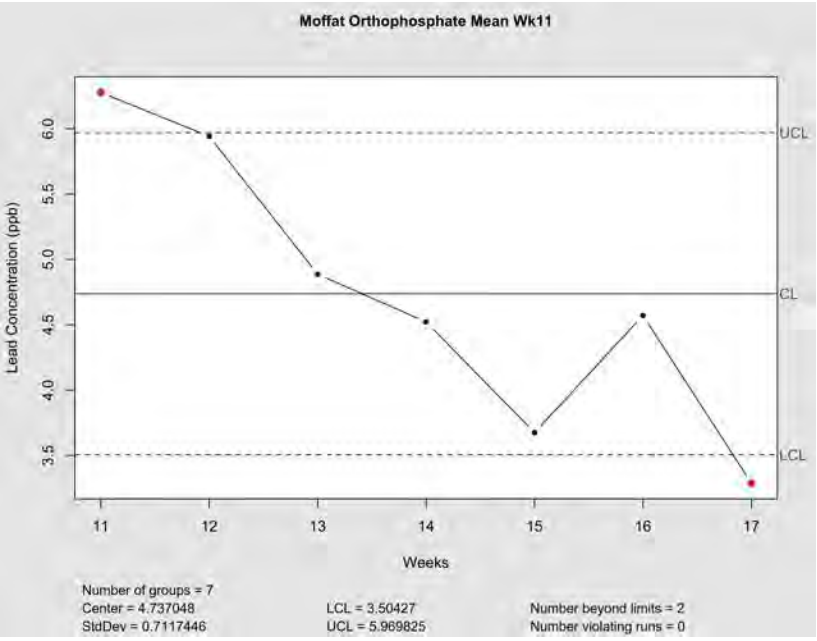


Figure 23 Control charts for pooled lead concentration data from the Moffat orthophosphate coupons

Copper Control Charts

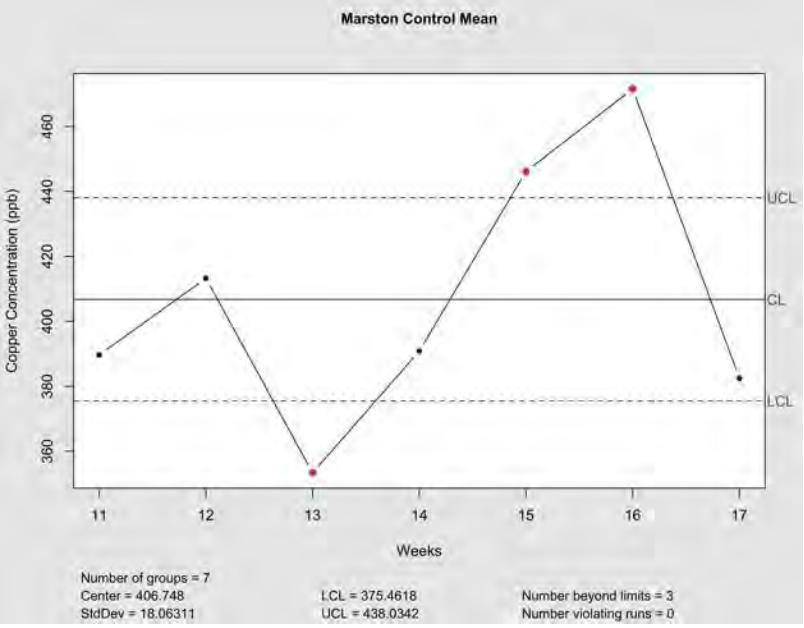


Figure 24 Control charts for pooled copper concentration data from the Marston control coupons

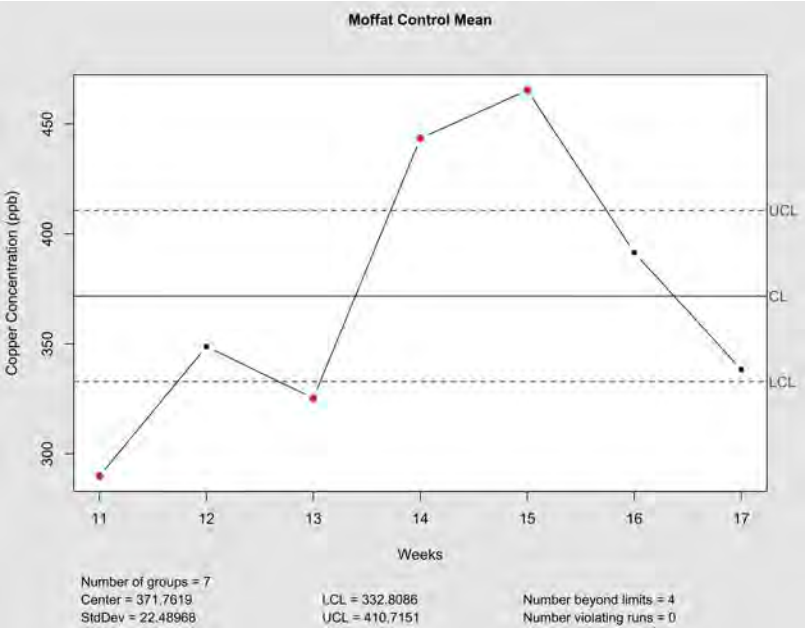


Figure 25 Control charts for pooled copper concentration data from the Moffat control coupons

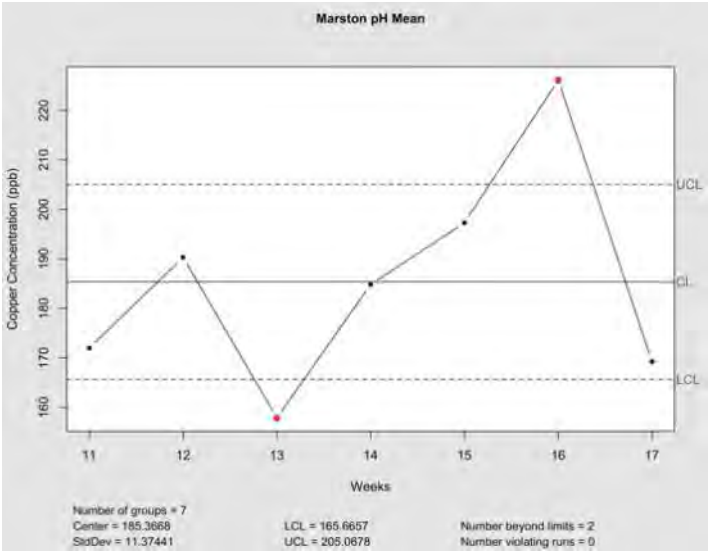


Figure 26 Control charts for pooled copper concentration data from the Marston pH coupons

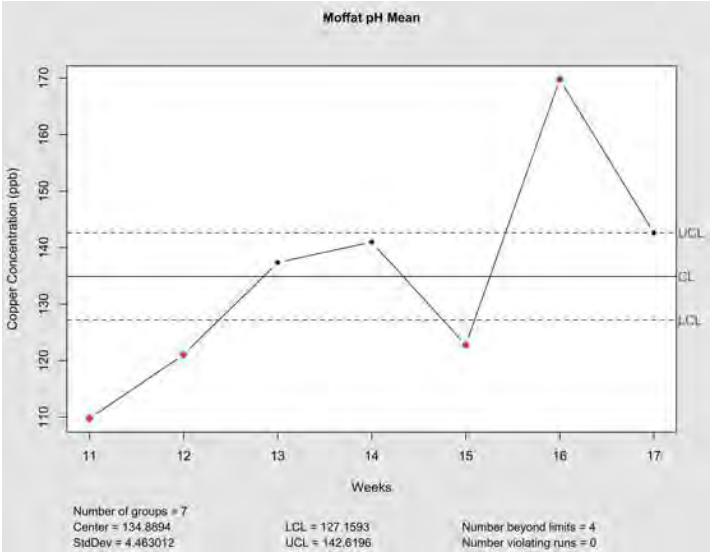


Figure 27 Control charts for pooled copper concentration data from the Moffat pH coupons

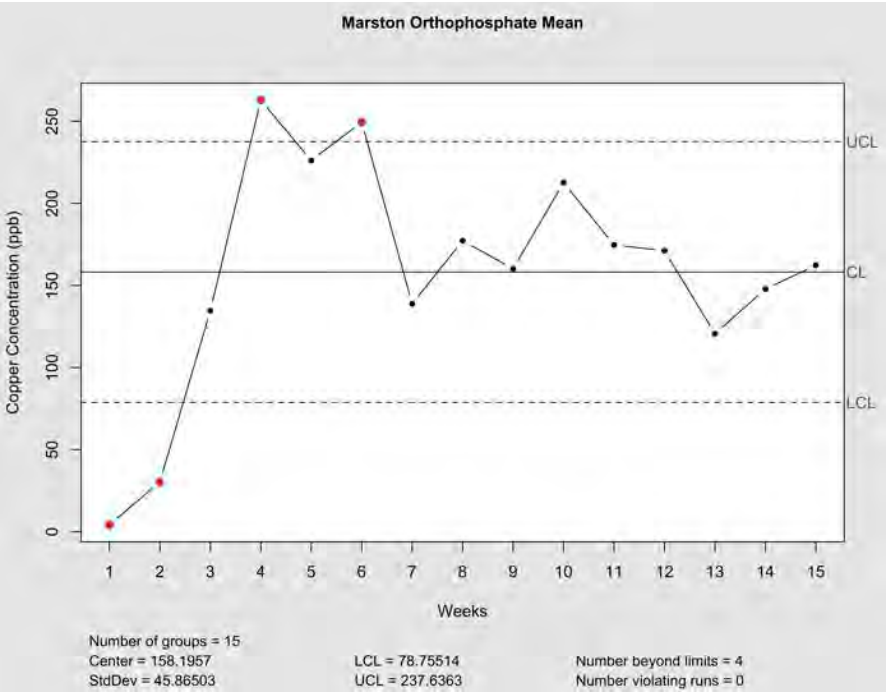


Figure 28 Control charts for pooled copper concentration data from the Marston orthophosphate coupons

