United States
Environmental Protection
Agency

Technical Support Document for the Final Lead and Copper Rule Improvements

Office of Water (4607M)
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1 Introduction

This technical support document provides detailed information on data sources, data collection, and technical analyses considered was considered in the development of the final Lead and Copper Rule Improvements (LCRI), specifically in the agency's analysis of the feasibility of lead service line replacement requirements, service line inventory, and action level. Chapter 2 of this document details the data and analysis considered in the feasibility of mandatory service line replacement requirements in the final rule, including methods for data collection of available lead service line replacement (LSLR) data and use of data from the One-Time Update to the Drinking Water Infrastructure Needs Survey and Assessment (Needs Survey). Chapter 3 of this document describes the data sources and analyses that were considered by the EPA in its analysis of the feasibility of service line identification and inventory development, including data from States that have already required the development and verification of service line inventories. Chapter 4 describes the data and analysis considered by the EPA in its analysis of the feasibility of lowering of the lead action level to 0.010 mg/L in the LCRI.

2 Feasibility of the Final LCRI's Service Line Replacement Requirements

2.1 Per-Connection Rate Assessment of LSLR Programs

The LCRI maintains a treatment technique approach to reduce lead in drinking water. In establishing treatment technique requirements, the Safe Drinking Water Act (SDWA) authorizes the EPA Administrator to identify treatment techniques that "prevent known or anticipated adverse effects on the health of persons to the extent feasible" (SDWA 1412(b)(7)(A)). Thus, service line replacement, part of the LCRI's treatment technique requirements, must prevent adverse health effects to the extent feasible in accordance with the statute and legislative history (see preamble section III.D).

To determine the mandatory service line replacement requirements that would protect the health of persons to the extent feasible for the proposed LCRI, the EPA identified water systems with service line replacement programs to replace both lead and galvanized requiring replacement (GRR) service lines and obtained data on the replacement rates they achieved. From January 2023 to May 2023, the EPA compiled replacement rate data from official sources, including State, local, and water system websites, peer-reviewed research articles, and conference proceedings. Websites providing information on replacement programs, such as non-profit websites (e.g., Environmental Defense Fund) were used to help identify which States and water systems the EPA should evaluate further for inclusion in the analysis. The EPA also became aware of replacement programs though queries of local media reporting. Each source describing replacement data was manually reviewed for data quality by the EPA's staff. This search yielded 44 service line replacement programs with available replacement rate data that met the EPA's exclusionary criteria. From this dataset of 44 replacement programs, the EPA excluded projected replacement rates because they do not indicate rates that have been achieved by water systems, which is stronger evidence of a replacement rate's feasibility. Additionally, the EPA excluded service line replacement programs which replace service lines solely in coordination with emergency repair or routine infrastructure because it is unlikely that these water systems are replacing lead and galvanized requiring replacement service lines to the extent feasible. In the proposed LCRI, the EPA sought comment requesting any additional service line replacement rate data achieved by systems in replacement programs meeting its criteria (i.e., excluding programs that only replace service lines in coordination with main replacement or emergency repair) (USEPA, 2023b). A Quality Assurance Protection Plan (QAPP) was developed for the LCRI outlining how the Needs Survey dataset was processed, analyzed, and the quality assurance processes conducted for this analysis. The QAPP additionally detailed data sources and analytical techniques used for the service line inventory progress (Chapter 3) and the underlying data and analysis for determination of the lead action level (Chapter 4).

For the final rule, the EPA updated the replacement rate dataset used in the proposed LCRI to include data submitted to the EPA in the public comment period on the proposed LCRI. This resulted in a total of 48 replacement programs with replacement rate data for the final rule's feasibility analysis (Exhibit 2.1).

Exhibit 2.1: System Characteristics and Replacement Rate Data from the Included LSLR Programs

City	State	Population Served	Total Number of LSL/GRR	% of Total SLs	Duration of Program	Avg. Replaced per year	Annual Replacements per 1,000 service connections	Years To Complete at This Rate
Cleveland[a]	OH	1,308,955	185,409	41%	2023	4,000 (2.2%)	8.8	45.5
Denver	CO	1,287,000	74,000	22%	Jan 2020 to Jan 2024	5,581 (7.0%)	17	14.3
Fort Worth	TX	853,762	1,790	0.31%	2016 to 2021	233 (13%)	0.40	7.7
Louisville[a]	KY	764,769	790	0%	2023	272 (34%)	0.96	2.9
Cincinnati	OH	750,200	51,951	0.70%	2016-2030	1,200 (2.3%)	4.9	43.5
Detroit	MI	713,777	80,000	29%	2023	2,060 (2.6%)	7.5	38.5
Tucson	AZ	675,686	600	0.31%	2016 to 2018	47.3 (7.9%)	0.25	12.7
Washington	DC	632,323	28,000	20%	2019-2023	933 (3.3%)	6.7	30.3
Pittsburgh	PA	520,000	16,000	22%	2016 to present	1,446 (9.0%)	20	11.1
Central Arkansas Water	AR	330,667	175	0.10%	2016-2017 (14 months)	115 (66%)	0.89	1.5
Saskatoon	Canada	313,000	4,582	6.10%	2017 to 2022	488 (11%)	6.5	9.1
Newark	NJ	294,274	23,189	64%	2019 to 2022	7,730 (33%)	212	3.0
Grand Rapids	MI	273,005	1,608	2.00%	2021 to 2022	304 (19%)	3.8	5.3
Spokane	WA	244,817	486	0.60%	2016 to 2018	162 (33%)	1.9	3.0
Trenton	NJ	217,000	20,000	32%	2017 to 2022	1,372 (8.0%)	22	12.5

