

DENVER WATER LEAD REDUCTION PROGRAM

ANNUAL REPORT – 2020

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Appendix A-2	Line by Line p-Value Changes by Status (December 5 to 31, 2020)

LIST OF ACRONYMS

ALSLR	Accelerated Lead Service Line Replacement
CCT	Corrosion Control Treatment
CDPHE	Colorado Department of Public Health and Environment
COE	Communications, Outreach and Education
CuLS	Copper plumbing with lead solder
EPA	Environmental Protection Agency
HE&EJ	Health equity and environmental justice
LCR	Lead and Copper Rule
LSL	Lead Service Line
LSLR	Lead Service Line Replacement
Order	Variance Order

EXECUTIVE SUMMARY

The Annual Program Year Report presents the comprehensive evaluation of the Lead Reduction Program performance to date using the equivalency model described in the Lead Reduction Program Plan with updated inputs based on actual implementation from the effective date of January 1, 2020, through December 31, 2020.

All performance metrics required in the Order have been achieved or exceeded:

- Results from lead sampling suggest that lead levels are declining at both LSL homes and copper plumbing with lead solder homes following operation with higher pH in the distribution system. 90th percentile lead levels from the second sampling period of 2020 is 4.4 µg/L as compared to 11.0 µg/L for the same sampling period in 2019.

TABLE ES-1. CCT PERFORMANCE BASED ON OVERALL 90TH PERCENTILE LEAD CONCENTRATION

LCR Six-Month Sampling Period	2019	2020
Spring Overall 90 th Percentile Lead Concentration	10.0 µg/L	6.7 µg/L
Fall Overall 90 th Percentile Lead Concentration	11.0 µg/L	4.4 µg/L

- By the end of 2020, a total of 5,287 LSL replacements were completed, exceeding the minimum number of annual replacements required under the order (4,477).
- Responses from the filter adoption survey suggest that 80 percent of customers are using their filters for drinking, cooking and to prepare formula if formula-fed infants reside at the household.
- Approximately 75 percent of samples collected from filters in the customer's homes had no measurable lead. The 90th percentile lead concentration in samples collected from filter samples in the field is 2.4 µg/L.

The equivalency model demonstrates that the holistic approach of the LRP is as effective as optimized corrosion control treatment with orthophosphate and in fact exceeds performance predicted with orthophosphate.

There is no change requested to the baseline inventory of 63,955 estimated lead service lines. Therefore, 4,477 lead service line services remain as the target for replacement in 2021.

Minor deviations from the Order are described at the end of this submission, related to terminology used in the map of the lead service line inventory posted to the Denver Water LRP website.

INTRODUCTION

Denver Water is committed to significantly reducing the lead exposure levels to customers from lead service lines and plumbing. The Lead Reduction Program provides a holistic and permanent lead reduction approach that will significantly reduce lead exposure to our customers and be less harmful to the environment. Implementation of the Lead Reduction Program Plan (LRPP) in accordance with the EPA's December 16, 2019, Variance Order (Order) and the November 15, 2019, letter from CDPHE regarding conditional approval of the request for modification of optimal corrosion control treatment (OCCT) began in December 2019. The EPA approved the variance request in the form of an Order for an initial three-year period to provide the opportunity to demonstrate the LRPP will effectively reduce lead in drinking water over the 15-year period requested.

This first annual report was prepared in compliance with paragraph 7.C of the Order and commitments in the 2019 LRPP. The report addresses the first program year for the period of January 1 through December 31, 2020. Twelve monthly reports and four quarterly reports have been provided to CDPHE for this time period. The annual report includes data and information from the monthly and quarterly reports as well as additional reporting as required by the Order.

What to Expect in this Annual Report: Reporting on LRP Activities

The purpose of the annual report is to present the results from the evaluation of the performance of the Lead Reduction Program in anticipation of an extension to the Order beyond the initial three-year period (see Table 1). The quarterly reports document the implementation of the Lead Reduction Program and describe the actions taken to reduce lead. A summary list of documents that were submitted to CDPHE and EPA in 2020 is included in this annual report. The documents were previously submitted and therefore are not appended to this annual report.

TABLE 1. WHAT TO EXPECT IN THIS ANNUAL REPORT

Item	What to Expect in this Annual Report
Paragraph 7.C of the Variance Order	Contain a summary of the information and data for the previous Program Year, including an assessment of which metrics were achieved. Present a comprehensive evaluation of LRPP performance to date using the equivalency model described in the LRPP with updated inputs based on actual LRPP implementation for: <ul style="list-style-type: none">• 90th percentile lead levels at LSL and copper plumbing with lead solder sites after operation of increased pH and alkalinity adjustment as CCT.• Number of LSL replacements conducted.• Filter adoption rate.• Filter performance in the field.
Additional Requirements	This section summarizes submissions to EPA and CDPHE identified in the LRPP. A summary and discussion of learning by doing is submitted separately.
Deviations (7.C)	This section documents deviations from the LRPP during the 2020 Program Year.
Appendices	Appendices include a summary of the number and type of LSL replacements and the changes to the status (p-value) of service lines in the LSL inventory made between December 5 and 31, 2020.

ASSESSMENT OF METRICS ACHIEVED

Compliance Metrics per Paragraphs 2.C, 3.D, 4.I, 5.G and 6.B

As required by the Order, the performance metrics for the five elements of the Lead Reduction Program, including the application of corrosion control treatment, the development – and regular updates – of the LSL inventory, the replacement of lead service lines, and the distribution of filter outreach and education materials, have been achieved. The overall performance of the LRP is evaluated by modeling performance under the conditions of the Order and comparing it to modeling performance with orthophosphate. A summary of the required performance metrics from the Order is provided in Table 2.

TABLE 2. SUMMARY OF COMPLIANCE METRICS

Paragraph	Description	Result
2.C	C. Corrosion Control Treatment Metric. Consistently <u>maintain in all parts of the System a minimum target pH of 8.5 during the first year of operation</u> under this Variance. In the future, maintain pH and alkalinity within the ranges designated by CDPHE in its modification decision under Section 11.26(3)(d)(ii) of 5 CCR 1002-11.	Achieved. Implemented March 3, 2020. ¹ CDPHE notified on August 13, 2020, that equilibrium was established in the distribution system.
3.D	D. LSL Inventory Compliance Metric. Investigate a minimum of 1.4 percent of the total estimated number of suspected and possible LSLs in the LSL Inventory each Program Year (based on a subset of Y as described in paragraph 3.A above), as adjusted. These investigations are performed independently of the LSL replacements.	Achieved. 3,326 investigations have been completed independently of the 2020 ALSLR Program. ²
4.I	I. Accelerated LSL Replacement Compliance Metric. Annually achieve at least a 7.0 percent cumulative average Program Year LSL replacement rate as determined based on reporting required in paragraph 7.B.	Achieved. 5,287 LSL replacements completed.
5.G	G. Filter Communication Compliance Metric. Make direct contact with lead outreach and education materials to 95 percent 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.	Achieved.³ Over 95 percent of all customers enrolled in the Filter Program were provided with outreach and education materials.
6.B	B. Comprehensive LRPP Performance Metric. Demonstrate to EPA's satisfaction, using the updated equivalency model results as reported under paragraph 7.C, that the <u>combined actual performance of the LRPP as implemented continues to be "at least as efficient as" orthophosphate treatment in reducing lead exposure</u> on an annual basis. Account for the CCT optimization period in this demonstration.	Achieved. See this report for the model output demonstrating that the LRP is more efficient than orthophosphate treatment.