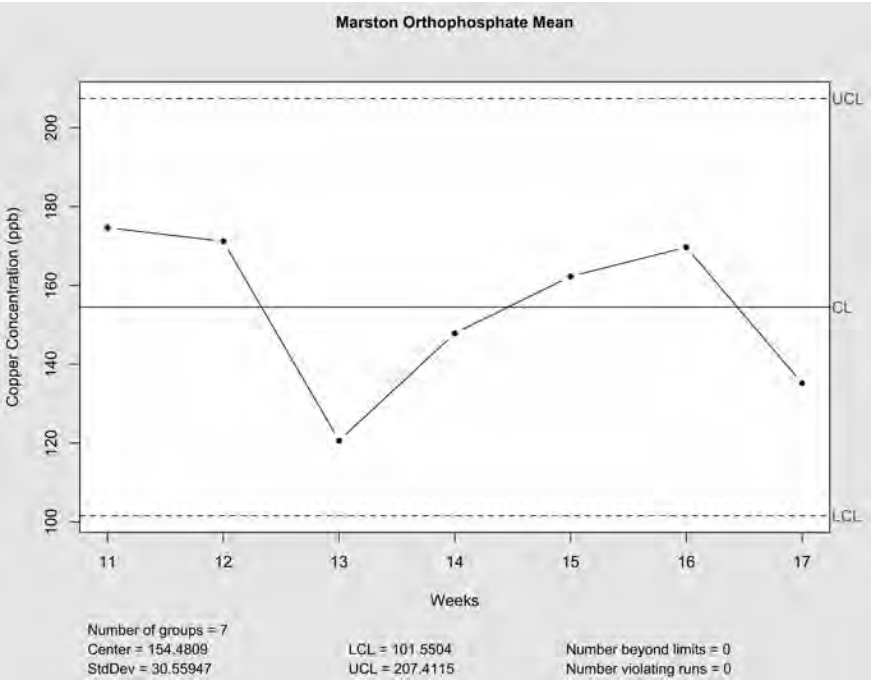


Figure 29 Control charts for pooled copper concentration data from the Moffat orthophosphate coupons

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APPENDIX III.E.3 – NITRIFICATION POTENTIAL OF ORTHOPHOSPHATE ADDITION AND INCREASED pH

September 2019

DENVER WATER

Appendix III.E.3:

Nitrification Potential of Orthophosphate Addition and Increased pH

Date: September 5, 2019

To: Denver Water

From: Corona Environmental Consulting, LLC

Introduction

The purpose of this appendix is to investigate the potential impacts of the two corrosion control strategies on nitrification occurrence in Denver Water's distribution system. Both corrosion control alternatives, orthophosphate addition and pH adjustment, have the potential to alter microbial communities within the distribution system by altering the C-N-P balance with the addition of phosphate, or by inhibiting microbial growth by increasing the pH.

Nitrification in chloraminated water systems is a common occurrence (AWWA 2013) and has been known to occur within Denver Water's distribution system. Nitrification was investigated in a 2016 Water Quality Model and Study completed by Bohannan Huston (2016), which concluded that episodic nitrification was observed in certain areas of the distribution system generally from September through November. These episodes coincided with decreases in production, and therefore, longer residence times (Bohannan Huston, 2016).

Nitrification is a two-step process that consists of a chemical reaction followed by a biological reaction. The chemical reaction is the auto decomposition of monochloramine which liberates free ammonia to the water. The biological reaction occurs when nitrifying bacteria use the free ammonia as a substrate, consuming the residual disinfectant. Nitrification is typified by the loss of the chloramine residual, increased microbial activity, depressed pH in poorly buffered waters, and the presence of nitrite and nitrate. Waters undergoing nitrification have also been shown to increase the concentrations of N-nitrosamines, such as N-nitrosodimethylamine (NDMA) and total N-nitrosamines (TONO), as well as disinfection by-products (DBPs) in chloraminated drinking water distribution systems depending on water quality conditions (Zeng & Mitch, 2016).

Data Review and Findings

The biological nitrification process requires specific water quality conditions to proceed, such as the bioavailability of nutrients (carbon, nitrogen, and phosphorus) and favorable pH and temperatures to promote nitrifying bacteria growth.

Nitrifying bacteria are mostly autotrophic, using inorganic carbon as their carbon source. In Denver Water's system this carbon source is carbonate. If an abundance of organic carbon exists in a system from the background organic matter, heterotrophic bacteria will outcompete nitrifiers and inhibit nitrification. Thus, nitrification is expected to proceed when there is high nitrogen concentration relative to

bioavailable carbon. Nitrification conditions are favorable in Denver Water's system as nitrogen is added during treatment as ammonia for chloramine formation.

The Marston and Moffat Treatment Plants' treated water nutrient conditions in terms of ammonia and bioavailable carbon are presented by a box and whisker plot in Figure 1. The box represents the range from the first to the third quartile with the whiskers extending to the 5th and 95th percentiles. Data outside these ranges are shown as individual dots. Assimilable organic carbon was estimated based on 10% of total organic carbon (TOC) being bioavailable (Camper et al., 2000; Terry & Summers, 2018). Ammonia nitrogen was calculated from the total chlorine residual in the lead pilot, assuming Denver Water's target chlorine-to-ammonia-as-nitrogen ratio of 4.5:1 (by mass). Denver Water's carbon and ammonia conditions lie within the region of heterotrophic and nitrifying bacteria colonization and is close to the region in which nitrifying bacteria dominate (Verhagen & Laanbroek, 1991). This indicates a high potential for nitrification and suggests the biological reaction is limited elsewhere.

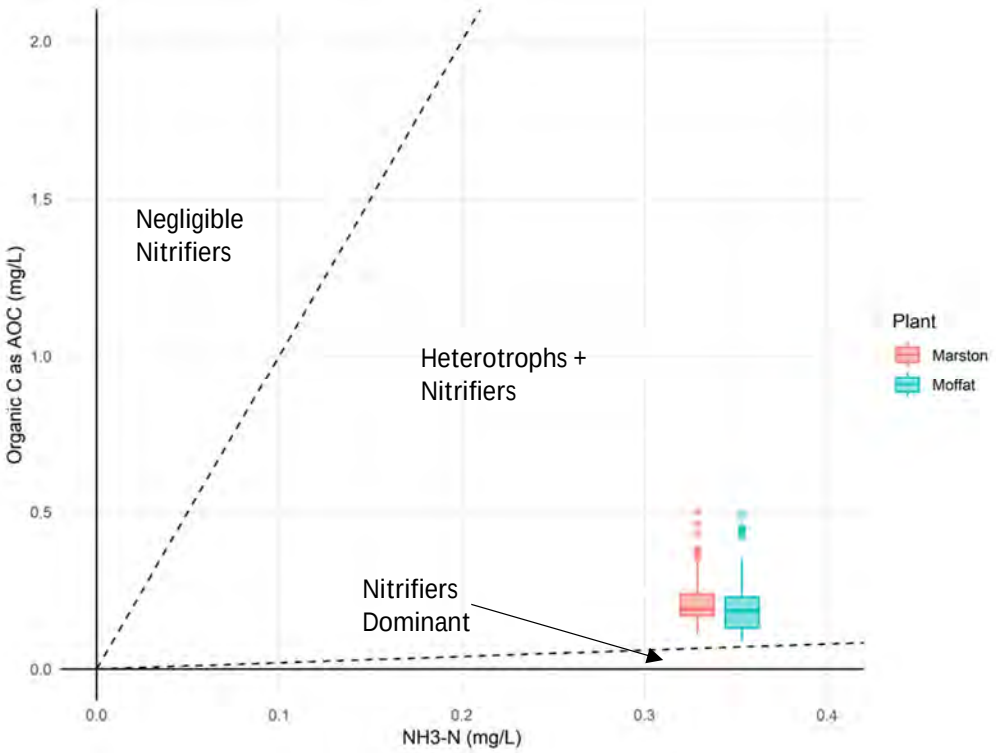

Figure 1 Effluent organic carbon and nitrogen concentrations at the Marson and Moffat Treatment Plants

Limited phosphorus concentrations in drinking water may inhibit the growth of nitrifiers in drinking water systems (AWWA, 2013). Specifically, phosphorus concentrations below 10 µg/L-P are considered limiting and concentrations below 25 µg/L-P are considered potentially limiting (AWWA, 2013). Furthermore, a study conducted by van der Aa et al. (2000) observed that in order to maintain sufficient nitrification, phosphorus concentrations of at least 10 µg/L-P are required. They also observed that concentrations of 30 µg/L-P are required to re-establish ammonia removal by nitrifiers at low temperatures. Phosphorus results obtained from the lead pilot are presented as a box and whiskers plot in Figure 2. Phosphorus in these systems originates from the source water, as phosphorus is not added as part of existing operations. These results indicate that nitrification in Denver Water's distribution system may be phosphorus limited. While phosphorus limitation in drinking waters is uncommon, it is not unexpected at Denver Water as the

water sources are first-use mountain runoff with few anthropogenic sources of phosphorus. Furthermore, any influent phosphorus is subject to coagulation with alum which tends to bind a fraction of the phosphorus for removal within the treatment plant.