City	State	Population Served	Total Number of LSL/GRR	% of Total SLs	Duration of Program	Avg. Replaced per year	Annual Replacements per 1,000 service connections	Years To Complete at This Rate
Aurora	IL	200,000	17,729	35.70%	2022	612 (3.5%)	12	28.6
Sioux Falls	SD	198,524	230	0.38%	2016-2017 (32 months)	115 (50%)	1.9	2.0
York	PA	197,177	2,300	2.90%	2017-2021	380 (17%)	5.8	5.9
Kalamazoo	MI	192,992	10,000	24%	2015 to Present	505 (5.0%)	12	20.0
Lansing	MI	166,000	12,150	22%	2004 to 2016	1,013 (8.3%)	18	12.0
Lancaster[a]	PA	120000	N/A	N/A	2012-2023	23 (N/A)	0.51	N/A
Elgin	IL	113,911	13,500	40.70%	2017-2022	292 (2.2%)	8.8	45.5
Green Bay	WI	107,395	2,028	5%	Jan 2016 to Sep 2020	357 (18%)	9.3	5.6
Quincy	MA	101,636	285	1.20%	April 2017-September 2018	206 (72%)	8.7	1.4
Flint	MI	98,310	12,035	37%	2016 to 2022	1,946 (16%)	59	6.3
Newton	MA	89,103	433	1.70%	2017-2019	144 (33%)	5.8	3.0
Somerville	MA	81,045	449	3.60%	2021 - 2022	86 (19%)	5.6	5.3
Evanston	IL	75,570	10,803	37.50%	2017-2022	184 (1.7%)	6.4	58.8
Framingham	MA	72,362	184	1.08%	2004-2016	1 (0.5%)	0.06	184.0
Madison	WI	71,160	8,000	9%	2000 to 2011	728 (9.1%)	8.4	11.0
St. Clair Shores	MI	59,715	1227	4.80%	2020	100 (8.1%)	4.0	12.3
Revere	MA	59,075	350	2.90%	2019-2021	83 (24%)	7.0	4.2
Bozeman	MT	56,000	170	0.70%	2016-2019	35 (20%)	2.9	5.0
N/A[b]	VT	N/A	N/A	N/A	2021-2023	167 (N/A)	N/A	N/A
Bloomfield	NJ	47,315	500	4.10%	2018 - 2021	130 (26%)	11	3.8
Battle Creek	MI	43,975	5,000	22.50%	2022	140 (2.8%)	6.3	35.7
Marlborough	MA	38,499	1,350	13%	May 2018 - Sept 2018	176 (13%)	17	7.7
Galesburg	IL	31,745	3,500	28%	2016 to present	530 (15%)	42	6.7
Village of Montgomery	IL	28,956	106	1.20%	Fall 2019 to Summer 2020	106 (100%)	12	1.0

City	State	Population Served	Total Number of LSL/GRR	% of Total SLs	Duration of Program	Avg. Replaced per year	Annual Replacements per 1,000 service connections	Years To Complete at This Rate
Norwood	MA	28,284	200	2.20%	2004-2008	40 (20%)	4.5	5.0
Sandusky	OH	25,793	N/A	N/A	2021	39 (N/A)	3.7	N/A
Winchester	MA	22,800	21	0.29%	Mar 2017 to 2019	7 (33%)	0.93	3.0
Birmingham	MI	20,472	730	8.60%	2020 to 2022	182 (25%)	21	4.0
Frankfort	IL	20,296	82	0.70%	2021-2022	41 (50%)	3.6	2.0
Menasha	WI	14,792	636	12%	2017 to 2023	106 (20%)	19	5.0
Stoughton	WI	13,078	700	14%	2021	700 (100%)	144	1.0
Mayville	WI	5,112	220	12%	2021	220 (100%)	116	1.0
Evart	MI	1,903	500	72.36%	2019	40 (8%)	58	12.5

[a] Replacement rate data identified in public comments to the proposed LCRI (USEPA, 2023b).
[b] System was reported anonymously in the Vermont Drinking Water and Groundwater Protection Division public comment on the proposed LCRI; thus, any identifying information about the system, including the number of service connections, was not available.
Water systems are sorted by population served. "N/A" is used for cells with no data available. "GRR" = galvanized requiring replacement. "SL" = service line. See Appendix 1 for the data sources for each water system.

Of the 48 systems for whom the EPA identified replacement rate data, 46 systems serve populations of more than 10,000 persons and 2 systems serve populations of 10,000 or fewer persons ("small" systems, as referred to in SDWA section 1412(b) and as finalized as the small water system threshold in the agency's Consumer Confidence Report regulation (63 FR 44524, USEPA, 1998)).