¹ pH adjustment was introduced on March 3, 2020, at Marston and Foothills and May 1, 2020, at Moffat. CDPHE confirmed distribution system equilibrium was established on August 14, 2020.

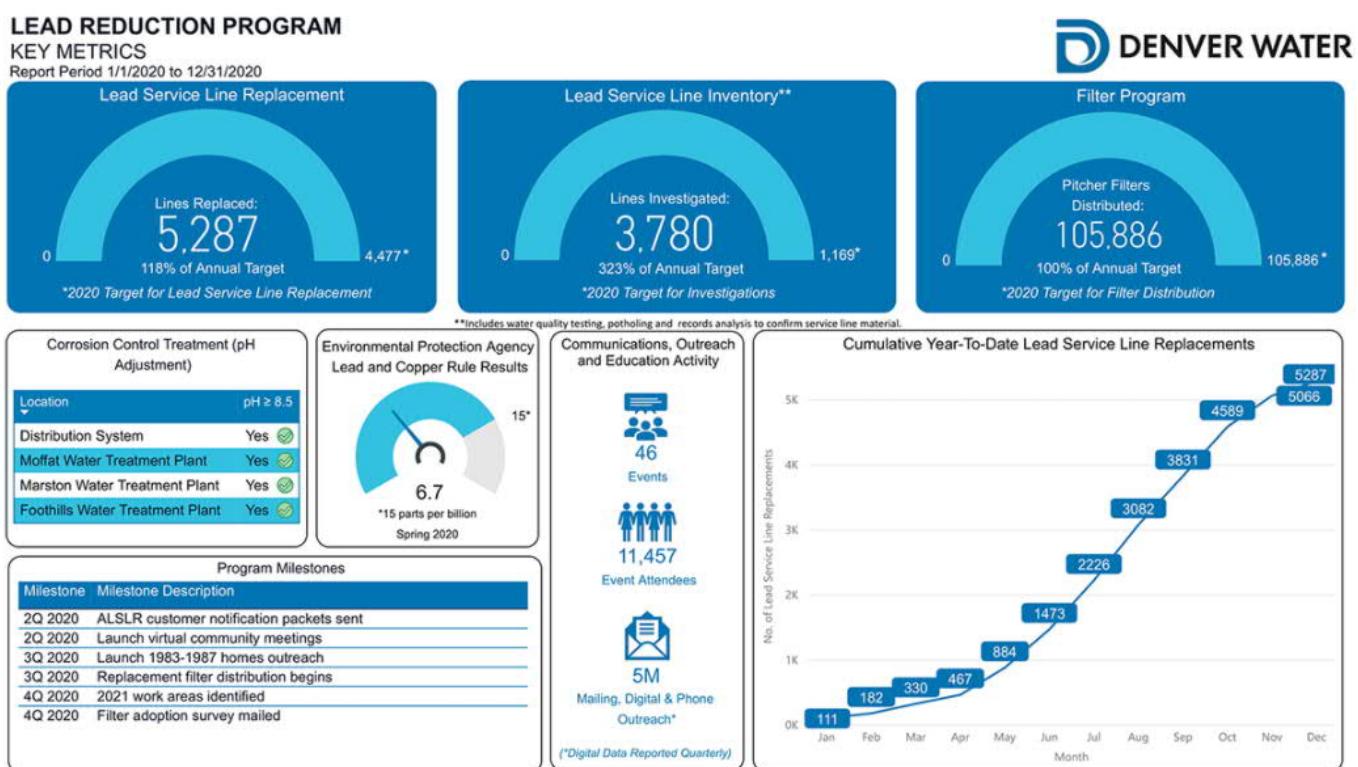
² No investigations were performed after December 4, 2020 (see fourth quarterly report).

³ See third quarterly report. Communicated to CDPHE on September 27, 2020.

Performance Dashboard

A dashboard communicates key metrics to share the progress of the Lead Reduction Program with the public. The dashboard with data for the first program year for the period of January 1 through December 31, 2020, was posted on the Denver Water LRP website on January 20, 2021, in both English and Spanish.⁴ The dashboard can be accessed at: <https://www.denverwater.org/your-water/water-quality/lead/dashboard>.

FIGURE 1. DASHBOARD OF METRICS ACHIEVED IN FIRST PROGRAM YEAR



⁴ See second quarterly report for an explanation of the metrics used in the dashboard.

DATA USED TO EVALUATE THE LRP PERFORMANCE

In this section the source of data used with the equivalency model is described in the context of the performance metrics identified in the Order.