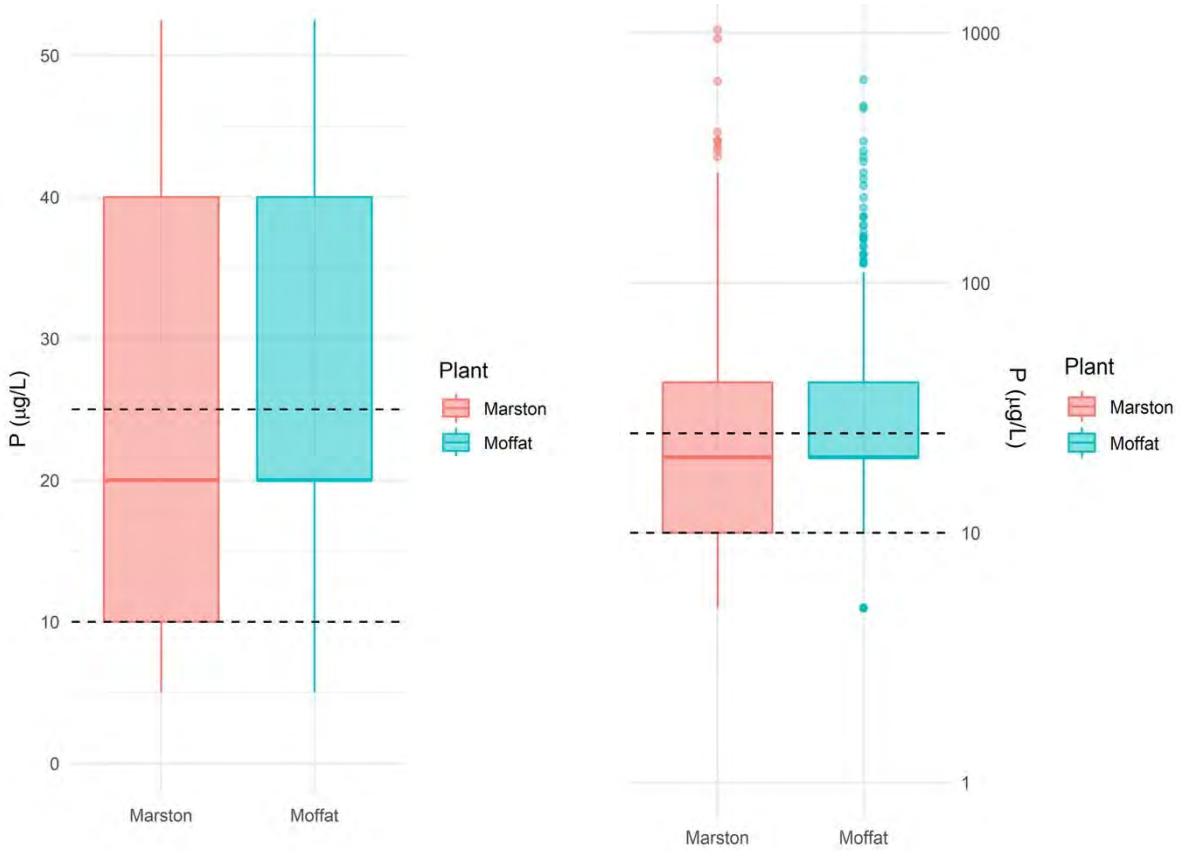

Figure 2 Marson and Moffat plants' influent phosphorus concentrations in arithmetic scale (a) and logarithmic scale (b). The 10 µg/L line represents the minimum concentration of phosphorus required to promote microbial activity, while the 25 µg/L dashed line represents potential phosphate limiting conditions.

Orthophosphate Addition

The addition of orthophosphate for corrosion control in the phosphorus limited distribution system is expected to increase nitrification frequency and severity. Consequently, Denver Water will have to proactively monitor and prevent nitrification to avoid disinfectant residual loss in the distribution system. Lower pH or fluctuations in pH that have been observed in poorly buffered waters, may also exacerbate lead release.

Nitrification control includes strategies to slow the chemical auto decomposition reaction of monochloramine and strategies to inhibit the biological reaction. Denver Water already practices good control of the chemical reaction by i) coagulating organics to reduce concentrations and stabilize the chloramine residual and ii) carefully controlling the chlorine-to-ammonia-as-nitrogen ratio during chloramine formation to minimize free ammonia in the effluent water. The most effective nitrification control strategy available to Denver Water in an orthophosphate CCT scenario is to increase the chloramine dose to prevent the onset of nitrification (Pintar et al., 2005; Zhang et al., 2009; AWWA, 2013). However, increasing the chloramine residual in chloraminated systems can further increase NDMA, TONO,

and other DBPs, as nitrifying biofilms release these compounds' precursors (Zeng & Mitch, 2016). The ability to decrease water age is limited due to Denver Water's distribution system size and the storage management operating strategy. Increasing pH in the orthophosphate scenario as a means to inhibit nitrification is not practical without extensive study as it reduces the effectiveness of lead control (AWWA, 1996).

pH/Alkalinity Adjustment

Under the proposed Lead Reduction Program, corrosion control practices at Denver Water will be modified to operate at a pH of 8.8 instead of the current pH target of 7.8, thereby inhibiting nitrification. Increasing pH to above 8.3 reduces the growth of nitrifying bacteria and reduces chloramine decay (Zhang et al., 2009; AWWA, 2013). Furthermore, Kirmeyer et al. (1993) found that the chlorine-to-ammonia-as-nitrogen ratio became less important at pH above 8.3, as monochloramine residuals are more stable and dichloramine formation (and the associated taste and odor problems associated with dichloramine) is minimized.

Conclusions

Introducing orthophosphate to Denver Water's phosphorus-limited distribution system has the potential to create favorable conditions for microbial growth and consequently, nitrification. Alternatively, increasing pH to 8.8 is expected to inhibit microbial growth, and therefore reduce the potential for nitrification in Denver Water's distribution system. Denver Water has a nitrification action plan, which is due to be updated by the end of the year. This plan describes how chloramine formation is managed, the operations and maintenance practices to reduce water age, and the water quality monitoring program for the distribution system.

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APPENDIX IV.A - PROPOSED TERMS AND CONDITIONS

September 2019

DENVER WATER

Note: This document sets forth Denver Water's proposed terms and conditions that will control if the variance to the treatment technique and the modification to the designated OCCT is granted. This document is preliminary and subject to modification.

Denver Water's Proposed Terms and Conditions for its Variance Request for Optimal Corrosion Control Treatment under SDWA 42 U.S.C. § 300g-4(a)(3)

In furtherance of Denver Water's variance request from 40 C.F.R. § 141.82(e) of the Optimal Corrosion Control Treatment Requirements under the Safe Drinking Water Act's Lead and Copper Rule, Denver Water is submitting its proposed terms and conditions which control during the term of the variance approval. The following proposed terms and conditions will become binding on Denver Water only upon the date that a variance becomes effective and so long as the variance remains in place. Except as otherwise provide herein, Denver Water must continue to follow the compliance requirements under the provisions of the Lead and Copper Rule as promulgated under state and federal law, 5 CCR 1002-11, 40 C.F.R. § 141.80-141.91, and as may be modified in the future.

1. Definitions:

A. *"Action level"* has the same meaning as action level in the Lead and Copper Rule, 40 C.F.R. § 141.80(c) and §§ 11.26(1)(c) and (2)(b) of the Colorado Primary Drinking Water Regulations (5 CCR 1002-11).

B. "*Adoption*" or *"Adopted"* for the purposes of the filter survey means that the customer enrolled in the filter program is using a filter NSF/ANSI (53) certified for lead removal for drinking, cooking, and infant fed formula (ingestion). Respondents who indicate that they use bottled water or an alternative NSF/ANSI (53) certified filter for ingestion will count as having adopted the use of a filter under paragraph 5.G.i. below.

C. "*Contact*" means direct mailing, water bill inserts, door hangers, in person contact, email, phone calls, educational materials accompanying filters and cartridges, or any other direct communication channels identified in Denver Water's communications, outreach, and education plan. Communications via information posted on the Denver Water website, social media websites, water bills, distribution of filters and replacement cartridges alone, or public notices required as a corrective action or a failure to meet a condition are excluded from this definition.

D. *"Customer Premise"*, for the purpose of these terms and conditions only, means a property or a residential unit within a multi-family property that receives water service pursuant to a Denver Water or distributor tap license.

E. "*Customer(s) Enrolled in the Filter Program*" means a customer premise, as defined herein where there is a known, suspected or possible lead service line (LSL), that will automatically be distributed a filter under section 5 below, unless otherwise refused by the customer.

F. "*Day*" means calendar day.

G. "*Effective Date*" means ninety-one (91) calendar days following approval of the variance or issuance of the State's modification decision, whichever occurs later.

H. *"Integrated System(s)"* means the defined term used in section 11.42(4) of 5 CCR 1002-11, as may be modified in the future. Currently, "integrated system" is defined as a "wholesale system and one or more consecutive systems with distribution systems that are physically connected [that] . . . choose to operate in a manner where the wholesaler assumes responsibility for compliance with one or more regulatory requirements applicable to the supplier responsible for the consecutive system, if the requirements of … section 11.42(4) are met."

I. *"Ingestion"* means the use of tap water for drinking, cooking, and infant fed formula.

J. *"Investigated"* refers to any activity used to identify the service line materials including a lead water quality test, potholing, visual inspection, or other methods that allows for a determination of the service line material.

K. *"Known LSLs"* are based upon direct evidence that gives a 100% estimated probability that a service line is an LSL.

L. "*Known, suspected and possible LSLs*" collectively refers to known LSLs, suspected LSLs, and possible LSLs.

M. "*Lead and Copper Rule (LCR) Regulatory Sampling*" means the collection of lead and copper tap samples for homes that have lead solder without a lead service lines and homes with lead service lines sampled in accordance with § 11.26 of 5 CCR 1002-11 and 40 C.F.R. § 141.86.

N. Lead Reduction Program Plan (LRPP) means Denver Water's Lead Reduction Program Plan dated September 2019.

O. *"Lead Service Line" or "LSL"* means a service line made of lead which connects the water main to the building inlet and any lead pigtail, gooseneck or other fitting which is connected to such lead line. This definition is intended to be inclusive of the term "Lead Service Line" as defined under section 11.26(1)(g) of 5 CCR 1002-11 and 40 C.F.R. § 141.2.

P. *"LSL Replacement"* is defined in paragraph 4.B, below.

Q. "*Orthophosphate Treatment*" means phosphate-based treatment as described in the Colorado Department of Public Health and Environment's (CDPHE) March 20, 2018 letter to Denver Water designating orthophosphate as optimal corrosion control treatment.

R. *"Possible LSLs"* are based on conflicting or missing data that provides an estimated probability value between 50% to 79% that a service line is an LSL.

S. "*Program Year*" has the same meaning as calendar year.

T. "*Public Notice*" for the purpose of this variance means either:

i. a Tier 2 public notice as described in § 11.33 of 5 CCR 1002-11 and 40 C.F.R. § 141.203, initiated within thirty (30) days following a CDPHE notice of a violation of the variance with messaging approved by CDPHE provided to all customers served by Denver Water;

ii. a public notice that contains the same elements of Tier 2 Public Notice described above initiated within sixty (60) days after learning of the need for corrective action provided to customers enrolled in the filter program to be delivered by making at least two (2) forms of direct contact with the customer subset, with messaging approved by CDPHE;

iii. a public notice by Denver Water that meets the requirements as described in § 11.26(7) of 5 CCR 1002-11 and 40 C.F.R. § 141.85, including public education associated with the Lead and Copper Rule initiated within sixty (60) days to all recipients specified in § 11.26(7)(c) of 5 CCR 1002-11 and 40 C.F.R. § 141.85(b);[1]

iv. a notice included in Denver Water's annual summary report; or

v. a Tier 3 public notice as described in § 11.33(4) of 5 CCR 1002-11 and 40 C.F.R. § 141.204, initiated as soon as possible but no later than 365 days following a violation or situation notification from CDPHE.