For the proposed LCRI, replacement rate data from 30 systems serving more than 50,000 persons were used, and the 95th percentile rate (or 0.039 annual replacements per household served) was determined to be the feasibility threshold on a per-household basis. In the final LCRI, the EPA expanded the analysis to include 12 additional systems serving between 10,001 and 50,000 persons to increase the sample size and allow the EPA to better understand the feasibility of service line replacement for a wider variety of large systems. Data for systems serving between 10,001 and 50,000 persons were originally documented in the supporting information for the proposed Lead and Copper Rule Improvements (USEPA, 2023b). In addition, data for three systems provided during the public comment period was added that had not previously been in the proposed LCRI dataset. Data from Newark, NJ and one of the four systems obtained in the LCRI public comments (due to being reported anonymously, see Exhibit 2.1) were excluded. In total, the EPA used replacement rate data from 44 systems to inform the final rule feasibility threshold expressed as a per-connection annual replacement rate. The 95th percentile value of this dataset is 39 replacements per 1,000 service connections (Exhibit 2.2).

EXHIBIT 2.2: SUMMARY STATISTICS ON THE ANNUAL REPLACEMENT RATES PER 1,000 SERVICE CONNECTIONS PREVIOUSLY ACHIEVED BY WATER SYSTEMS, BY SIZE CATEGORY

	Median	75th Percentile	90th Percentile	95th Percentile	Maximum
System Size	**Annual Replacements per 1,000 Service Connections**				
Serving more than 10,000 people (n=44)	6.6	12	21	**39**	144
Serving 10,000 or fewer people (n=2)	58	N/A	N/A	N/A	116
All Systems (n=46)	6.8	11	32	59	144
System Size	**Annual Replacements per 1,000 Households Served**				
Serving more than 10,000 people (n=44)	5.1	8.2	18	39	135
Serving 10,000 or fewer people (n=2)	81	N/A	N/A	N/A	109
All Systems (n=46)	6.2	10	36	53	135

For the final LCRI, the EPA estimated the total time it would take each system identified for the analysis in Exhibit 2.1 to complete their mandatory service line replacement program, assuming systems consistently replace lead and GRR service lines at the average annual replacement rates identified in Exhibit 2.1. until all their lead and GRR service lines are replaced. This was calculated by dividing 100% by the average percent of service lines replaced per year based on the documented period in Exhibit 1.1. For example, York, PA, replaced an average of 17% of their lead and GRR service lines per year from 2017-2021, which equates to 100/17 or 5.9 years to completion.

Among the 44 systems serving more than 10,000 people, 27 (61%) systems were, at the time of this analysis, replacing service lines at a rate that would lead to the completion of their replacement programs in 10 years or less.

Availability of LSLR Data in Small Systems

Although not included in the EPA's assessment of an annual per-service connection replacement rate, the EPA did identify two small systems (serving ≤10,000 people) with data from official data sources. The EPA does not expect this is due to a lack of small systems conducting LSLR, but rather the EPA expects the prevalence of official data in the sources investigated is more likely available for larger systems as opposed to smaller systems. This is likely due in part to the 2000 EPA Public Notification Rule requirement for all systems serving 100,000 or more persons to post their annual water quality reports online, while there is no current requirement for systems serving fewer than 100,000 persons (USEPA, 2000). The revised Consumer Confidence Report requirements lowers this threshold to 50,000 persons (89 FR 45980). The EPA observed in the data used to populate Exhibit 1 that systems serving approximately 30,000 or more people were more likely to have websites that were updated frequently enough to post information on LSLR rates, possibly reflecting the greater capacity of systems in this size range to maintain a website even when not specifically required to do so. For systems serving fewer than 30,000 people in this dataset however, the EPA observed that they were less likely to have updated their own independent website to reflect LSLR rates. For example, the data for the only system serving ≤ 3,300 people was obtained from a storyboard prepared by a consulting firm on the system's behalf, and official data from many other systems serving fewer than 30,000 people but more than 10,000 people (Frankfort, Stoughton, Mayville, Winchester, Norwood, etc.) were all obtained from reports prepared by their respective State agencies rather than by the systems themselves.

Examining systems that have been awarded Bipartisan Infrastructure Law (BIL) funds for LSLR provides evidence that additional small systems have service line replacement programs for which information on replacement rates was not available from official sources used to identify replacement rates. Of the 85 systems receiving BIL funds for LSLR, 20 systems (23.5%) served fewer than 3,300 people and a further 23 (27.1%) served between 3,300 and 10,000 people. Together, 50.6% of systems that have been awarded BIL funding serve 10,000 people or fewer ("BIL LSLR funded projects as of 9-25-23.xlsx").

Similarly, the EPA is aware of additional systems for which service line replacement programs and activities are underway; however, official data sources on replacement rates are not available. For example, replacement programs have been identified through news articles in Massachusetts (City of Chicopee, n.d.; Rhodes, 2023), Ohio (Garner, 2022; Vasko, 2022), Michigan (Schulwitz, 2022), and Wisconsin (Leischner, 2022) that mention upcoming lead service line identification and replacement programs, but the accompanying water department websites either do not exist or do not contain updated data on replacement rates.

Service Connections in Lieu of Households Served

For the final rule, the EPA evaluated replacement rate data on a per-service-connection basis, rather than a per-household-served basis as in the proposed rule. The EPA received public comment recommending the agency include service connections rather than households in this evaluation to simplify and improve the implementability of the LCRI. In the EPA's Federal Safe Drinking Water Information System (SDWIS) database, the term "Service Connections Count" can be viewed to obtain the number of service connections for any water system nationwide. No column exists for the number of households of each water system in SDWIS, leaving the calculation of the household term up to each individual water system (USEPA, 2023b).

