

# LEAD REDUCTION PROGRAM PLAN

Submitted to EPA, September 2019



# EXECUTIVE SUMMARY

## 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.



**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.



**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.



**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.



**Creates a Regional Solution**

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



**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

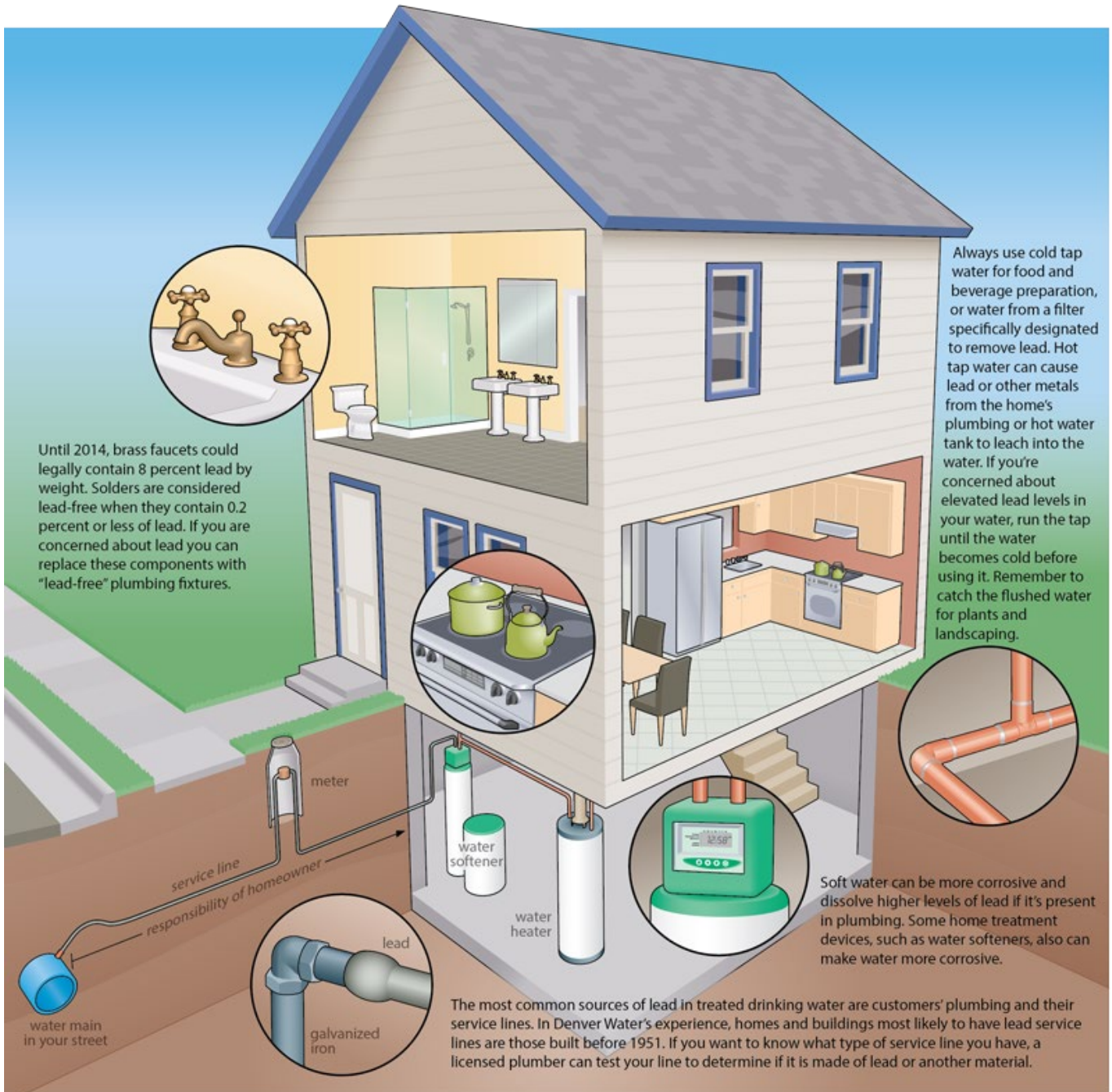




FIGURE 3: HISTORY OF LEAD IN DRINKING WATER

# The Evolution 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
90 <sup>th</sup> 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 90<sup>th</sup> 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<sub>3</sub> 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**