U. *"Suspected LSLs"* are based upon available data that provides an estimated probability value between 80% to 99% estimated probability (i.e. homes built before 1951) that a service line is an LSL.

V. *"System*" means the community water system that Denver Water owns and operates (PWS ID# CO0116001) and the integrated systems covered under Master Meter, Read and Bill, and Total Service agreements with Denver Water as detailed in Appendix III.B.1 of the Lead Reduction Program Plan submitted by Denver Water in support of its variance request.

W. *"Variance End Date"* means fifteen (15) years after the effective date, unless extended by EPA.

2. Corrosion Control Treatment:

A. *pH/Alkalinity Adjustment Corrosion Control Treatment*. By the effective date, Denver Water must begin to make adjustment to pH and alkalinity as corrosion control

[1] The public notice requirements under Subpart Q of the LCR (40 C.F.R, § 141.201 *et seq.*) will continue to apply if there is a violation of the schedule, and/or any terms and conditions of the variance –tier 1 and tier 2 notices, respectively.

treatment (CCT) according to an implementation schedule and treatment targets approved by CDPHE. Denver Water must maintain the corrosion control parameters and targets within the ranges designated by CDPHE under § 11.26(3)(d)(iii) of 5 CCR 1002-11 and 40 C.F.R. § 141.82(h).

B. *Monitoring and Sampling:*

i. *LCR Regulatory Sampling for Action Level 90th Percentile Calculation.* During the variance, Denver Water must maintain Lead and Copper Rule (LCR) sampling sites pursuant to § 11.26(2) of 5 CCR 1002-11 and 40 C.F.R. § 141.86 for lead service lines and lead solder sites.

ii. *Use of Sampling Results.* Lead water quality tests collected to identify LSLs for the inventory under this variance and to verify lead concentrations post-replacement shall not be used in the calculation of the 90th percentile. Any customer-requested samples that meet the Tier 1 sampling requirements will still be included in Denver Water's compliance calculations.

iii. *Monitoring for Water Quality Parameters*. Denver Water must follow §§ 11.26(4)(j)-(l) of 5 CCR 1002-11 and 40 C.F.R. §§ 141.82(g)-(i) for treatment technique compliance determinations for continued operation and maintenance of the CCT.

C. *CCT Compliance Metrics, Corrective Actions, and Failures.*

i. *CCT Compliance.* For each six-month sampling period, Denver water must achieve LCR Regulatory Sampling at or below the LCR Action Level based upon the 90th percentile calculation.

ii. *Corrective Action.* If compliance has not been achieved under 2.C.i., Denver Water must follow the requirements of the LCR in the case of a lead or copper Action Level exceedance under § 11.26 of 5 CCR 1002-11 and 40 C.F.R. § 141.82. If Denver Water's LCR regulatory sampling exceeds the LCR's Action Level as measured at the 90th percentile for two (2) LCR monitoring periods within the duration of the variance, Denver Water has failed to meet the condition in 2.C.i., and either:

a. this variance shall terminate; or

b. CDPHE will require Denver Water to follow the corrosion control treatment steps under § 11.26(3)(c) of 5 CCR 1002-11, in which case the variance will be continued pending the results from corrosion control treatment studies until CDPHE makes a determination under § 11.26(3)(c)(ii). EPA may nevertheless terminate this variance in the interests of public health under paragraph 7.D below.

c. In either case above, CDPHE will issue Denver Water a treatment technique violation and Denver Water must conduct a Tier 2 public notice to all customers under 1.T.i above.

3. Lead Service Line Inventory:

A. *LSL Inventory.* Denver Water must create and maintain on an ongoing basis an inventory of the material used for each service line used for drinking water that is a known, suspected, and possible LSL associated with a customer premise within Denver Water's system, and update the inventory each program year in agreement with CDPHE as LSLs are replaced and the material used for service lines are investigated. The inventory must include private service lines, and must include all LSLs within the system, including in the service areas of all distributors who are a part of the system. Denver Water must complete the initial LSL inventory no later than thirty-five (35) days after the effective date. The total estimated number of known, suspected, and possible LSLs equals (Y) as further described in paragraph 4.A below. Any updates to (Y) will be submitted in Denver Water's annual summary report described in paragraph 6 below.

B. *Investigation of Service Line Materials*. On an ongoing basis Denver Water must investigate known, suspected, and possible LSLs using lead water quality tests, potholing, visual inspections, or other means that supports a determination of the service line material. The number of known, suspected and possible LSLs for the purpose of investigating properties for the first year following the variance approval will be based on the (Y) factor, as adjusted under paragraph 4.A below. Denver Water must incorporate its findings under this subsection into its required LSL inventory annual updates.

C. *Publication of LSL Inventory.* No later than seventy (70) days following the effective date, Denver Water must provide public access to its LSL inventory on its external customer website, which will allow the public to view whether service line materials used for any customer premise in the system is (i.e. lead, copper, or unknown). During the term of this variance, Denver Water must continue to provide public access to its LSL inventory, including access to any updates to its inventory required under this section 3. For owners or residents of a customer premise who call Denver Water by phone, Denver Water must disclose whether its inventory shows that the owner's or resident's service line is a known, suspected and possible LSL, is unlikely to be an LSL or is a non-lead service line.

D. *LSL Inventory Compliance Metrics, Corrective Actions, and Failures.*

i. *Compliance Metric.* Denver Water must investigate a minimum of 1.4% of the total estimated number of suspected and possible LSLs in the LSL inventory each program year until 20% of the total estimated number of suspected and possible LSLs are investigated based upon the inventory at the beginning of the first program year (based on a subset of Y as described in paragraph 4.A below) as adjusted. These investigations are performed independently of the LSL replacements under paragraph 4 below.

ii. *Corrective Action.* If Denver Water does not conduct the minimum 1.4% of investigations by the end of the program year, the denominator (Y) in paragraph 4.A below will revert to the value established at the beginning of the previous program year, less LSL replacements for the previous program year, until Denver Water achieves compliance with this paragraph. Denver Water must also provide public notice that the metric was not met in its annual summary report under paragraph 1.T.iv above.

iii. *Completion of Inventory.* When Denver Water has completed the confirmation of the material for all suspected and possible LSLs under paragraph 3.D.i., Denver Water must provide written notice to CDPHE and this variance metric will terminate.

4. Accelerated Lead Service Line Replacement Program:

A. *LSL Replacement*. By the effective date, Denver Water must begin to implement accelerated LSL replacement in its system and replace all known LSLs within 15 years of the effective date. By the end of program year 1, Denver Water must achieve a 6.0% replacement rate,[2] and by the end of program year 2, Denver Water must achieve a 6.5% replacement rate based upon the known, suspected and possible LSLs (Y) at the beginning of the program year. By the end of the third program year and every program year thereafter, Denver Water must maintain a minimum cumulative annual average replacement rate of 7.0% per year. At the end of each program year, the cumulative program year average must be calculated using the total number of LSLs replaced during the term of the variance (X) divided by the total estimated number of known, suspected, and possible LSLs (Y), consistent with the most recent update of the LSL inventory. Program year adjustments to (X) and (Y) will be made at the end of each program year with the approval of EPA and CDPHE based upon any changes to the total estimated number of known, suspected and possible LSLs in Denver Water's updated LSL inventory except as otherwise provided in paragraph 3.D.ii above; provided, however, all LSLs must be replaced within 15 years of the effective date. For program year 1, X = 3,838 and Y= 63,955.

B. *LSL Replacement Defined*. For the purpose of calculating the cumulative program year average replacement rate, the following types of LSL replacements will count as credit for an entire LSL replacement:

i. full LSL replacement of a single service line;

ii. replacement of an existing partial LSL that results in a non-lead service line from the main to the first fitting inside the structure;

iii. replacement of a galvanized service line downstream of an existing or previously existing LSL, including any lead that is part of the upstream segment of the service line; and

[2] If the effective date is after January 1, 2020, the 6.0% replacement rate for the first program year will be prorated through December 31, 2020 by dividing the number of remaining full months from the effective date to the end of the Calendar Year by 12 and multiplying this factor by the 6.0% replacement rate.

iv. LSL replacement completed by other governmental agencies, developers, homeowners, non-profits, etc. and inspected by Denver Water.

C. *Replacement to Fitting.* All LSLs must be replaced from the main up to the first fitting inside the structure excluding any portion of the service line that is copper. If there is no fitting within five feet of the location where the service line enters the structure, Denver Water must install a fitting to allow for connection of the service line at a location convenient for Denver Water.

D. *Partial LSL Replacements.* Denver Water may not make a partial replacement of an LSL during the term of the variance except when i. emergency repairs must be made to a service line or water main to protect the distribution system; or ii. property owner consent cannot be obtained or the property cannot be accessed. A partial replacement that does not result in complete replacement of all portions of the LSL shall not be counted as an LSL replacement for the purposes of the accelerated LSL replacement program until the partial LSL is fully replaced.

E. *Post Replacement Samples*. Denver Water must offer to collect and analyze lead samples at homes where LSLs have been replaced six (6) months post LSL replacement.

F. *Test Out.* The "test out" provision in 40 C.F.R. § 141.84(c) and § 11.26(6)(b)(i)(B) of 5 CCR 1002-11 does not apply while Denver is subject to this variance. Any lines that "test out" do not count toward LSLs that were replaced under the terms of this variance.

G. *Property Owner Consent.* Denver Water must contact property owners at the customer premise before replacement to secure the property owner's documented consent. Work at the customer premise may commence once consent is documented. If Denver Water has not made contact with a property owner, Denver Water must use reasonable efforts to secure consent. Reasonable efforts must include at least three attempts to contact the property owner including an attempt to send at least two (2) written requests by U.S. mail to the property owner at the most recent mailing address identified through Denver Water records for consent to replace the LSL at the property, and an attempt to obtain permission by making in-person contact with the property owner if necessary. If documented consent to replace the LSL is not granted after reasonable efforts are made to achieve consent, the property will be added to Denver Water's Service Line Refusal List as described in paragraph 4.H. below.

H. *Customer Refusals and Changes in Customer Accounts.* Denver Water must maintain records of the addresses of all structures at which the property owner does not consent to LSL replacement (Service Line Refusal List). When Denver Water customer account records indicate a change in ownership at the customer premise, Denver Water must determine whether the address is on the Service Line Refusal List, and within ninety-one (91) days of a change in Denver Water account records, undertake reasonable efforts to obtain permission from the new property owner of the customer premise to replace the LSL. Reasonable efforts include the efforts described in paragraph 4.G. above. If permission is granted and conditions allow for

the LSL to be accessed and safely replaced, Denver Water must replace the LSL. By the variance end date, Denver Water must replace all LSLs at properties on the Service Line Refusal List.