The EPA evaluated the effect that the change from using replacement rates based on households served to service connections in the distribution system had on the results of the feasibility analysis. Comparable summary statistics for per-household-served replacement rates show only minor differences from per-service-connection rates in Exhibit 2.2, highlighting that calculating the replacement rate threshold as per-service connection does not result in significant changes as compared to a per household rate threshold. (Exhibit 2.2).

2.2 Projection of Systems Expected to Exceed Deferral Threshold Using Updated Needs Survey Data

Projected Number of Eligible Systems for Deferred Deadlines

For the final rule, the EPA estimated the number of systems eligible for a deferred deadline by projecting the number of systems that are likely to exceed 39 annual replacements per 1,000 service connections. In its revised feasibility analysis, the EPA utilized updated data by analyzing responses from the One-Time Update to the 7th Drinking Water Infrastructure Needs Survey and Assessment (or Needs Survey), published in May 2024 (USEPA, 2024a). The Needs Survey collected data to represent the DWSRF-eligible infrastructure projects that are necessary in the 20-year period from January 2021 to December 2040. For the first time, the most recent Needs Survey collected service line material information to include the cost to replace LSLs, in accordance with the America's Water Infrastructure Act of 2018 (USEPA, 2023a). The service line material questionnaire provided for water systems to list the number of service lines that they have categorized as lead, galvanized lines downstream of lead pipe, lead connectors, unknown pipes, or connectors, and service lines of other or unknown materials. Seventy-five percent of water systems provided responses to the service line material questionnaire. The EPA surveyed all large community water systems (CWSs) serving more than 100,000 people, a random sample of CWSs serving between 3,301 and 100,000 people in each state, and national random samples of CWS serving fewer than 3,300 people and non-public non- community water systems. The EPA analyzed information from the One-Time Update on 3,588 water systems that provided service line material information (USEPA, 2024a). The Updated Needs Survey dataset includes responses from 1,786 out of approximately 4,500 community water systems (CWSs) serving more than 10,000 people and 1,626 out of approximately 40,000 CWSs serving 10,000 or fewer people. Responses were also received from 126 non-community water systems (including transient and non-transient systems); however, among these systems, no lead or GRR service lines were reported. The response rate 2 (RR2) among CWSs according to AAPOR standards (AAPOR, 2023) was 6.9%. The RR2 considering only systems serving greater than 10,000 people was 40%. This difference is due to the larger number of CWS serving 10,000 people or fewer. Of the 49,396 CWSs listed in the SDWIS database, 44,867 serve 10,000 people or fewer (91%). Accordingly, the amount of the population served by participating CWSs is much higher than the RR2 value. Specifically, among CWSs serving more than 10,000 people, participating CWSs represent nearly 200 million people, approximately 74% of the total population among these CWSs. Additionally, the AAPOR cooperation rate 2 (COOP2) was 97%, highlighting the high degree of participation among systems which were contacted. For more information on the Needs Survey process and methodology, please see USEPA, 2023a.

Furthermore, the EPA could not connect 50 water systems to the SDWIS/Fed data, possibly due to changes in water system status or consolidation of systems. Therefore, responses from 3,412 CWS were used to determine their estimated number and proportion of lead and GRR service lines, and their required annual replacement rate to meet a 10-year deadline.

Consistent with the approach in the proposed rule, the EPA accounted for the presence of unknown service lines using two different methods (low-bound and best) to estimate the total number of lead and GRR service lines in each system. For the low-bound estimate, the EPA assumed that all reported unknown service lines are non-lead service lines when calculating each system's annual replacement per service connection value. For the best estimate, the EPA evaluated unknown lines using methodology consistent with the EPA's analysis of the Needs Survey results for the Drinking Water State Revolving Fund (DWSRF) allocations (USEPA, 2023a). For this method, the EPA projected the composition of reported unknown lines by (1) applying the combined percentage of known lead and GRR service lines among all known service lines for each State and (2) applying that rate to all unknown service lines within systems in that State. This method allowed the EPA to account for unknown service lines when estimating the number of systems eligible for a deferred deadline under the final rule.

The EPA estimated the total number of systems exceeding the per-connection rate threshold by calculating the proportion of surveyed systems in each population size category estimated to exceed the threshold. This allowed the EPA to extrapolate results to all remaining (i.e., non-surveyed) systems in each size category. Exhibit 2.3 shows number and percent of all systems estimated to exceed the eligibility threshold for a deferred deadline under the proposed and final LCRI (Exhibit 2.3). The EPA calculated the low and best estimates for each scenario. The scenarios include the proposed rule and the final rule. The EPA also included the number of water systems that would have exceeded the eligibility threshold using the proposed per-household rate with the updated Needs Survey data (alternate scenario). This analysis was conducted to determine the difference in projected eligibility for deferred deadlines based upon the choice of normalization variable (households vs service connections).