<b>Communications, Outreach and Education</b>
<p><b>Denver Water is committing to:</b></p> <ul style="list-style-type: none"> <li>• Educate and engage with residents, customers, distributors, local public health agencies and government stakeholders about lead awareness and reduction efforts.</li> <li>• Educate the public on measures they can take to reduce their exposure to lead in water used for drinking, cooking and infant formula preparation.</li> <li>• 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.</li> <li>• Seek feedback from residents and other stakeholders to learn best practices and effective ways to implement program activities.</li> <li>• Strive for 100% participation in the Filter Program.</li> </ul>
<b>Lead Service Line Inventory</b>
<p><b>Denver Water is committing to:</b></p> <ul style="list-style-type: none"> <li>• Research, investigate and document the presence of customer-owned lead service lines.</li> <li>• Help customers identify if they have a lead service line.</li> <li>• Maintain a current lead inventory and map.</li> <li>• Confirm materials at properties with a suspected or possible lead service line.</li> <li>• Use the inventory to target communications, outreach and education efforts at areas with the greatest risk.</li> </ul>
<b>Filter Program</b>
<p><b>Denver Water is committing to:</b></p> <ul style="list-style-type: none"> <li>• 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.</li> <li>• Educate and inform residents on the importance of using filters for drinking water.</li> <li>• 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.</li> </ul>
<b>Accelerated Lead Service Line Replacement Program</b>
<p><b>Denver Water is committing to:</b></p> <ul style="list-style-type: none"> <li>• Replace all known lead service lines in 15 years.</li> <li>• Replace 7.0% of the lead service line inventory each program year, based on a cumulative annual average.</li> <li>• 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.</li> <li>• 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.</li> </ul>
<b>Corrosion Control Treatment</b>
<p><b>Denver Water is committing to:</b></p> <ul style="list-style-type: none"> <li>• Maintain water quality by implementing corrosion control treatment through pH/alkalinity adjustment.</li> <li>• 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.</li> </ul>

## 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
<b>Lead Service Line Inventory</b>	Must investigate a minimum of 1.4% of total LSLs in inventory per year.	<ul style="list-style-type: none"> <li>• Achieve compliance by following year.</li> <li>• Provide notice of corrective action to customers with filters.</li> </ul>	If less than 1.4% investigations occur for three program years: <ul style="list-style-type: none"> <li>• Notice to all customers.</li> </ul>
<b>Filter COE</b>	Outreach and education materials provided each year to at least 95% of households enrolled in the Filter Program.	<ul style="list-style-type: none"> <li>• Must achieve compliance by following year.</li> <li>• Notice to customers with filters.</li> </ul>	If Denver Water fails to provide outreach and education materials to at least 95% of households enrolled in the Filter Program for three years: <ul style="list-style-type: none"> <li>• Notice to all customers.</li> </ul>
<b>Filter Program</b>	Achieve minimum filter adoption rate of 65% per year.	<ul style="list-style-type: none"> <li>• If filter adoption rate is less than 65% in a year, increase outreach and education efforts to improve filter use.</li> <li>• Notice of corrective action to customers with filters.</li> </ul>	If failure to achieve 65% adoption rate for three years: <ul style="list-style-type: none"> <li>• Termination of variance.</li> <li>• Notice to all customers.</li> </ul>
<b>Accelerated Lead Service Line Replacement</b>	Must achieve 7.0% cumulative annual average replacement rate each year.	<ul style="list-style-type: none"> <li>• Achieve compliance by following year.</li> <li>• Notice to customers with filters.</li> </ul>	If less than 7.0% of lead service lines are replaced for three years: <ul style="list-style-type: none"> <li>• Termination of variance.</li> <li>• Notice to all customers.</li> </ul>
<b>Corrosion Control Treatment</b>	Lead and Copper Rule sampling results remain below action level for lead.	<ul style="list-style-type: none"> <li>• Must adjust corrosion control and distribution management.</li> <li>• Customer education and notice.</li> </ul>	If action level exceeded for two monitoring periods: <ul style="list-style-type: none"> <li>• Must provide customer notice.</li> <li>• Termination of variance unless CDPHE requires otherwise.</li> </ul>

### 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**

<b>Assumption</b>	<b>Orthophosphate (at 2 mg/L as PO<sub>4</sub>)</b>	<b>Variance</b>
<b>Excluding Existing Service Line Replacement Efforts</b>	\$322M to \$506M	\$265M to \$362M
<b>Including Existing Service Line Replacement Efforts</b>	\$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](http://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](https://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.