I. *LSLs Discovered After Variance Term.* Denver Water must continue to replace any LSL discovered after the variance end date and report any LSL replacements to CDPHE on an annual basis. This condition shall survive the term of the variance.

J. *Accelerated LSL Replacement Compliance Metrics, Corrective Actions, and Failures.*

i. *Compliance Metric*. Denver Water must achieve at least a 6.0% LSL replacement rate by the end of program year 1, 6.5% in program year 2, and beginning the end of program year 3 and thereafter a 7.0% cumulative annual average LSL replacement rate each program year.

ii. *Corrective Action.* If the compliance metric in paragraph 4.J.i. is not achieved after program year 3, Denver Water must increase LSL replacements to achieve a 7.0% cumulative annual average replacement rate by the end of the next program year. In addition, Denver Water shall provide public notice to all customers who have known, suspected, or possible LSLs that correction under this variance metric under 1.T.ii

5. Filter Program:

A. *Filters.* Denver Water must distribute to the occupant of all customer premises with known, suspected and possible LSLs one (1) filter and enough replacement cartridges for the first six months of use. Denver Water shall begin to distribute filters and cartridges within ninety-one (91) days of the effective date and complete distribution one hundred and eighty-two (182) days following the effective date. If Denver Water does not distribute all of the filters and cartridges by the above deadline, then Denver Water must conduct public notice to all customers enrolled in the filter program under paragraph 1.T.ii. All filters and cartridges distributed must be certified NSF/ANSI (53) for lead removal and not remove fluoride. Denver Water need not distribute a filter and replacement cartridge to a customer premises if the occupant confirms that their household uses bottled water, an existing under the sink filter certified NSF/ANSI (53) for lead removal, refrigerator filter certified NSF/ANSI (53) for lead removal, or other lead removal device that is certified NSF/ANSI (53) for lead removal for ingestion purposes.

B. *Filter Replacement Cartridges.* Denver Water must distribute replacement cartridges to customers enrolled in the filter program per the filter manufacturers' recommended replacement rate unless the customer refuses the filter or replacement cartridges. Replacement filters must be provided to each customer premise enrolled in the filter program until six months after replacement of a customer premise's LSL or until the time the service line of the property is confirmed to be non-lead. If Denver Water does not distribute all of the replacement cartridges per the manufacturers' recommended replacement rate, then Denver Water must conduct public notice to all customers enrolled in the filter program under paragraph 1.T.ii.

C. *Changes in Customer Accounts.* If a change in the customer name of the water account associated with a customer enrolled in the filter program occurs at any time, then Denver Water must distribute a new filter within thirty-five (35) days of the change in customer account and replacement cartridges per manufacturers recommended replacement rate to the new customer so long as the customer premise or a residential unit at the customer premise is enrolled in the filter program.

D. *Filters for Infants in '83 to '87 Customer Premises*. If a customer has a formula-fed infant/child up to 24 months of age and resides in a customer premise that is built between 1983-1987 and served by a copper service line with lead solder, upon customer request Denver Water must provide a free lead water quality test kit. If the water quality results in the first draw show lead concentrations above 3 ppb, Denver Water must offer a filter and enough replacement cartridges to last the customer until a child at the customer-premise exceeds the age of 24 months.

E. *Filter Adoption Assessment.*

i. *Surveys.* Denver Water must conduct a survey each program year of randomly selected customers enrolled in the filter program to receive at minimum 1,059 responses. The minimum number of required responses may be reduced upon written approval of CDPHE and EPA as the number of customers enrolled in the filter program decline during the term of this variance. The survey must inquire whether the customer has adopted the filter for water used for infant formula if applicable, cooking and drinking or is using bottled water or a filter device that is certified NSF/ANSI (53) for lead removal not provided by Denver Water for infant formula, cooking and drinking. The filter survey will be provided to and approved by CDPHE before distribution to customers enrolled in the filter program. If Denver Water:

a. Does not conduct the annual survey during any program year, then Denver Water will be issued a treatment technique violation and must conduct public notice to all customers under paragraph 1.T.i.

b. If Denver Water does not collect the minimum number of received survey responses during any program year, then Denver Water must conduct public notice to all customers enrolled in the filter program under paragraph 1.T.v, unless CDPHE determines that Denver Water must conduct public notice under paragraph 1.T.ii.

ii. *Survey of Filter Adoption Rate.* All of the received survey responses will be used to calculate the filter adoption rate based on the number of responses that confirm adoption of the filter, or use of bottled water or alternative filer device not provided by Denver Water that is certified NSF/ANSI (53) for ingestion. All respondents who indicate that they do not use the filter, bottled water, or alternative filter device that is certified NSF/ANSI (53) for cooking but have adopted for drinking water and infant fed formula, if the latter is applicable to the respondent, will be summed and multiplied by 50% and the result may be counted as having adopted a filter for the purposes of determining the average filter adoption rate in paragraph 5.G.i. below.

iii. *Bottled Water and Alternative Filter Devices*. Customers who indicate that they use bottled water or alternative filter device certified NSF/ANSI (53) will continue to be customers enrolled in the filter program unless they refuse a filter or contact Denver Water to opt-out of the filter program. Denver Water will maintain a list of customers who have refused filters or opted-out of the filter program and provide the list to CDPHE upon request.

F. *Filter Performance*.

i. *Confirmation of Filter Performance Before Distribution*. Before distributing filters to customers enrolled in the filter program in program year one, Denver Water will test the lead removal effectiveness of 12 units of each type of filter to be distributed to customers using water from Denver Water's pipe racks as described in the LRPP from at least one Denver Water treatment plant in accordance with a testing protocol approved by CDPHE to confirm that the filters meet their NSF/ANSI (53) certification. All filter testing results will be reported to CDPHE. Denver Water will not distribute a filter model that fails to meet the NSF/ANSI (53) certification based upon the lead samples collected under this paragraph.

ii. *Confirmation of Filter Performance in Field*. To confirm performance of filters in use at customer premise, Denver Water will collect fifty (50) samples from filters in use by customers enrolled in the filter program who are also enrolled in Denver Water's LCR regulatory sampling program in accordance with a testing protocol approved by CDPHE. Samples will be collected from filters used by customers enrolled in the filter program at the same frequency as LCR regulatory sampling and reported to CDPHE and EPA.

iii. If Denver Water does not complete testing of filters under this section 5.F. in accordance with the CDPHE approved protocols, Denver Water must provide public notice in accordance with paragraph 1.T.ii. above.

G. *Filter Adoption Compliance Metrics, Corrective Actions, and Failures.*

i. *Compliance.* Denver Water must achieve a filter adoption rate of 65% at the end of each program year.

ii. *Corrective Action*. If this metric is not achieved at the end of a program year, then Denver Water must achieve a 65% filter adoption rate by the end of the following program year. Denver Water will also provide public notice to customers enrolled in the filter program under paragraph 1.T.ii.

H. *Filter Communication Compliance Metrics, Corrective Actions, and Failures.*

i. *Compliance*. Denver Water must make direct contact with lead outreach and education materials to 95% of all customers enrolled in the filter program in every program year. Compliance shall be documented by mailing lists and mail receipts,

lists of customer email addresses for customers who elect to receive email communication, or other forms of documentation approved by CDPHE.

ii. *Corrective Action*. If Denver water does not achieve compliance with paragraph 5.H.i., then Denver Water must increase outreach efforts to reach 95% of Denver Water customers enrolled in the filter program, and Denver Water must also provide public notice to all customers enrolled in the filter program of its failure to achieve the metric under paragraph 1.T.ii.

6. Recordkeeping and Reporting Requirements:

A. *Reporting.* In the event that Denver Water determines that it will not meet any of the terms and conditions as defined in this document, Denver Water must notify CDPHE and EPA no later than two business days after the determination occurs. CDPHE will provide any resulting requirements (e.g., notification of violation, public notice requirements, etc.) to Denver Water (and copy EPA) in writing.

B. *Recordkeeping.* On an ongoing basis for the term of the variance, Denver Water shall record, maintain records of, and report each year the following information. Denver Water will provide any of the "raw" data to CDPHE or EPA, when requested. Unless otherwise stated, the reporting and recordkeeping requirements under the LCR remain in effect:

i. *CCT.*

a. all lead and copper regulatory sampling results, as required in § 11.26 of 5 CCR 1002-11;
b. CCT parameters for pH and alkalinity; and
c. all water quality sampling results collected as part of Denver Water's investigation of LSLs and post LSL replacement.

ii. *LSL Inventory.*

a. total number of service lines;
b. the total number of replaced LSLs during the variance;
c. the total number of known, suspected, and possible LSLs;
d. the total number of unlikely LSLs;
e. the total number of non-LSLs;
f. the number of investigations conducted each year to improve the LSL inventory;
g. an updated distribution system map; and
h. the rationale for requesting a change in the status of a service line in the inventory (e.g. investigation, replacement, water quality data, etc.).

iii. *LSL Replacements.*

a. the address and date of all LSL replacements occurring during the variance, including by year;
b. the type of LSL replacement (full, partial including galvanized, by third party);
c. the service line refusal list, including addresses of customer premises on the refusal list and documented attempts to contact the property owner; and
d. those customer premises where Denver Water performed a partial LSL replacement due to an emergency repair and property owner consent could not be obtained.

iv. *Filters.*

a. addresses of customer premises where filters and replacement cartridges have been provided;
b. the total number of filters and replacement cartridges distributed per program year;
c. a summary of filter survey responses per program year (i.e., descriptive statistics), the response rate, the percent filter adoption for each year of the variance, and the specific survey questions and responses;
d. a list of customer accounts reporting the use of bottled water or a filter certified NSF/ANSI (53) for removal of lead, and any changes in the list;
e. a list of customers enrolled in the filter program who have refused a filter or replacement cartridges or have opted out of enrollment in the filter program; and
f. filter lead sampling results collected under paragraph 5.F above.

v. *Compliance Metrics*. Results achieved under the compliance metrics in sections 2.C, 3.D, 4.J, 5.G, and 5.H above.

vi. *Communications, Outreach and Education*. A summary of activities conducted under the Communications, Outreach and Education program, including the updated communications, outreach and education plan for the new program year. The summary will include, at a minimum:

a. a description of outreach activities conducted;
b. a list of any partner organizations who conducted, or were involved in the implementation of the communications, outreach and education plan; and
c. if in-person or telephone surveys are conducted, the answers to filter usage survey questions that were asked, date and time of call.

vii. *Health Equity and Environmental Justice.* A summary of activities conducted and designed to address health equity and environmental justice (HE&EJ) principles set forth in the Lead Reduction Program Plan (LRPP), including:

a. a description of how the HE&EJ principles are being incorporated into the accelerated LSL replacement program, lead filter program, and communications, outreach and education plan;
b. socioeconomic or demographic data collected through the survey that may inform the filter adoption rate by neighborhood or demographic group to the extent practical; and
c. socioeconomic or demographic data collected from or other sources (e.g. census data, local public health agencies) to target communications, outreach and education programs to specific neighborhoods, demographic cohorts, or non-English speaking groups.