EXHIBIT 2.3: LOW-BOUND AND BEST ESTIMATES OF SYSTEMS LIKELY TO EXCEED THE PER-CONNECTION REPLACEMENT THRESHOLD IN THE FINAL LCRI COMPARED TO THE PROPOSED LCRI AND THE ALTERNATE PER-HOUSEHOLD SCENARIO

Threshold	Eligible Systems Serving >10,000	Eligible Systems Serving ≤ 10,000	Total Eligible Systems (All Sizes)	Percent of Total Systems Eligible (All Sizes)
Final Rule: 39 replacements per 1,000 connections	101-116 (2.2-2.6%)	387-498 (0.9-1.1%)	488-614	1.0-1.2%
Alternate Scenario for the Final Rule: 39 replacements per 1,000 households served	68-83 (1.5-1.8%)	415-609 (0.9-1.4%)	483-692	1.0-1.4%
Proposed Rule: 0.039 replacements per household served[a]	146-437 [A] (1.5-4.5%)	570-1,737 [A] (1.4-4.3%)	716-2,174 [A]	1.4-4.4%

[a] The proposed rule used the results of the 7th Drinking Water Infrastructure Needs Survey and Assessment (Needs Survey), while the final rule analysis used the results of the One-Time Update to the Needs Survey released in 2024.

The results in Exhibit 2.3 show that the 10-year replacement deadline for the final LCRI is feasible for the vast majority of water systems nationwide. It also demonstrates that the EPA's updated deferred deadline eligibility criteria based on the final rule's updated feasibility analysis makes only a minor impact on the percentage of systems projected to exceed the deferred deadline threshold as compared to the proposed rule.

The use of a per-service-connection basis in the final rule results in a slightly higher proportion of systems serving more than 10,000 persons eligible for deferred deadlines as compared to the alternate scenario per-household-served basis (Exhibit 2.3). These results demonstrate a very small impact on using a per-service-connection basis versus a per-household-served basis. The EPA expects, however, that the use of a per-connection basis is more representative of the feasibility of the required scale of service line replacement for large systems Using the average size of a household is not an accurate predictor of the number of service lines in a system nor is it a predictor of the number of bill paying households in a system. For example, for water systems with many multifamily homes or complexes the average size of a household is not an accurate predictor of the number of service lines in a system. Chicago, IL, has 484,979 reported service connections. If the per-household-served basis was used, Chicago's population served of 2,746,388 would be divided by 2.53 persons per household (the average persons per household from the 2020 Census Bureau used in the proposed rule), resulting in an estimated 1.1 million households served. This is twice as many service connections that the city actually has and does not accurately reflect the proportion of service lines that require replacement. As a result, when the number of service connections is used to normalize Chicago's 430,067 projected service lines requiring replacement, it results in a value of 89 annual replacements per 1,000 service connections, as opposed to a value of 39 annual replacements per 1,000 households served.

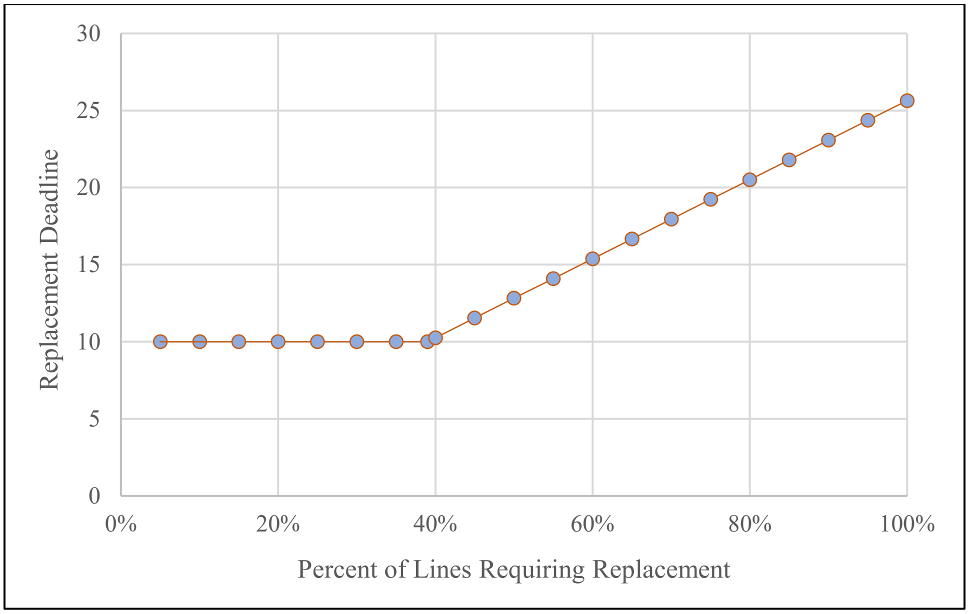
The difference in projections for the 0.039 annual replacements per household served scenario from the proposed rule to the alternative scenario of 39 annual replacements per 1,000 households served in the final rule is due to the use of the One-Time Update to the Needs Survey results. Prior to the One-Time Update to the Needs Survey, several potential errors in the dataset had been documented, such as no response from New York City (who had documented the number of service lines of each type in their water system online) and the likely erroneous reporting of 200,000 LSLs in Houston, TX (Alkafaji, 2023). These issues were corrected in the One-Time Update to the Needs Survey data, in addition to other changes in responses from various systems and the addition of responses from other systems that did not respond previously (USEPA, 2024a). The updated data had only a minor effect on the low-bound estimate because unknown lines were assumed to be non-lead for the low-bound estimate and only changes in reported number of lead or GRR service lines caused changes in low estimates. The best estimate had more changes with the One-Time Update to the Needs data. For example, the removal of the 200,000 erroneously reported LSLs in Houston impacted every Texas system because unknown service lines were projected based on the percentage of reported lead and GRR service lines statewide (USEPA, 2023a). Removing 200,000 LSLs from the statewide pool reduced the State percentage of reported lines that were lead or GRR service lines, thus many unknown lines in Texas systems that were projected as lead or GRR service lines in the proposed rule are no longer projected as lead or GRR service lines in the final rule. Corrections and refinements such as these resulted in significantly fewer systems projected to exceed the specified eligibility thresholds in the final rule analysis.