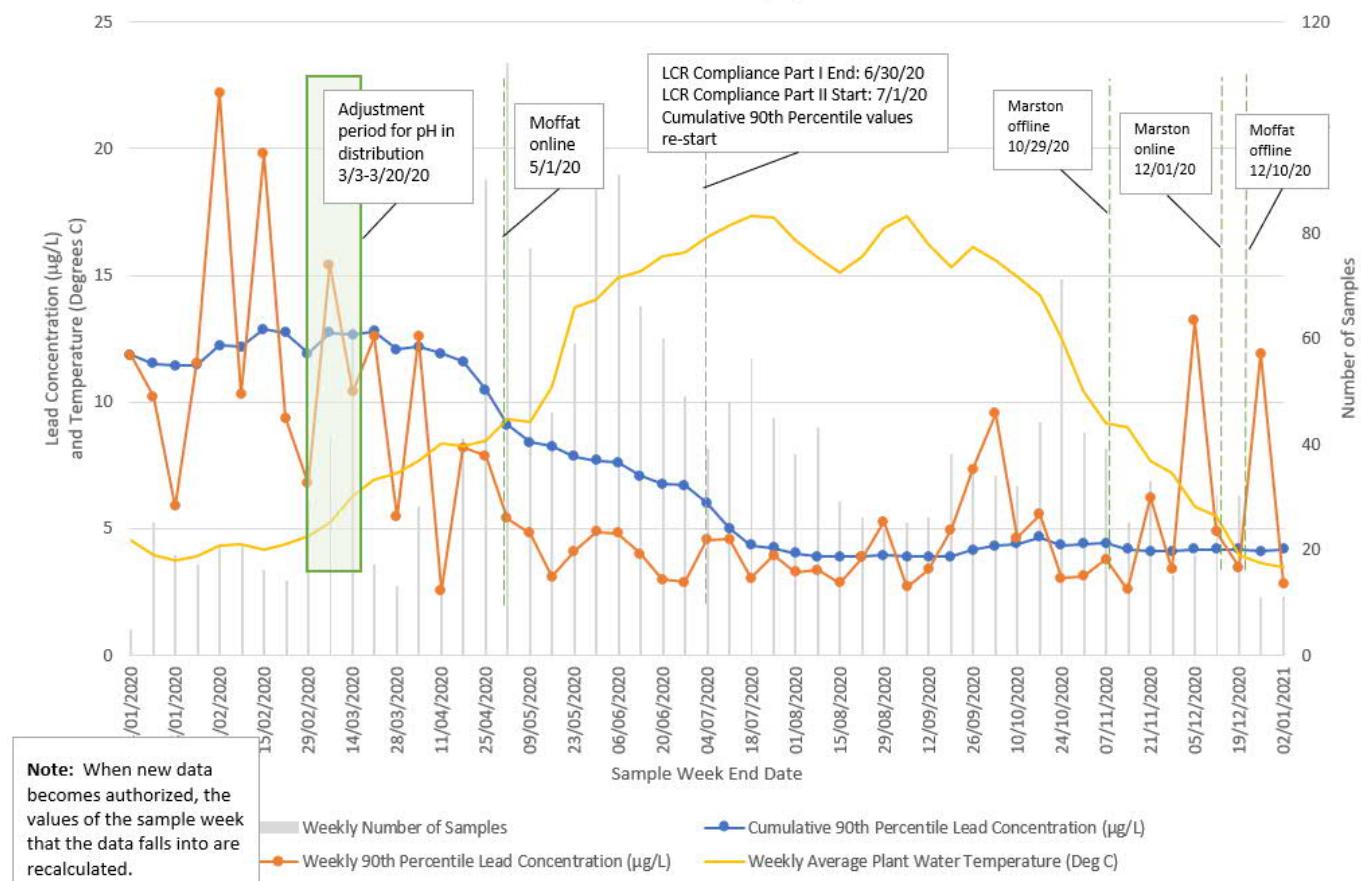
Corrosion Control Treatment

Corrosion control treatment (CCT) with pH adjustment is used to manage lead release from homes with copper plumbing with lead solder, although homes with a lead service line that opt out of the LRP are also offered some protection from pH adjustment. Treatment to adjust pH above 8.5 was initiated at the Marston and Foothills Water Treatment Plants on March 3, 2020; treatment was initiated at the Moffat Water Treatment Plant when it was returned to service on May 1, 2020. The positive impact of a higher and more consistent pH in treated water to reduce lead levels measured at the customer's tap is shown in Figures 2 and 3, based on compliance samples and customer-requested samples.

FIGURE 2. CORROSION CONTROL TREATMENT PERFORMANCE AT LSL PROPERTIES

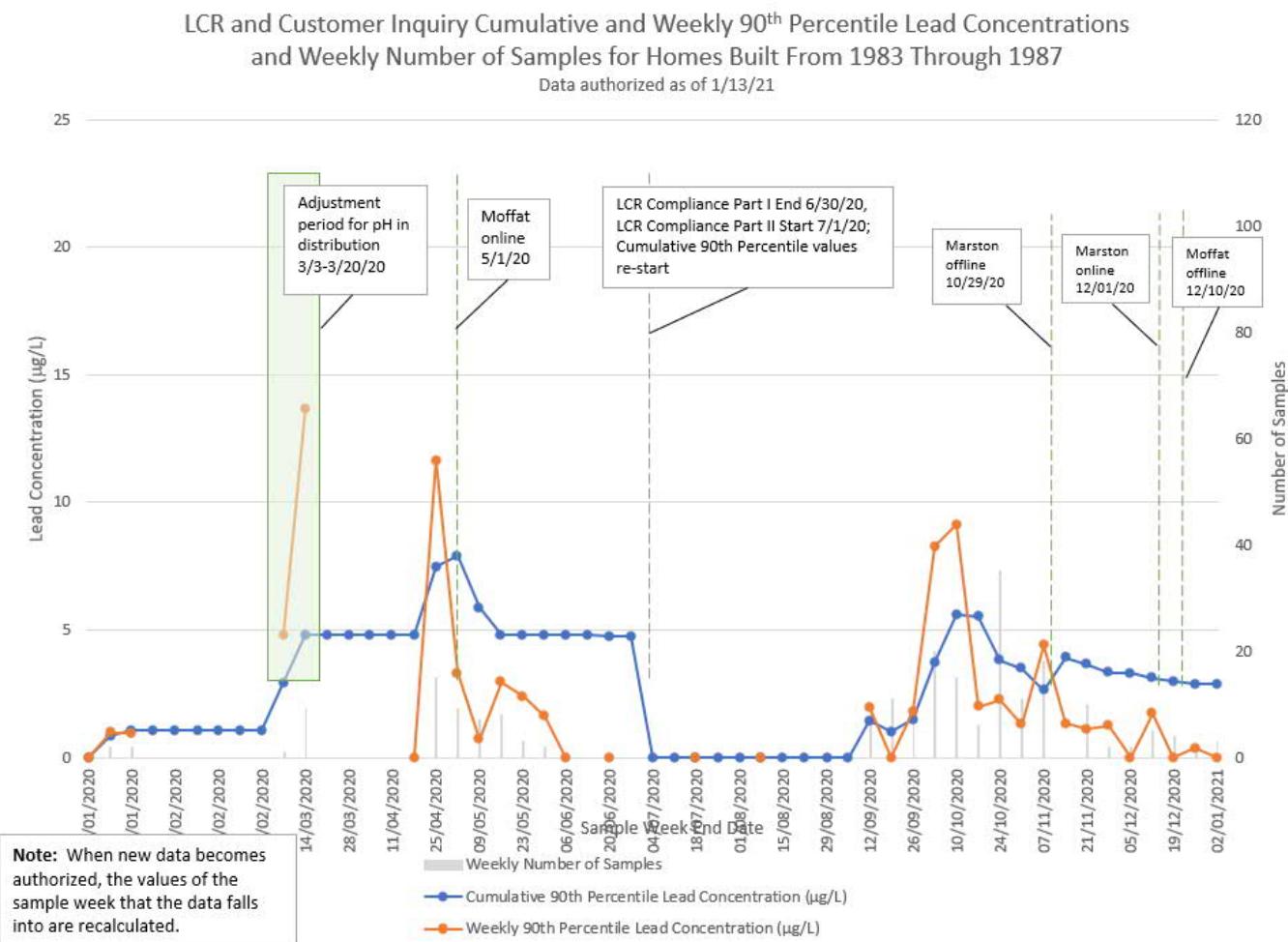
Weekly 90th and Cumulative 90th Percentile Lead Concentrations for LCR Compliance Samples,
Weekly Number of Samples, and Weekly Average WTP Temperature

Data authorized as of 1/13/21



The cumulative 90th percentile lead level in the system before the pH change on March 3, 2020, was approximately 13 µg/L. Soon after the pH stabilized at 8.8, the lead levels started declining and leveled out by August at a 90th percentile lead concentration below 5 µg/L. This represents a greater than a 60 percent decrease in lead levels.