C. *Annual Program Year Reports.* No later than thirty-five (35) days following the end of a program year, Denver Water must submit a program year report to CDPHE and EPA, containing a summary of the information and data required under this section 6 for the previous program year, including an assessment of which metrics were achieved and the status of any corrective actions. This requirement remains in effect for the term of the variance. The annual report will also document any modification requests made by Denver Water to the Lead Reduction Program Plan or deviations from the LRPP during the most recent program year, along with a rationale for the request. If CDPHE or EPA provides any comments or requests related to the annual report, Denver Water must provide a written response within thirty-five (35) calendar days that addresses any identified comments/requests.

7. General Miscellaneous Provisions:

A. *Enforcement*. CDPHE has primary implementation and enforcement authority over the variance, subject to EPA oversight. CDPHE will implement, oversee, and enforce these terms and conditions, and may make recommendations to EPA to terminate or continue this variance, provided that EPA has the authority to ultimately decide whether to continue this variance.

B. *Revisions to the Lead and Copper Rule.* If EPA revises the federal LCR in a manner that affects the provisions and conditions of this variance, then EPA may modify or revoke this variance in a manner that is consistent with federal law.

C. *Lead Reduction Program Plan*. Denver Water will work in good faith to fully implement Section III of the LRPP. If Denver Water deviates from Section III the LRPP during the term of the variance or fails to implement Section III of the LRPP, Denver Water will provide notice to CDPHE within thirty-five (35) days with a description of the deviation from section III of the LRPP and the reason for the deviation. In no case shall a deviation from Section III of the LRPP modify these terms and conditions, except as provided in paragraph 7.J below. In the event of a

conflict between these terms and conditions and Section III of the LRPP, these terms and conditions take precedence.

D. *Enforcement.* Notwithstanding any metric and/or corrective action identified herein, EPA and CDPHE may take enforcement if EPA or CDPHE find, in their sole discretion, that Denver Water has not complied with any requirement of the variance in accordance with 42 U.S.C. §§ 300g-3(a)(1) and 300g-4(b) of the SDWA, including when:

i. Denver Water does not comply with its terms and conditions;

ii. A material aspect of Section III of the LRPP has not been implemented in good faith;

iii. Denver Water requests that EPA terminate the variance; or

iv. EPA or CDPHE believes that there is a risk to public health.

An enforcement action does not automatically terminate the variance.

E. A*utomatic Termination of Variance.* This variance terminates if one or more of the following conditions occur:

i. Denver Water fails to replace LSLs at the required minimum cumulative program year average rate of 7.0% for a total of three program years; or

ii. Denver Water fails to achieve a minimum of 65% filter adoption rate in a program year for a total of three program years.

If the variance is terminated Denver Water will provide public notice under 1.T.i

F. *Optimal Corrosion Control Treatment*. If EPA revokes the variance under paragraph 7.D. or the variance automatically terminates under paragraph 7.E, within 182 Days Denver Water shall install and operate orthophosphate as its designated optimal corrosion control treatment, in accordance with CDPHE's March 20, 2018, OCCT determination, and provide public notice to its customers in accordance with paragraph 1.T.i above. The initial dose of orthophosphate must be 2 mg/L. The specific orthophosphate dose may be further modified by CDPHE according to the provisions under 40 C.F.R. § 141.82(h).

G. *Effective Date of Termination or Revocation of the Variance*. Termination or revocation of the variance will be effective within 182 days of automatic termination under paragraph 7.E. above, or EPA's revocation under section 7.D. above, whichever occurs first. Failure to complete installation and operation of orthophosphate by this deadline will be considered a treatment technique violation under § 11.26 of 5 CCR 1002-11.

H. *Notice of Lead Reduction Program Plan.* No later than 14 days following effective date, Denver Water must begin a multi-media public information campaign and customer notification by written letter and pamphlet to notify customers enrolled in the filter program of Denver Water's variance, including the accelerated LSL replacement program and the distribution of the NSF/ANSI (53) certified filters for lead removal.

I. *Term of Variance.* Unless EPA revokes or modifies, the terms, this variance shall extend from the effective date through the variance end date, or until EPA accepts the notice of completion pursuant to section 7.L. below. Additionally, as described in, paragraph 4.I, Denver Water shall replace within six (6) months of discovery, any LSLs discovered after the variance end date. Denver Water must provide an annual summary of these efforts to CDPHE by January 10th of each calendar year for the previous program year.

J. *Modification of Conditions.* EPA may modify the conditions of this variance in consultation with CDPHE. EPA will notify Denver Water thirty-five (35) days prior to the effective date of any modification.

K. *Notices.* All notices, reports, disclosures, or other communications required or related to this variance must be sent via certified U.S. Mail, overnight express delivery service, or electronic means to the recipients and addresses below.

EPA:
Safe Drinking Water Branch Chief
Water Division U.S. Environmental Protection Agency, Region 8
1595 Wynkoop St.
Denver, CO 80202-1129
Current E-mail: **[To be added upon finalization.]**

Denver Water:
James S. Lochhead
CEO/Manager
Denver Water
1600 West 12th Avenue
Denver, Colorado 80204
E-mail: **[To be added upon finalization.]**

Office of General Counsel:
ATTN: Jessica Brody
Denver Water
1600 West 12th Avenue
Denver, Colorado 80204
E-mail: **[To be added upon finalization.]**

CDPHE:
Jill Hunsaker Ryan
Executive Director
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, CO 80246
E-mail: **[To be added upon finalization.]**

All reports will be sent to Drinking Water Compliance Assurance through its on-line portal at https://wqcdcompliance.com/login or through such other means as designated in writing by CDPHE.

Attorney General's Office
ATTN: **[To be added upon finalization.]**

L. *Notice of Completion.* Denver Water may submit a notice of completion of the terms and conditions of this variance to CDPHE, with a copy to EPA, by the variance end date or earlier in accordance with this variance. EPA may either accept or reject Denver Water's notice of completion in writing within thirty-five (35) days of receipt.

APPENDIX VII.A – LEAD REDUCTION PROGRAM COST ESTIMATES

September 2019

DENVER WATER

Cost Estimate Summary:

Denver Water and the MOU stakeholders developed planning level financial impact estimates for the orthophosphate and variance alternatives.

The "Low" capital costs, annual operating costs, and assumptions are shown in Table VII.A-1. The "High" capital costs, annual operating costs, and assumptions are shown in Table VII.A-2.

Denver Water currently replaces lead service lines at a rate of 700 per year, with an additional 500 per year replaced through redevelopment, for a combined total of 1,200 per year. Denver Water will be required to increase the rate of lead service line replacements to 780 per year to replace all lead services for the orthophosphate alternative within 50 years (780 x 50 + 500 x 50). Denver Water's cost for replacement of approximately 780 lead services lines per year is included in the cost estimates. The developers cost for replacement of 500 lead service lines per year is not included in the cost estimates.

A Net Present Value summary for the 50-year period using the capital and operating costs is shown in Table VII.A-3. The low and high cost estimate range reflects different assumptions for the timing and need of various capital projects and associated operating costs. The assumptions are incorporated into the life-cycle costs for both scenarios; specifically 50 years for orthophosphate and 15 years for the variance. The NPV summary reflects a discount rate of 1.5% and an inflation rate of 0%. The discount rate is based on the US Office of Management and Budget memorandum titled *2019 Discount Rates for OMB Circular No. A-94* of December 18, 2018. Assumptions regarding timing for the low and high operating capital and operating costs are shown in Tables VII.A-1 and VII.A-2, respectively.

A total investment summary for the Low and High capital and operating costs for the 50-year and 15-year period is shown in Table VII.A-3. The total investment summary includes the capital and operating costs for the life of the program.

Table VII.A-1:Regional Estimated Financial Impacts For OCCT and LSL Removal Alternatives -Low Cost Estimates in Today's Dollars