Length of Deferred Deadlines

The EPA calculated the range of maximum length of the deferred deadlines for all systems with available data from the Needs Survey, including the One-Time Update, that would have to replace at least 39 service lines per 1,000 service connections per year, based upon the best-available estimate of the number of lead and GRR service lines. The calculated value does not take into account the potential for the State to set a faster rate where feasible upon regular check-ins with the State, therefore the actual deferred deadlines may be shorter than the maximum length. The maximum length in years of each system's deferred deadline was calculated by multiplying the number of service connections by 0.039 (equivalent to 39 replacements per 1,000 service connections). The total number of lead and GRR service lines was then divided by this value, in years, to determine the length of the deferred deadline for each system. Thus, for a given system, both the number of service connections and the number of lead and galvanized requiring service lines in the system are required to be known. For this reason, the length of deferred deadlines could only be calculated for systems included in the One-Time Update to the Needs Survey, and the EPA could not determine a reliable way to calculate the distribution of deferred deadline lengths among systems expected to be eligible. Since the Needs Survey aimed to capture a representative sample of systems nationwide, a similar distribution of deferred deadline lengths is expected for systems nationwide. Under the best estimate, a total of 64 out of the 3,412 surveyed CWSs would be eligible for a deferred deadline, providing a maximum deadline of 1 to 19 additional years to complete mandatory service line replacement. This range of deferred deadlines corresponds to a total maximum timeline to complete service line replacement ranging from 11 to 29 years. Most systems evaluated, however, that are eligible for a deferred deadline would be required to complete mandatory service line replacement in 15 or fewer years (59%). In the Needs Survey sample dataset, fewer systems serving 10,000 or fewer people were found to be eligible for deferred deadlines (n = 3, median = 15.4 years) than systems serving more than 10,000 people (n = 61, median = 13.4 years), however the small systems that were eligible had longer deadlines.

For any system which is aware of their number of service lines requiring replacement and service connections, the length of the deferred deadline can be determined by dividing the percentage of lines requiring replacement (number of lead and GRR service lines/total number of service connections) by 0.039 replacements per service connection. This calculation applies to systems of all sizes. Thus, for any system, the length of a potential deferred deadline available can be visualized in Exhibit 2.4.

Exhibit 2.4: Length of Deferred Deadline for a Generic System of Any Size with a Given Proportion of Service Lines Requiring Replacement



It is important to note that this calculation is based upon the listed number of service connections in SDWIS for each water system. The number of service connections in SDWIS was used to apply a consistent metric to all water systems but the number of service connections in SDWIS may not always be exactly equivalent to the number of service lines reported in a service line inventory, depending on characteristics of each individual water system. These discrepancies, however, are expected to be relatively small and impact a relatively limited subset of systems (e.g. only two systems from the Needs Survey dataset had more service lines requiring replacement than listed service connections in SDWIS).

The EPA expects that many systems that qualify for the deferred deadline are likely to replace service lines at a faster rate than shown in Exhibit 2.4 due to LCRI requirements and incentives, along with available funding and guidance/technical assistance.
Furthermore, States are required to regularly review and approve deferred deadline replacement rates and set a faster replacement rate for systems where feasible.

2.3 Removing the Proposed Threshold for Maximum Number of Annual Replacements

The EPA proposed a second pathway for water systems to defer their replacement deadline. If 10% of the total number of known lead and GRR service lines in a system's replacement pool is greater than 10,000 service lines (i.e. the system has more than 100,000 lead or galvanized requiring replacement lines), the system would be able to defer its replacement deadline such that it is not required to replace more than 10,000 service lines per year unless the State sets a shortened deadline. This pathway is not included in the final LCRI.

To evaluate the potential impacts of the 10,000 replacements per year threshold, the projections based upon the best estimates from the One-Time Update to the Needs Survey data were analyzed. The number of reported lead and GRR service lines, the number of unknown service lines, and the best estimate case (incorporating projected unknowns in the same manner as the above analysis) were all examined.

All systems from the Needs Survey dataset were examined, and all 32 water systems with a combined total of more than 100,000 lead, GRR, and unknown service lines are posted to the docket ("List of Large Systems.xlsx"). In the Needs Survey, the best estimate includes three water systems over 100,000 lead and GRR service lines. Two of these systems, Chicago, IL and Cleveland, OH, will qualify for a deferred deadline via exceedance of the 39 replacements per 1,000 service connections criteria. The remaining system, New York, NY, has a required replacements per year value less than 39 replacements per 1,000 service connections, and thus is expected to be feasible based on the EPA's feasibility analysis.

While the best estimate projection of Needs Survey systems accounts for unknown service lines based upon the percentage of service lines classified as lead or GRR at the State level, it is possible some systems have a higher rate of lead and GRR service line occurrence than the projected value. For this reason, the EPA examined the number of reported unknown service lines for each water system and calculated what percentage of remaining unknown service lines would have to be classified as a lead or GRR service line for each water system to exceed 100,000 lead and GRR service lines ("List of Large Systems.xlsx"). The percentage of unknowns classified as a lead or GRR service line to exceed 100,000 total lines requiring replacement ranged from 21% to 97% (average=61%).