FIGURE 3. CORROSION CONTROL TREATMENT PERFORMANCE AT PROPERTIES WITH COPPER PLUMBING AND LEAD SOLDER



The calculated 90th percentile lead concentration for the spring and fall LCR six-month sampling periods are shown in Table 3. When results are compared for 2019 (before operating with pH adjustment) and 2020 (which includes a period with pH adjustment), a decrease in lead release is observed in the metric used as a basis of compliance with the Lead and Copper Rule.

TABLE 3. CCT PERFORMANCE BASED ON THE OVERALL 90TH PERCENTILE LEAD CONCENTRATION

LCR Six-Month Sampling Period	2019	2020
Spring Overall 90 th Percentile Lead Concentration	10.0 µg/L	6.7 µg/L
Fall Overall 90 th Percentile Lead Concentration	11.0 µg/L	4.4 µg/L

Integrating Data for Lead Levels into the Equivalency Model

The equivalency model uses actual lead levels measured from the taps of customers to represent lead levels from i) properties with copper plumbing and lead solder and ii) properties with no other known source of lead (i.e., non-lead in the LSL Inventory). Additionally, the model uses actual lead levels from filter performance sampling in the field to represent the reductions to lead levels at LSL homes that use a filter.

For properties with a LSL (i.e., known lead in the LSL Inventory) lead levels are represented by data collected from the pipe rack studies.⁵ This was necessary because the only data available for orthophosphate treatment applied to LSLs were generated by the pipe rack studies. This is a conservative approximation of lead release, as the pipe rack studies have been shown to release higher concentrations of lead than observed in the field; therefore, comparing lead levels from the taps of customers for the LRP condition yet using lead levels from pipe rack studies with orthophosphate is not a representative comparison.

Finally, to model lead levels after LSL replacement, the properties are treated as copper plumbing with lead solder because the premise plumbing may still contain lead:tin solder.

LSL Inventory and Investigations

Investigations

Refinement of the LSL Inventory of service line materials used in the water system continues. Investigations are performed at properties to improve the assumptions that were used to develop the LSL Inventory. The number of properties which are investigated and result in a change in status to known lead or non-lead are counted toward the required 1.4 percent of the LSL Inventory investigated each year. A completed investigation at a property may include desktop evaluation of available data from Denver Water, distributors, and customers; water quality sampling; potholing and/or visual investigation. After 15 years of the LRP, there should be no remaining properties in the LSL Inventory categorized as suspected or possible lead and known LSLs should be replaced.

Definitions used to categorize the service line material:⁶

Known Lead = based upon direct evidence that gives a 100 percent estimated probability that a service line is an LSL

Suspected Lead = based upon available data that provides an estimated probability value between 80 to 99 percent that a service line is an LSL (i.e., homes built before 1951)

Possible Lead = based on conflicting or missing data that provides an estimated probability value between 50 to 79 percent that a service line is an LSL

Unlikely Lead = 2 percent estimated probability of finding lead.

Non-Lead = 0 percent likelihood of finding lead.

⁵ See Lead Reduction Program Plan for a description of the pipe rack studies.

⁶ As described in paragraphs 1.k, 1.w, and 1.r for known, suspected and possible lead, respectively. Note that the definition of lead includes galvanized materials.

A property at which the status (as described by the p-value) of a service line is changed is counted as a completed investigation if the following conditions apply:

- 1) The property is originally classified as a suspected or possible lead service (see paragraphs 3.B and 3.D in the Order).
- 2) The investigation was performed independently of LSL replacement and not as part of the 2020 ALSLR Plan (see paragraph 3.D in the Order).
- 3) The investigation results in a change in status of a service line to either a known lead ($p = 1$) or unlikely lead ($p = 0.02$) or non-lead ($p = 0$) (see paragraphs 7.B.ii.f and h in the Order). For example, a water quality result with lead measured above 5 µg/L in the second or third sample bottle in the 3-bottle test would result in an adjustment to the p-value to 1.
- 4) An investigation that results in a status change can involve one or more methods including pothole, water quality samples, visual inspection, or other methods.

Investigative potholing is used at properties to improve the knowledge of the service line at properties that are not included in the 2020 ALSLR Plan. Investigative potholing is used at properties with a possible or suspected lead service line (i.e., $p \geq 0.5$ and $p < 1$). A three-point verification is used to identify the service line: a pothole from the main to water meter, a pothole from the water meter to the building, and a visual inspection inside the building where the service line enters. Potholing on its own is not conclusive for “non-lead” but it can be used in combination with other investigative methods to determine that a property is “unlikely” to have a lead service (i.e., p-value of 0.02). To confirm “unlikely lead”, there can be no lead or galvanized present in the three points used for potholing and there can be no contradictions with the desktop records review and/or water quality sampling results.

If copper is observed at three points (i.e., COPP-COPP-COPP is observed at two exterior potholes and one interior location), the service line is not categorized and the p-value is not adjusted; rather, the property is subjected to additional investigation efforts (i.e., water quality sampling, data review⁷, additional potholing⁸) to help identify the service line material.

Investigative water quality results with lead measured above 5 µg/L in the second or third bottle of the 3-bottle test are conclusive for a lead service line. Lead measured below this threshold at properties with an initial status of possible or suspected lead (i.e., p-value ≥ 0.5) is inconclusive for non-lead and additional investigations or review of data are needed to determine the status of the service line material. Lead measured below this threshold at properties with an initial status of unlikely lead (i.e., $p < 0.5$) is considered conclusive for non-lead and no additional investigations are undertaken and the property remains excluded from the LRP. Finally, lead measured below the detection limit of 1 µg/L is also considered indicative of non-lead when no

⁷ Additional data review refers to consideration of additional historical records or information available from the property owner that was either not previously available or considered.

⁸ Additional potholing refers to performing additional potholes between the main and meter as well as between the meter and the building.

contradictions with other data sources exist. The total number of investigations completed in the first program year is shown in Table 4.

TABLE 4. NUMBER OF INVESTIGATIONS COMPLETED IN 2020

Number of Properties Investigated ¹	Count
Required Number of Investigations	1,168 (1.4 percent of suspected and possible lead services from the September 2019 inventory)
Number of Investigations Completed in 2020	3,326

¹ Number meeting criteria of “investigation”, i.e., independent of the 2020 ALSLR Program and resulting in a status change in the material of the service line.