Cost Category and Subcategory	Incremental Capital or Total Item Costs					Operating Costs					Assumptions and Notes for the NPV
	Orthophosphate @ 3 mg/L and LSLR in 50 years	Orthophosphate @ 2 mg/L and LSLR in 50-Years	Orthophosphate @ 1 mg/L and LSLR in 50-years	Orthophosphate @ 0.5 mg/L and LSLR in 50-years	Variance Option: pH 8.8 w/ 15-Yr ALSLR Program	Orthophosphate @ 3 mg/L	Orthophosphate @ 2 mg/L	Orthophosphate @ 1 mg/L	Orthophosphate @ 0.5 mg/L	Variance Option: pH 8.8 w/ 15-Yr ALSLR Program	
A - Wastewater Treatment Plant Expenses											
Metro Wastewater Reclamation District (MWRD)	$129,000,000	$129,000,000	$129,000,000	$0	$0	$4,590,000	$3,170,000	$1,790,000	$30,000	$0	Capital cost starting in 2036. O&M start in 2036 through end of 50 year period.
South Platte Water Renewal Partners (SPWRP)	$0	$0	$0	$0	$0	$250,000	$200,000	$80,000	$40,000	$0	Starting in 2023
South Adams County Water and Sanitation District (SACWSD)	$0	$0	$0	$0	$0	$91,200	$60,000	$30,000	$0	$0	Starting in 2025
Broomfield	$0	$0	$0	$0	$0	$256,000	$171,000	$86,000	$43,000	$0	Starting in 2020. Capital costs as referenced in CDPHE July 2019 memo
ACWWA (Inverness Supply)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	Not in WISE group but in Cherry Creek Basin.
WISE Participants (Centennial, etc.)	$4,500,000	$3,000,000	$1,500,000	$700,000	$0	$18,800	$12,500	$6,300	$3,100	$0	Starting in 2020. Capital costs as referenced in CDPHE July 2019 memo
Subtotal A - Wastewater Treatment Plant	***$133,500,000***	***$132,000,000***	***$130,500,000***	***$700,000***	***$0***	***$5,206,000***	***$3,613,500***	***$1,992,300***	***$116,100***	***$0***	
B - Stormwater & Non-Point Irrigation Treatment											
Phosphorus Removal - City and County of Denver Stormwater	$14,080,000	$9,400,000	$4,680,000	$2,360,000	$0	$2,462,000	$1,641,000	$821,000	$410,000	$0	Capital and operating costs starting in 2030.
Phosphorus Removal - Service Areas Outside City and County of Denver Stormwater	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	Included with Above
Subtotal B - Stormwater & Non-Point	***$14,080,000***	***$9,400,000***	***$4,680,000***	***$2,360,000***	***$0***	***$2,462,000***	***$1,641,000***	***$821,000***	***$410,000***	***$0***	
C - Watershed Non-Point Treatment											
Recreational Impacts @ Barr Lake and Milton Reservoir	$0	$0	$0	$0	$0	$364,000	$281,500	$199,000	$116,500	$0	Operating cost start in 2020 and extend through 2029.
Barr/Milton In Canal Treatment	$0	$0	$0	$0	$0	$723,500	$343,900	$147,000	$1,650	$0	Operating costs start in 2020 and extend for 50-years. Costs vary over time.
DW Gravel Lakes Treatment	$0	$0	$0	$0	$0	$290,000	$290,000	$290,000	$290,000	$0	Operating costs start in 2020 and extend through 2035.
Subtotal C - Watershed Non-Point Treatment	***$0***	***$0***	***$0***	***$0***	***$0***	***$1,377,500***	***$915,400***	***$636,000***	***$408,150***	***$0***	
D - Non-Denver Water WTP Improvements											
Thornton	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
Aurora	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$0	$157,000	$157,000	$157,000	$157,000	$0	Capital and operating cost start in 2020 (amount for first 15-years then 15% for remainder)
Broomfield OCCT	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$0	$60,000	$40,000	$20,000	$10,000	$30,000	Capital and O&M Starting in 2020. Reduce by 25%.
South Adams County Water and Sanitation District (SACWSD)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	No cost anticipated.
East Cherry Creek Valley (ECCV)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	ECCV will reduce purchase of DW to maintain low phosphorus levels in their watershed basin.
Subtotal D - Non-Denver Water WTP	***$11,000,000***	***$11,000,000***	***$11,000,000***	***$11,000,000***	***$0***	***$217,000***	***$197,000***	***$177,000***	***$167,000***	***$30,000***	
E - Denver Water WTP & Distribution Expenses											
Foothills WTP Upgrade	$2,900,000	$2,900,000	$2,900,000	$2,900,000	$2,900,000	$1,000,000	$670,000	$330,000	$170,000	$500,000	Starting in 2020
Marston WTP Upgrade	$3,000,000	$3,000,000	$3,000,000	$3,000,000	$3,000,000	$250,000	$167,500	$82,500	$42,500	$100,000	Starting in 2020
Moffat WTP Upgrade	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$250,000	$167,500	$82,500	$42,500	$100,000	Starting in 2020
Denver Water - Marston Washwater Recycling	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$0	$196,000	$196,000	$196,000	$196,000	$0	Starting in 2020
Increased Nitrification Control	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
Subtotal E - Denver Water WTP Expenses	***$17,100,000***	***$17,100,000***	***$17,100,000***	***$17,100,000***	***$7,100,000***	***$1,696,000***	***$1,201,000***	***$691,000***	***$451,000***	***$700,000***	
F - Filter Program											
Distribution and Management	$0	$0	$0	$0	$33,406,000	$0	$0	$0	$0	$0	Starting in 2020 and end in 2034, ~93,200 filters distributed in year 2020
Subtotal F - Filter Program	***$0***	***$0***	***$0***	***$0***	***$33,406,000***	***$0***	***$0***	***$0***	***$0***	***$0***	
G - ALSLR Program											
ALSLR Program	$0	$0	$0	$0	$254,250,000	$0	$0	$0	$0	$0	Starting in 2020 and end in 2034, ~64,000 LSL at $4,500/each + 7,500 LSL replaced by developers at no cost.
Potholing and WQ Sampling Program	$0	$0	$0	$0	$5,932,500	$0	$0	$0	$0	$0	Starting in 2020, 9,700 potholes and 39,000 WQ Samples
Subtotal G - ALSLR Program	***$0***	***$0***	***$0***	***$0***	***$260,182,500***	***$0***	***$0***	***$0***	***$0***	***$0***	
H - Current LSLR Process											
Current LSLR Process	$184,275,000	$184,275,000	$184,275,000	$184,275,000		$0	$0	$0	$0	$0	Starting in 2020, 64,000 LSL at $4,500/each + 25,000 LSL replaced by developers at no cost (5% internal management cost)
Potholing and WQ Sampling Program	$5,733,000	$5,733,000	$5,733,000	$5,733,000							Starting in 2020, 10,600 potholes and 42,300 WQ Samples (rely on physical identification versus predictive model, 5% internal management cost)
Subtotal H - Current LSLR Process	***$190,008,000***	***$190,008,000***	***$190,008,000***	***$190,008,000***	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***	
Total Estimated Fiscal Impact	**$365,700,000**	**$359,500,000**	**$353,300,000**	**$221,200,000**	**$300,700,000**	**$11,000,000**	**$7,600,000**	**$4,300,000**	**$1,600,000**	**$730,000**	

Notes:
1. No, unanticipated, and unknown costs are represented as $0.

Table VII.A-2: Regional Estimated Financial Impacts For OCCT and LSL Removal Alternatives - High Cost Estimates in Today's Dollars

Cost Category and Subcategory	Incremental Capital or Total Item Costs					Operating Costs					Assumptions and Notes for the NPV
	Orthophosphate @ 3 mg/L and LSLR in 50 years	Orthophosphate @ 2 mg/L and LSLR in 50-Years	Orthophosphate @ 1 mg/L and LSLR in 50-years	Orthophosphate @ 0.5 mg/L and LSLR in 50-years	Variance Option: pH 8.8 w/ 15-Yr ALSLR Program	Orthophosphate @ 3 mg/L and LSLR in 50 years	Orthophosphate @ 2 mg/L and LSLR in 50-Years	Orthophosphate @ 1 mg/L and LSLR in 50-years	Orthophosphate @ 0.5 mg/L and LSLR in 50-years	Variance Option: pH 8.8 w/ 15-Yr ALSLR Program	
A - Wastewater Treatment Plant Expenses											
Metro Wastewater Reclamation District (MWRD)	$129,000,000	$129,000,000	$129,000,000	$0	$0	$4,590,000	$3,170,000	$1,790,000	$30,000	$0	Capital cost starting in 2036. O&M start in 2036 through end of 50 year period.
South Platte Water Renewal Partners (SPWRP)	$0	$0	$0	$0	$0	$250,000	$200,000	$80,000	$40,000	$0	Starting in 2023
South Adams County Water and Sanitation District (SACWSD)	$0	$0	$0	$0	$0	$91,200	$60,000	$30,000	$0	$0	Starting in 2025
Broomfield	$0	$0	$0	$0	$0	$256,000	$171,000	$86,000	$43,000	$0	Starting in 2020. Capital costs as referenced in CDPHE July 2019 memo
ACWWA (Inverness Supply)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	Not in WISE group but in Cherry Creek Basin.
WISE Participants (Centennial, etc.)	$4,500,000	$3,000,000	$1,500,000	$700,000	$0	$18,800	$12,500	$6,300	$3,100	$0	Starting in 2020. Capital costs as referenced in CDPHE July 2019 memo
Subtotal A - Wastewater Treatment Plant	***$133,500,000***	***$132,000,000***	***$130,500,000***	***$700,000***	***$0***	***$5,206,000***	***$3,613,500***	***$1,992,300***	***$116,100***	***$0***	
B - Stormwater & Non-Point Irrigation Treatment											
Phosphorus Removal - City and County of Denver Stormwater	$177,960,000	$133,800,000	$13,360,000	$6,680,000	$0	$7,623,000	$5,278,000	$2,336,000	$1,168,000	$0	Capital and operating costs starting in 2030.
Phosphorus Removal - Service Areas Outside City and County of Denver Stormwater	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	Included with Above
Subtotal B - Stormwater & Non-Point Irrigation	***$177,960,000***	***$133,800,000***	***$13,360,000***	***$6,680,000***	***$0***	***$7,623,000***	***$5,278,000***	***$2,336,000***	***$1,168,000***	***$0***	
C - Watershed Non-Point Treatment											
Recreational Impacts @ Barr Lake and Milton Reservoir	$0	$0	$0	$0	$0	$364,000	$281,500	$199,000	$116,500	$0	Operating cost start in 2020 and extend through 2029.
Barr/Milton In Canal Treatment	$0	$0	$0	$0	$0	$723,500	$343,900	$146,600	$1,650	$0	Operating costs start in 2020 and extend for 50-years. Costs vary over time.
DW Gravel Lakes Treatment	$0	$0	$0	$0	$0	$290,000	$290,000	$290,000	$290,000	$0	Operating costs start in 2020 and extend through 2035.
Subtotal C - Watershed Non-Point Treatment	***$0***	***$0***	***$0***	***$0***	***$0***	***$1,377,500***	***$915,400***	***$635,600***	***$408,150***	***$0***	
D - Non-Denver Water WTP Improvements											
Thornton	$20,000,000	$20,000,000	$20,000,000	$20,000,000	$0	$200,000	$134,000	$66,000	$33,000	$0	Capital and operating cost start in 2020 (amount for first 15-years then 15% for remainder)
Aurora	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$0	$157,000	$157,000	$157,000	$157,000	$0	Capital and operating cost start in 2020 (amount for first 15-years then 15% for remainder)
Broomfield OCCT	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$0	$60,000	$40,000	$20,000	$10,000	$30,000	Capital and O&M Starting in 2020. Reduce by 25%.
South Adams County Water and Sanitation District (SACWSD)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	No cost anticipated.
East Cherry Creek Valley (ECCV)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	ECCV will reduce purchase of DW to maintain low phosphorus levels in their watershed basin.
Subtotal D - Non-Denver Water WTP	***$31,000,000***	***$31,000,000***	***$31,000,000***	***$31,000,000***	***$0***	***$417,000***	***$331,000***	***$243,000***	***$200,000***	***$30,000***	
E - Denver Water WTP & Distribution Expenses											
Foothills WTP Upgrade	$2,900,000	$2,900,000	$2,900,000	$2,900,000	$2,900,000	$1,000,000	$670,000	$330,000	$170,000	$500,000	Starting in 2020
Marston WTP Upgrade	$3,000,000	$3,000,000	$3,000,000	$3,000,000	$3,000,000	$250,000	$167,500	$82,500	$42,500	$100,000	Starting in 2020
Moffat WTP Upgrade	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$250,000	$167,500	$82,500	$42,500	$100,000	Starting in 2020
Denver Water - Marston Washwater Recycling	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$0	$196,000	$196,000	$196,000	$196,000	$0	Starting in 2020
Increased Nitrification Control	$0	$0	$0	$0	$0	$100,000	$100,000	$100,000	$100,000	$0	Starting in 2020
Subtotal E - Denver Water WTP Expenses	***$17,100,000***	***$17,100,000***	***$17,100,000***	***$17,100,000***	***$7,100,000***	***$1,796,000***	***$1,301,000***	***$791,000***	***$551,000***	***$700,000***	
F - Filter Program											
Distribution and Management	$0	$0	$0	$0	$48,501,200	$0	$0	$0	$0	$0	Starting in 2020 and end in 2034, ~119,250 filters distributed in year 2020
Subtotal F - Filter Program	***$0***	***$0***	***$0***	***$0***	***$48,501,200***	***$0***	***$0***	***$0***	***$0***	***$0***	
G - ALSLR Program											
ALSLR Program	$0	$0	$0	$0	$403,975,000	$0	$0	$0	$0	$0	Starting in 2020 and end in 2034, ~64,000 LSL at $6,500/each + 7,500 LSL replaced by developers at no cost.
Potholing and WQ Sampling Program	$0	$0	$0	$0	$6,525,750	$0	$0	$0	$0	$0	Starting in 2020, 9,700 potholes and 39,000 WQ Samples
Subtotal G - ALSLR Program	***$0***	***$0***	***$0***	***$0***	***$410,500,750***	***$0***	***$0***	***$0***	***$0***	***$0***	
H - Current LSLR Process											
Current LSLR Process	$266,175,000	$266,175,000	$266,175,000	$266,175,000		$0	$0	$0	$0	$0	Starting in 2020, 64,000 LSL at $6,500/each + 25,000 LSL replaced by developers at no cost (5% internal management cost)
Potholing and WQ Sampling Program	$5,733,000	$5,733,000	$5,733,000	$5,733,000							Starting in 2020, 10,600 potholes and 42,300 WQ Samples (rely on physical identification versus predictive model, 5% internal management cost)
Subtotal H - Current LSLR Process	***$271,908,000***	***$271,908,000***	***$271,908,000***	***$271,908,000***	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***	
Total Estimated Fiscal Impact	**$631,500,000**	**$585,800,000**	**$463,900,000**	**$327,400,000**	**$466,100,000**	**$16,400,000**	**$11,400,000**	**$6,000,000**	**$2,400,000**	**$730,000**	