2.4 Potential for Faster Replacement Rates in the Future

Several factors may facilitate accelerated service line replacement rates in the future that would not have been available for past replacement programs evaluated in the feasibility analysis. Therefore, it is possible that in the future systems may be able to replace service lines faster than the final LCRI's feasibility threshold. States are required to set a faster replacement rate where feasible for a system.

The EPA anticipates that as water systems and their contractors gain more experience conducting service line replacement, they are likely to become more efficient in conducting replacements and engaging with customers and therefore be able to complete them more quickly and using fewer resources. For example, Denver Water has released annual reports documenting the progress of their LSLR program since January 2020 and has documented key lessons learned to streamline the LSLR process in each reporting (Denver Water, 2023b). Over this time, LSLR conducted have increased from 5,287 in 2020 to 6,891 in 2023.

Advancements in service line replacement have been and are also expected to continue to be documented in various sources. Resources on replacing service lines, such as lessons learned from systems with proactive replacement plans or experiences implementing a new technology, are available from several sources to support systems to implement their replacement programs (see Appendix 2 for examples). These resources can help water systems save time and resources by providing information and best practices through the lessons learned from other systems. Similarly, as systems develop their service line inventories following the 2021 LCRR compliance date of October 16, 2024, and submission of initial inventories, availability on service line inventory information is likely to increase (see Appendix 3 for examples).

3 Feasibility of Service Line Inventory Requirement

The EPA analyzed service line inventory data from five States in which submission of service line inventories had been required, along with data from the Needs Survey, to evaluate progress made in past efforts to identify unknown service lines. Updated service line inventory data from Illinois and the data resulting from the One-Time Update of Needs Survey was available and incorporated into the final rule's feasibility analysis.

3.1 States with Service Line Inventory and Replacement Requirements

In 2016, both California and Ohio passed legislation requiring systems to develop LSL inventories, where Ohio required systems to submit a map identifying areas in the system that are known or likely to contain LSLs by 2017, and California required systems to compile an inventory of known lead user service lines[1] and likely lead user service lines by 2018 (California Legislature 2017; Voltzer, 2016). A 2019 survey conducted by 120Water received responses from 2,811 out of 4,402 CWSs and NTNCWSs in California and documented that only 8.7 percent of the service lines inventoried were classified as unknown (860,962 out of 9,852,421 lines) after three years of LSL investigations (Walker and Jacquette-Morrison, 2019). The 120Water survey also recorded that, by early 2020 in Ohio, 1,919 CWSs and NTNCWSs had submitted maps of areas known or likely to contain LSLs to the State even though the data itself was not publicly accessible[2] (Walker and Jacquette-Morrison, 2019).

In 2018, both Michigan and Wisconsin adopted rules requiring submission of an LSL inventory, both requiring initial submissions by 2020. The Wisconsin Public Service Commission published the results of the systems inventory data in 2020, in which only five percent of reported system-side service lines and six percent of reported customer-side service lines were characterized as unknown (Public Service Commission of Wisconsin, 2021). The Michigan Department of Environment, Great Lakes, and Energy (EGLE) also published inventory data in 2020, showing

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[1] California refers to a service line as a user service line. According to the California Code of Regulations (CCR), a user service line is the "pipe, tubing, and fittings connecting a water main to an individual water meter or service connection" (22 CCR § 64551.60). The definition of a lead user service line includes lead goosenecks or pigtails connected to the user service line on the water system side of the meter. This definition does not include the service line from the meter to individual homes (the customer side), so water systems can classify what is considered a partial LSL as a lead user service line.

[2] The Ohio Environmental Protection Agency created a webpage that hosts all maps submitted by systems: https://epa.ohio.gov/divisions-and-offices/drinking-and-ground-waters/reports-and-data/lead-lines-mapping. This webpage was last updated January 6, 2022, and includes 1,997 map entries.

44 percent of all service lines are listed as unknown across the state (Michigan Department of Environment, Great Lakes, and Energy, 2020). Of these 44 percent of unknown service lines, however, 25 percent of unknowns were reported as "unknown-likely not lead" and seven percent were reported as "unknown-likely lead. This indicates that systems have an indication of where LSLs and non-lead service lines may be located. The EPA notes all such lines would be considered unknown under the proposed LCRI.

The EPA is also aware of systems not required by their State who have worked to develop service line inventories, such as the following systems: the City of Grand Forks, ND; the City of Lincoln, NE; the City of Somerville, MA; the City of Troy Department of Public Utilities, NY; DC Water, DC; Marshfield Utilities, WI; Memphis Light, Gas, and Water, TN; Milwaukee Water Works, WI; Pittsburgh Water and Sewer Authority, PA; and Saint Paul Regional Water Services, MN (USEPA, 2023b; USEPA, 2024c).

Updated Inventory Information from Illinois Database

In 2017, Illinois passed a law that required CWSs to develop and submit a water distribution system material inventory (or service line inventory), to the Illinois Environmental Protection Agency (Illinois EPA) beginning in 2018 (Illinois Municipal Code 2017). In 2022, this law was repealed by a statewide LSLR regulation, which requires systems to identify all unknown lines by their applicable replacement deadline (between 15 and 50 years) (Illinois General Assembly 2021). The Illinois EPA posts system inventory progress to their website each, starting with 2017, and provides a downloadable dataset that contains the inventory data of each system. As of 2024, the State had received inventories from a total of 1,769 unique systems (Illinois EPA, 2022). Over five years of recorded data, the percentage of unknown service lines reported statewide decreased from 41% in 2017 to 16% in 2022 (Exhibit 3.1).