Integrating the LSL Inventory into the Equivalency Model

Data included in the year-end inventory⁹ for the period of January 1 through December 31, 2020, is summarized as follows:

- Replacements completed by ALSLR contractors between March 12 and December 17, 2020, the last day of the year that contractors worked in the field.¹⁰
- Replacements completed by Transmission and Distribution (T&D) between January 2 and December 31, 2020, including from water main projects, emergency repairs, and critical customers (such as schools and child care facilities).¹¹
- Replacements completed by third parties, including tap cuts (cut and reactivated in 2020), reimbursements and properties inspected by Denver Water completed between January 2 and December 31, 2020.¹²
- There were no replacements documented by distributors.

The initial LSL Inventory and the inventory from December 30, 2020, are used as an input to the equivalency model to evaluate performance. An overview of the LSL Inventory is provided in Table 5.

⁹ See Appendix A-2 Line by Line p-Value Changes by Status (December 5 to 31, 2020) and previous quarterly reports.

¹⁰ By LRP policy, properties with a p-value ≥ 0.5 are scheduled for verification and replacement. The service line is assumed to be lead and no additional p-value review is made to establish otherwise. A replacement is not counted if copper is observed upon full excavation or pulling of the entire service line.

¹¹ The last replacement of 2020 was on December 30. T&D replacements are counted as a lead service line replacement if i) the initial p-value is ≥ 0.5 regardless of what is described by field crews as the “prior” material or ii) documentation from another source indicates that lead or galvanized is observed.

¹² The last tap cut and reactivation counted as a replacement occurred on December 21, 2020. The last reimbursement and the last inspection of a third-party replacement was completed on December 28 and 31, 2020, respectively.

TABLE 5. LEAD SERVICE LINE INVENTORY AS OF DECEMBER 30, 2020

Status of Service Line	Sept 6, 2019 Submittal (Aug 8 Data)	Feb 5, 2020 Submittal (Jan 28 Data)	Jan 29, 2021 Submittal (Dec 30 Data)
			INITIAL or BASE INVENTORY ¹
Known Lead	1,066	1,149	7,507
Suspected Lead	61,374 ⁴	60,549 ⁴	54,178
Possible Lead	22,106 ⁴	21,788 ⁴	19,894
Unlikely Lead	89,388	90,745	88,475
Non-lead	145,766	146,528	150,642
Total Number of Services	319,700	320,759	320,696
TOTAL ESTIMATED Number of Lead Service Lines	63,955	63,195	63,211

¹ The “base inventory” is the basis for the 7 percent LSL replacements per year.

² Provided an initial inventory within 35 days of the effective date of the Order, per paragraph 3.A.

³ The “year end inventory” is used in the application of the equivalency model to evaluate the performance of the LRP.

⁴ “Possible lead” includes service lines where $0.5 \leq p\text{-value} < 0.8$. In the Base Inventory and February 5, 2020, Submittal, service lines with $p\text{-value} = 0.7$ were included as “suspected lead.” This was corrected in the third quarterly report.

Number of LSL Replacements Conducted

At least 7 percent of the total estimated number of lead service lines must be replaced each year. Based on the initial LSL Inventory of Table 4, this is equivalent to 4,447 LSL replacements a year and serves as the target for 2021. The total number of lead services lines replaced between January 1 and December 31, 2020, was just over 8 percent as shown in Table 6. The number and dates of replacements are used as an input to the equivalency model.

TABLE 6. TYPE OF LSL REPLACEMENTS COMPLETED IN 2020

Type of LSL Replacement January 1 through December 31, 2020	Denver Water (Water main, Emergency, and ALSLR) ¹	Third Party (Developer, Homeowner, and Other) ²	Total
Full Lead Replacement	2613	143	2756
Partial Lead Replacement (No Lead After Replacement)	2107	10	2117
Full Galvanized Replacement	22	0	22
Partial Galvanized (No Lead or Galvanized After Replacement)	390	2	392
TOTAL REPLACEMENTS³, with No Lead Remaining After Replacement	5,132	155	5,287
Emergency Repair, Partial Replacement (i.e., consent NOT granted, lead remains in the ground) ⁴	15	0	15

¹ Includes LSL replacements completed as part of water main replacements, emergency repairs, scheduled replacements, and ALSLR individual and geographic replacements completed by Denver Water or its contractors.

² Third party includes LSL replacements completed by developers, property owners and other government agencies.

³ See Appendix A-1 Addresses and Types of Replacement (December 5 to 31, 2020).

⁴ See quarterly reports for a description of the conditions that resulted in a partial lead service line remaining and response.

Filter Adoption Rate

Filters are used to reduce exposure to lead before the lead service line is replaced and for six months following LSL replacement. The rate of filter adoption by customers enrolled in the LRP is used as an input in the equivalency model.

Filter adoption assumes customers are accepting, installing, using, and maintaining their pitcher filter properly, including replacing the filter cartridge at the appropriate time and using the pitcher filter for drinking, cooking, and infant formula, as applicable. The minimum filter adoption rate identified in the Lead Reduction Program Plan necessary to match the performance of the orthophosphate alternative is 65 percent.

Overview of Survey Employed to Estimate the Filter Adoption Rate

It was previously determined that for a filter adoption rate of at least 60 percent, a minimum of 1,059 filter adoption survey responses are required to estimate the filter adoption rate with at least 95 percent confidence and no more than 5 percent error.¹³

SURVEY QUESTIONS:

1. **Do you always, or most of the time, use your pitcher provided by Denver Water for drinking water?**
 Yes
 No – I use unfiltered tap water.
 No – I use bottled water, or a different type of filtration system certified to remove lead in accordance with NSF/ANSI 53 standards (e.g., fridge, under the sink filter, sink-mounted filter).
2. **Do you always, or most of the time, use your pitcher when you are cooking foods where water is a base ingredient (examples: making rice, beans, soup)?**
 Yes No
- 2a. **If your answer to No. 2 above is no, why are you not using the pitcher for cooking?**
 Prefer to use unfiltered tap water.
 Prefer to use bottled water for cooking food.
 Prefer to use a different type of filtration system certified to remove lead in accordance with NSF/ANSI 53 standards (e.g., fridge filter, under the sink filter, sink-mounted filter).
 Do not cook.
 Other
3. **Do you have a formula-fed infant (under 24 months of age) in your household?**
 Yes No
- 3a. **If yes, what water do you always use to mix the formula (select all that apply)?**
 Not applicable (I don't feed formula to my infant, or use pre-mix/ready mix)
 Water from the pitcher filter
 Bottled water
 Water filtered by an alternative filter device (fridge filter, under the sink filter, sink-mounted filter or other filter) certified to remove lead in accordance with NSF/ANSI 53 standards
 Unfiltered tap water

¹³ See Appendix III.C.1 (Filter Adoption) of the Lead Reduction Program Plan.
DENVER WATER

The questionnaire for the formal Filter Adoption Survey was approved by EPA on September 10, 2020.¹⁴ In the first week of October, the survey questionnaire was mailed to 20,000 random properties, equivalent to approximately 20 percent of customers enrolled in the Filter Program. The Filter Adoption Survey participants submitted survey responses online or mailed in hard copy responses. Survey respondents were requested to answer questions one through three (regarding filter adoption for filtered water used for drinking, cooking, and infant formula) for inclusion in the analysis and calculation of the overall percent filter adoption. A total of 3,987 survey responses were received between October 8 and November 23, 2020. The response rate of almost 20 percent is indicative of the public's interest - and support - of the LRP.