Notes:
1. No, unanticipated, and unknown costs are represented as $0.

Table VII.A-3: NPV and Total Investment Summary Information

NPV Summary

1. Ortho Option – Item A, B, C, D, and E (ie. Cost of ortho addition without LSLR)

	Capital			
	3mg/L	2mg/L	1mg/L	0.5mg/L
Ortho w/o LSLR - HIGH	$ 244,042,455	$ 219,718,821	$ 155,932,376	$ 52,744,424
Ortho w/o LSLR - LOW	$ 141,345,606	$ 136,851,806	$ 132,332,228	$ 29,895,257

	Operation			
	3mg/L	2mg/L	1mg/L	0.5mg/L
Ortho w/o LSLR - HIGH	$ 407,708,994	$ 286,059,824	$ 148,434,030	$ 64,720,974
Ortho w/o LSLR - LOW	$ 266,279,775	$ 185,573,545	$ 104,640,372	$ 41,270,955

	Combined			
	3mg/L	2mg/L	1mg/L	0.5mg/L
Ortho w/o LSLR - HIGH	$ 651,751,449	$ 505,778,645	$ 304,366,407	$ 117,465,399
Ortho w/o LSLR - LOW	$ 407,625,381	$ 322,425,351	$ 236,972,600	$ 71,166,212

Total Investment

Ortho Option – Item A, B, C, D, and E (ie. Cost of ortho addition without LSLR)

	Capital			
	3mg/L	2mg/L	1mg/L	0.5mg/L
Ortho w/o LSLR - HIGH	$ 315,070,000	$ 280,450,000	$ 188,620,000	$ 56,348,400
Ortho w/o LSLR - LOW	$ 175,680,000	$ 169,500,000	$ 163,280,000	$ 31,160,000

	Operation			
	3mg/L	2mg/L	1mg/L	0.5mg/L
Ortho w/o LSLR - HIGH	$ 620,209,917	$ 434,470,231	$ 223,496,899	$ 93,400,077
Ortho w/o LSLR - LOW	$ 402,817,113	$ 280,104,859	$ 156,583,063	$ 57,803,607

	Combined			
	3mg/L	2mg/L	1mg/L	0.5mg/L
Ortho w/o LSLR - HIGH	$ 935,279,917	$ 714,920,231	$ 412,116,899	$ 149,748,477
Ortho w/o LSLR - LOW	$ 578,497,113	$ 449,604,859	$ 319,863,063	$ 88,963,607

NPV Summary

2. Variance Option = E + F + G - H (Cost of Variance without LSLR)

	Capital
Variance w/o LSLR - High	$ 336,700,000
Variance w/o LSLR - Low	$ 239,200,000

	Operation
Variance w/o LSLR - High	$ 25,700,000
Variance w/o LSLR - Low	$ 26,000,000

	Combined
Variance w/o LSLR - High	$ 362,400,000
Variance w/o LSLR - Low	$ 265,200,000

Comment: Higher than Total Investment because subtracting a 50-year LSLR NPV from a 15-year variance NPV (NOT A COMPARABLE NPV NUMBER)

Total Investment

Variance Option = E + F + G - H (Cost of Variance without LSLR)

	Capital
Variance w/o LSLR - High	$ 194,200,000
Variance w/o LSLR - Low	$ 136,700,000

	Operation
Variance w/o LSLR - High	$ 36,500,000
Variance w/o LSLR - Low	$ 37,200,000

	Combined
Variance w/o LSLR - High	$ 230,700,000
Variance w/o LSLR - Low	$ 173,900,000

Table VII.A-3: NPV and Total Investment Summary Information

NPV Summary

3. Ortho Option – Item A, B, C, D, E, and H (with Current LSLR)

	Capital			
	3mg/L	2mg/L	1mg/L	0.5mg/L
Ortho w/ LSLR - HIGH	$ 320,900,000	$ 296,600,000	$ 232,800,000	$ 129,600,000
Ortho w/ LSLR - LOW	$ 195,000,000	$ 190,600,000	$ 186,000,000	$ 83,600,000

	Operation			
	3mg/L	2mg/L	1mg/L	0.5mg/L
Ortho w/ LSLR - HIGH	$ 407,700,000	$ 286,100,000	$ 148,400,000	$ 64,700,000
Ortho w/ LSLR - LOW	$ 266,300,000	$ 185,600,000	$ 104,600,000	$ 41,300,000

	Combined			
	3mg/L	2mg/L	1mg/L	0.5mg/L
Ortho w/ LSLR - HIGH	$ 728,600,000	$ 582,700,000	$ 381,200,000	$ 194,300,000
Ortho w/ LSLR - LOW	$ 461,300,000	$ 376,200,000	$ 290,600,000	$ 124,900,000

Total Investment

Ortho Option – Item A, B, C, D, E, and H (with Current LSLR)

	Capital			
	3mg/L	2mg/L	1mg/L	0.5mg/L
Ortho w/ LSLR - HIGH	$ 587,000,000	$ 552,400,000	$ 460,500,000	$ 328,300,000
Ortho w/ LSLR - LOW	$ 365,700,000	$ 359,500,000	$ 353,300,000	$ 221,200,000

	Operation			
	3mg/L	2mg/L	1mg/L	0.5mg/L
Ortho w/ LSLR - HIGH	$ 620,200,000	$ 434,500,000	$ 223,500,000	$ 93,400,000
Ortho w/ LSLR - LOW	$ 402,800,000	$ 280,100,000	$ 156,600,000	$ 57,800,000

	Combined			
	3mg/L	2mg/L	1mg/L	0.5mg/L
Ortho w/ LSLR - HIGH	$ 1,207,200,000	$ 986,900,000	$ 684,000,000	$ 421,700,000
Ortho w/ LSLR - LOW	$ 768,500,000	$ 639,600,000	$ 509,900,000	$ 279,000,000

NPV Summary

4. Variance Option = E + F + G (with Current LSLR)

	Capital
Variance - High	$ 413,500,000
Variance - Low	$ 292,900,000

	Operation
Variance - High	$ 25,700,000
Variance - Low	$ 26,000,000

	Combined
Variance - High	$ 439,200,000
Variance - Low	$ 318,900,000

Total Investment

Variance Option = E + F + G (with Current LSLR)

	Capital
Variance - High	$ 466,100,000
Variance - Low	$ 326,700,000

	Operation
Variance - High	$ 36,500,000
Variance - Low	$ 37,200,000

	Combined
Variance - High	$ 502,600,000
Variance - Low	$ 363,900,000

NPV Summary

5. Delta Between Orthophosphate Option at 2 mg/L and Variance (without Current LSLR)

	Combined
Variance - High	$ 66,600,000
Variance - Low	$ 3,500,000

Total Investment

Delta Between Orthophosphate Option at 2 mg/L and Variance (without Current LSLR)

	Combined
Variance - High	$ 212,300,000
Variance - Low	$ 85,700,000

NPV Summary

6. Delta Between Orthophosphate Option at 2 mg/L and Variance (with Current LSLR)

	Combined
Variance - High	$ 143,500,000
Variance - Low	$ 57,300,000

Total Investment

Delta Between Orthophosphate Option at 2 mg/L and Variance (with Current LSLR)

	Combined
Variance - High	$ 484,300,000
Variance - Low	$ 275,700,000