Definitions Used to Calculate the Filter Adoption Rate

Definitions are provided in Table 7 to describe the consistent application of the data from the filter adoption survey when measuring the filter adoption rate. The percentage filter adoption for drinking and/or cooking and infant formula is used as a single input in the equivalency model.

TABLE 7. DEFINITIONS FOR FILTER ADOPTION RATE AS USED IN THE EQUIVALENCY MODEL

**YES to filter use for drinking water = Q1 yes pitcher filter +
Q1 alternative filter/bottled water**

YES to filter use for cooking = Q2 yes +
[Q2 no and one of Q2a bottled water + Q2a alternative filter + Q2a do not cook + applicable Q2a other]

YES to formula-fed infant¹ = Q2 yes +
[and one or more of Q3a N/A + Q3a pitcher filter + Q3a bottled + Q3a alternative filter]

TOTAL Filter Adoption Rate as defined in the Order =
1 x (yes drinking, yes cooking, yes formula-fed infant) +
0.5 x (yes drinking, yes formula-fed infant only)
÷ total eligible responses

Percent filter adoption for drinking = (YES to filter use for drinking water)
÷ total eligible responses

Percent filter adoption for cooking = (YES to filter use for cooking)
÷ total eligible responses

Where total eligible responses = mailed responses with answers to Q1, Q2 and Q3
+ electronic responses using the “submit” button

¹ Includes customers that responded that they do not have a formula-fed infant in their household and are not expecting.

¹⁴ See third quarterly report (Appendix FIL-29 OMB Approved Adoption Survey Questions).
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Using the definitions of Table 7 and in accordance with paragraph 5.E.ii of the Order, the total filter adoption rate for 2020 is calculated at 80 percent as shown in Table 8. This percentage is used in the equivalency model.

TABLE 8. FILTER ADOPTION RATE ESTIMATED FROM FILTER ADOPTION SURVEY

Question	Total Responding Yes	Total Surveys Received	Percent Yes
Q1. Filtered or bottled water used for drinking water	3,715	3,987	93%
Q2. Filtered or bottled water used for cooking ¹	2,700	3,987	68%
Q3. Filtered or bottled water used for formula-fed infant in households that self-identify as an existing or expecting family	99	102	97%
Total Filter Adoption Rate as used in the equivalency model²			80%

¹ Includes those customers that responded that they do not cook.

² As described in paragraph 5.E.ii of the Order and the number used in the equivalency model.

Filter Performance in the Field

To confirm that customers enrolled in the Filter Program are effectively using filters to reduce lead exposure, the Order mandates filter performance testing in the filter per paragraph 5.F.ii. Results can be used to identify poor performing filters if lead breakthrough is measured; this was not the case in 2020. Field testing of pitcher filters has shown high degrees of lead control. The filter effluent from 108 field tests resulted in 78 measurements that were below the method detection limit of 1 µg/L.¹⁵ The 90th percentile lead concentration from the filters was 2.4 µg/L.

Integrating Filter Adoption and Performance into the Equivalency Model

The filter adoption rate is used in the equivalency model by randomly selecting the number of remaining lead service lines equal to the adoption rate. For example, in 2020, there were an estimated 63,955 lead service lines at the beginning of the year¹⁶, with 5,287 being replaced¹⁷, leaving 58,668 LSLs. The 80 percent adoption rate¹⁸ is interpreted as 46,934 are filtered and 11,734 are assumed unfiltered. These service lines are assigned lead concentrations randomly drawn from the observed distribution of lead in filter effluent generated from filter performance testing in the field. This reduces lead concentrations assigned to properties with a lead service line and protected via the pitcher filter to concentrations far below the expected levels that would have occurred with only the addition of orthophosphate.

¹⁵ See second and fourth quarterly reports for individual results.

¹⁶ See Table 4.

¹⁷ See Table 5.

¹⁸ From Table 7.

LRP PERFORMANCE USING THE EQUIVALENCY MODEL

The Order requires the use of a comprehensive LRP performance metric. The metric is produced using actual performance data of various elements of the LRP to show the program “*as implemented continues to be ‘at least as efficient as’ orthophosphate treatment in reducing lead exposure on an annual basis.*”

The equivalency model is a statistical model that compares modeled lead concentrations at each service line in the service area for conditions representing LRPP implementation versus the projected performance of orthophosphate, designated as optimal corrosion control treatment. LRP conditions include the use of pH and alkalinity adjustment as corrosion control treatment, accelerated lead service line replacement (in addition to replacements routinely carried out as part of water main projects, emergency repairs and by third parties), pitcher filters for lead reduction prior to LSL replacement, and communications, outreach and education. OCCT conditions include the use of orthophosphate and the historical average rate of routine lead service line replacements.

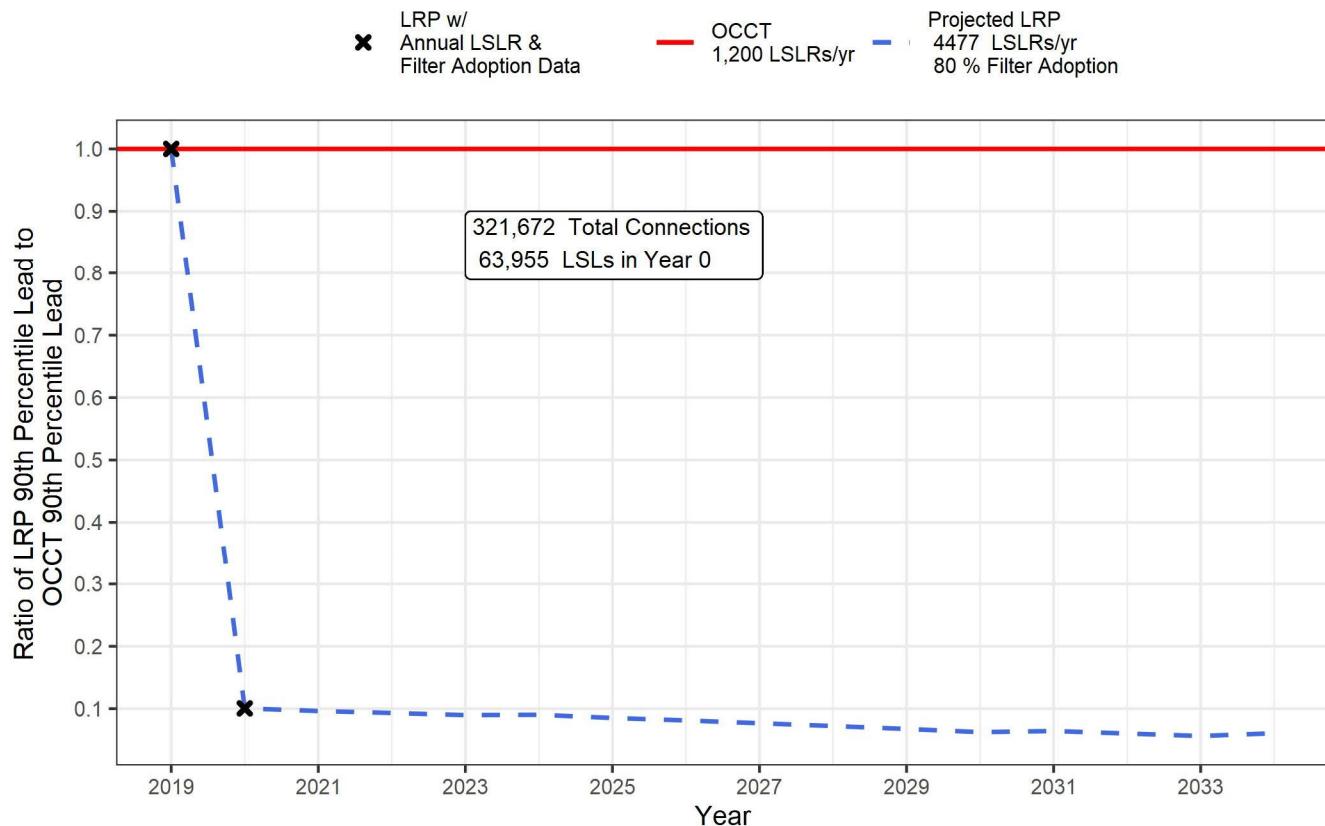
The equivalency model includes actual data from:

- 1) Lead concentrations from LCR compliance samples and customer requested samples at properties with copper plumbing and lead solder (CuLS) and other sites after operation of increased pH adjustment as corrosion control treatment (CCT).
- 2) Number of LSL replacements conducted.
- 3) Filter adoption rate.
- 4) Filter performance in the field.

The primary output of the model is an indexed performance of the LRP to the presumed OCCT conditions for each year, as shown in Figure 4. The index is calculated as the 90th percentile lead concentration from the LRP model divided by the 90th percentile lead concentration from the OCCT model. Results less than or equal to 1.0 demonstrate the LRP is “at least as efficient as” OCCT and in compliance with the Order. The points in Figure 4 reflect actual conditions each year (shown as a black X), the lines reflect projected numbers for future years (shown in solid red for the OCCT condition and dashed blue for the LRP condition).

Lead service line replacements for OCCT conditions are based on the historical rate of 1,200 LSLRs completed annually, which is assumed constant. For the LRP condition, there were 5,287 confirmed LSLRs in 2020, with future LSLRs assumed equal to the 7 percent mandated annual target (7 percent of 63,955 = 4,477). A filter adoption rate of 80 percent was used for each year based on the 2020 filter adoption rate.

FIGURE 4. EQUIVALENCY MODEL OUTPUT FOR 2020



The model outputs of Figure 3 indicate that the LRP approach has resulted in systemwide lead concentrations that are approximately 10 percent of the expected OCCT lead concentrations when measured at the 90th percentile. These results indicate that systemwide lead concentrations are lower than they would have been under OCCT conditions. Thus, better performance of the LRPP is demonstrated compared with OCCT for 2020.

ADDITIONAL REQUIREMENTS AND DELIVERABLES

Since the effective date of the Order, milestones and submissions required in the Order or the LRPP have been documented. A summary of submissions and deliverables provided to CDPHE and EPA is provided in Table 8; actual documents have been provided previously.

TABLE 9. SUMMARY OF METRICS ACHIEVED IN 2020

Reference Paragraph	Metric and Description	Result
2.A	Begin adjustment of pH and alkalinity for CCT no later than March 20, 2020.	See first quarterly report and March and May monthly reports.
2.B.iii	Monitor water quality parameters following LCR six-month reporting periods.	See CCT Implementation Plan first submitted on March 6, 2020, and approved by EPA on July 17, 2020.
2.B.iv	Identify and address elevated lead levels. Submit Elevated Lead Response Plan within 90 days of effective date.	See CCT Implementation Plan first submitted March 6, 2020. See monthly reports for response description (i.e., replace LSL).
2.C	Maintain minimum target of 8.5 for pH across the distribution system during first year of operation.	See monthly reports for data for pH measured in treated water and the distribution system.
3.A	Complete the initial LSL inventory no later than 35 days after the effective date. Maintain LSL inventory and update on annual basis to account for replacements.	See letter submitted February 4, 2020.
3.B	Incorporate investigations of service line materials into the required LSL inventory annual updates.	See quarterly reports.
3.C	Publish LSL inventory to public map on the external customer website no later than 70 days after the effective date.	See letter submitted March 5, 2020.
3.D	Investigate a minimum of 1.4 percent of the total estimated number of suspected and possible LSLs in the LSL inventory each program year.	See quarterly reports.
4.A	Implement accelerated LSL replacement within 90 days of the effective date.	See letter submitted March 26, 2020.
4.E	Offer and conduct one-time lead sampling at homes where LSLs have been replaced within six months post-LSL replacement.	See quarterly reports.
4.H	Undertake reasonable efforts to obtain permission from new property owner (if refused by previous) within 91 days of a change in account records. Maintain records of the specific addresses of all structures at which the property owner does not consent to LSL replacement.	See quarterly reports.
4.I	Achieve at least a 7.0 percent cumulative average Program Year LSL replacement rate.	See this report.

Reference Paragraph	Metric and Description	Result
5.A	<p>Initiate initial filter distribution, six months of replacement cartridges and education materials within 90 days of the effective date.</p> <p>Complete distribution of the educational materials, filters, and cartridges within 270 days of the effective date.</p>	See letters submitted March 26 and September 27, 2020.
5.B	Deliver replacement cartridges until six months after replacement of a LSL or until the time the service line of the property is confirmed as non-lead.	See quarterly reports.
5.C	<p>Provide new residents with filter educational materials no later than two weeks following the change in customer account.</p> <p>Distribute a new filter and replacement cartridges to new customer within 35 days of the change in customer account.</p>	See quarterly reports.
5.D	Offer free drinking water lead testing to select households and offer a filter and replacement cartridges if first draw shows lead concentrations above 3 µg/L.	See third and fourth quarterly reports.
5.E.i	Receive a minimum of 1,059 filter adoption survey responses.	See fourth quarterly report.
5.F.i	Test lead removal effectiveness of twelve units of each type of filter within 90 days of effective date.	See letter submitted February 13, 2020.
5.F.ii	Collect samples from filters in at least 50 locations enrolled in the filter program and also in the LCR compliance tap sampling program.	See second and fourth quarterly reports.
5.G	Make direct contact with lead outreach and education materials to 95 percent of all customers enrolled in the filter program in every Program Year.	See letter submitted September 27, 2020.
6.B	Demonstrate using the updated equivalency model results that the LRPP is “at least as efficient as” orthophosphate treatment.	See this report.
7.B.i.a	Provide an elevated lead response plan within 90 days of the effective date.	See CCT Implementation Plan first submitted March 31, 2020.
7.B.i.b	Report elevated lead levels and actions taken to reduce exposure within 10 days after the end of each calendar quarter in the first Program Year.	See quarterly reports.
7.B.i.c	Report results of all lead and copper compliance tap sampling and customer requested samples within 10 days after the end of each calendar quarter in the first Program Year.	See monthly and quarterly reports.
7.B.i.d	Report CCT water quality parameters for pH and alkalinity monthly, no later than the tenth day of the following month.	See monthly reports.
7.B.i.e	Report all lead and water quality results collected as part of the investigation of LSLs and post LSL replacement and service line material monthly, no later than the tenth day of the following month.	See monthly reports.

Reference Paragraph	Metric and Description	Result
7.B.ii	Report the metrics of the LSL inventory within 10 days after the end of each calendar quarter in the first Program Year.	See quarterly reports.
7.B.iii	Report the metrics of the LSL replacements within 10 days after the end of each calendar quarter in the first Program Year.	See quarterly reports.
7.B.iv	Report the metrics of the filter distribution, refusals and performance within 10 days after the end of each calendar quarter in the first Program Year.	See quarterly reports.
7.B.v	Report results achieved under the compliance metrics (2.C, 3.D, 4.I, 5.G and 6.B) within 10 days after the end of each calendar quarter in the first Program Year.	See quarterly reports.
7.B.vi	Summarize the activities conducted under the COE program within 10 days after the end of each calendar quarter in the first Program Year.	See quarterly reports.
7.B.vii	Summarize the activities conducted and designed under the HE&EJ principles within 10 days after the end of each calendar quarter in the first Program Year.	See quarterly reports.
8.G	Begin a multi-media public information campaign and customer notification to notify customers of the variance within 90 days of the effective date.	Launched on March 23, 2020.
LRPP III.E (p 70)	Monthly trending of LCR compliance samples and customer requested samples.	See monthly reports and this report.
LRPP III.E (p 70)	Install automated pH control loops at all three treatment plants by March 2020.	Installed as described in Table 2.
LRPP III.E (p 65)	Targeted communications for 1983-87 homes to self-identify expecting and existing families with formula-fed infants and children up to 2 years of age; offer water quality sampling; provide filter if lead measured > 3 µg/L.	Described with sections 5.D and 7.B.vi. Outreach materials launched August 21, 2020.
LRPP III.E (p 71)	Complete distribution system modeling, evaluating pH, disinfection by-products and water age by January 31, 2020. Submit nitrification control plan by June 30, 2020 to address sampling, monitoring and flushing. (Nitrification Control Plan dated July 7, 2020).	Submitted January 22, 2021.
Voluntary	Share results from continued operation of the pipe racks. (Lead Pipe Rack Results Technical Memo dated July 6, 2020, and covering sampling from October 1, 2019, to June 15, 2020).	Submitted January 22, 2021.
LRPP III.B (p 51)	Use results from investigations to update the predictive model which is used to plan and prioritize efforts of the COE Plan, ALSLR Program and Filter Program.	Ongoing. See quarterly reports.

Reference Paragraph	Metric and Description	Result
LRPP III.D (p 62)	Provide education and filters to residents of multi-family properties on the Service Line Refusal List.	Not applicable for reporting period.
LRPP III.D (p 57)	Replace LSL at properties with consistently high lead release and critical care customers.	See elevated lead response summary in quarterly reports.
LRPP III.D (p 58)	Complete approximately 2,000 investigations per year in the first five years of the Lead Reduction Program to update the predictive model and improve the quality of information in the LSL Inventory.	See Table 4 and quarterly reports.
LRPP III.D (p 60)	Property owners will be reminded via English and Spanish signage placed at the limits (ends of streets) within geographic work areas four to five weeks in advance of construction.	Implemented July 20, 2020.
LRPP III.D (p 60)	Provide flushing instructions following LSL replacement.	Ongoing. Provided to all customers as part of the post-LSL replacement education package.
LRPP III.C (p 56)	If the localized filter adoption rate is less than 75%, additional outreach and education will be provided to that area.	Analysis of results from the filter adoption survey is ongoing.
LRPP III.C (p 55)	Survey filter use as part of ALSLR Program following LSL replacement.	Ongoing. See quarterly reports.
LRPP III.E (p 64)	Targeted messaging to homes with copper piping and lead solder to flush the tap after periods of non-use.	Ongoing. See quarterly reports.
LRPP III.F (p 74)	Engage Stakeholder Advisory Committee to support Learning by Doing element.	Ongoing. See quarterly reports.
LRPP V (p 77)	Commitment to continue to consult and collaborate with the organizations and HE&EJ experts, stakeholders, community members and customers to continually improve upon integration of the HE&EJ principles with the LRP.	Ongoing. See quarterly reports.
LRPP V (p 79)	Collaborate with other agencies to address lead exposure from all sources.	Ongoing. See quarterly reports.

DEVIATIONS (AND CLARIFICATIONS)

During the 2020 Program Year, Denver Water sought EPA input on requested clarification and in certain instances, permission to deviate from the Order. Under paragraph 7.C of the Order, Denver Water is required to “document any deviations from the LRPP during the most recent Program year.” A summary of deviations and clarifications is presented below.

Deviations

- Change terminology used in the inventory map posted to the website from “lead, copper, or unknown” to “confirmed lead service line, likely lead service line, unlikely lead service line, and no lead service line” as communicated in writing to CDPHE and EPA on January 24, 2020.
- Use other methods to investigate lead at multi-family dwellings and commercial properties as the 3 L sample is ineffective.
- Use a single bottle sampling procedure (i.e., 1st draw, 1-liter) for post-LSLR sampling at multi-family and commercial properties as confirmed in email correspondence from EPA on July 17, 2020.

Clarifications

- Measurable lead in samples obtained from filter testing in the field established as greater than 1 µg/L as clarified in email correspondence from EPA on September 16, 2020.
- Remove and provide new pitcher filter if lead is measured $\geq 10 \mu\text{g}/\text{L}$ at LCR sites included in filter performance testing in the field as described in the CCT Implementation Plan submitted on June 6, 2020 and approved by EPA on July 17, 2020.