Exhibit 3.1: Summary of Remaining Unknown Service Lines in Service Line Inventories Submitted to Illinois EPA from 2017-2022

Year	Number of Systems Reporting	Percent Unknown-Statewide[1]	Percent Unknowns of Median System	Percent Unknowns of 75th Percentile System	Percent Unknowns of 90th Percentile System
2017	1,660	41% (41%)	5.8%	83%	100%
2018	1,750	28% (31%)	0%	61%	100%
2019	1,755	21% (29%)	0%	42%	97%
2020	1,757	21% (28%)	0%	39%	97%
2021	136	18% (20%)	0%	20%	73%
2022	1,430	16% (26%)	0%	14%	72%

[1]In 2018, systems were permitted to classify some unknowns as "Unknown-Not Lead." The statewide percent unknown is provided: not including these lines as unknown and (including "Unknown-Not Lead" with other unknowns).

Notably, in 2017, the year the service line inventory law was passed, the median percentage of unknown service lines remaining was 5.8%, indicating that many systems had already determined all or nearly all of the service line materials and completed or nearly completed their service line inventory. Additionally, even systems who did have unknown service lines at the start of the program were generally able to identify materials relatively quickly. The 75th percentile system, which had 83% of service lines characterized as unknown in 2017, was able to reduce the percentage of unknowns remaining by 69%, down to only 14% remaining in 2022. Thus, for most systems, more than half of remaining unknown service lines were able to be identified within the first 4 years of service line identification efforts. Further, Illinois data as of 2022 does not represent final inventories (which are not due according to Illinois State law until 2024), and thus some systems had not yet begun identifying service lines, but unknown service lines in these systems are still included in these statistics. Analysis of data at the individual system level shows that many systems have already made substantial progress on their inventories and achieved substantial rates of service line material identification. For example, the median system in Illinois had zero percent of unknown lines reported in 2018, which is only one year after the previous inventorying law went into effect. Thus, more than half of all systems identified all their remaining unknown service lines within the first year. This shows that in Illinois, one of the states with the highest estimated number of LSLs, the median system has already determined the material of all their service lines. This suggests that water system records for the many systems are available, and prior identification work may have taken place. Additionally, analysis of the number of systems with unknown service lines remaining in 2022, the deadline for the Illinois initial inventory, can provide the best available approximation of the number of unknown service lines expected to remain nationally following the 2021 LCRR initial inventory. At the Illinois initial inventory deadline in 2022, only 44 of the 1,430 (3.1%) systems reporting service line inventories in 2022 had not yet begun identifying service lines and half of reporting systems had zero unknown service lines remaining. Of these 44 systems, 40 were small systems, however these systems represented only 3.6% of all small systems. For the LCRI, the analysis of eligibility for deferred deadlines will not occur until the LCRI compliance date in 2027, three years after the due date for the LCRR initial inventory in 2024. Thus, these statistics from Illinois, which are comparable to the LCRR initial inventory, do not account for the same amount of time for unknown investigation that will occur prior to the LCRI compliance date and LCRI baseline inventory due date used for deferred deadline eligibility. Therefore, the vast majority of systems of all sizes had made progress identifying unknown service lines by the initial inventory deadline in Illinois and would have several additional years for service line identification prior to the point where eligibility for deferred deadlines would be evaluated.

3.2 Updated Inventory Information from the Needs Survey to Inform Inventory Development Feasibility

The 7th Drinking Water Infrastructure Needs Survey and Assessment (or Needs Survey) was administered by the EPA in 2021, followed by a one-time update to the data collected in 2023 (USEPA, 2024a). The Needs Survey provides data to evaluate service line materials nationwide. The EPA utilized the more recent 2023 data to update the 2021 data and determine the progress of service line inventories as of 2023.

For the purposes of this analysis, the EPA evaluated responses from 3,588 water systems, representing 1,786 from systems serving 10,000 or more people, 1,626 systems serving fewer than 10,000 people, 126 non-community water systems, and 50 systems which were not able to be mapped to SDWIS information. While the Needs Survey is nationally representative across system sizes due to the random selection of water systems serving fewer than 100,000 people to be surveyed, there is a higher degree of uncertainty in applying service line information to non-surveyed systems serving fewer than 10,000 people. This is due to the relatively larger number of systems serving 10,000 or fewer people (approximately 45,000 in SDWIS) compared to those serving 10,000 or more people (approximately 4,500 in SDWIS).

Of the 3,412 community water systems with available data in the 2023 data, the median system had 65% of service lines reported as a known material, leaving 35% of service lines not classified. This 35% of lines without a known material type includes responses from 760 systems (22%) that did not report the composition of any service lines in their survey response. Of the 2,652 systems who reported the status of at least one service line, the median system had only 6.5% of service lines categorized as unknown (Exhibit 2.2). This suggests that, for most systems who have started their service line identification programs as of 2023, service line records are available or other methods are being effectively used. It is important to note that the one-time update was collected in 2023, one year before the 2021 LCRR initial inventory deadline, and thus systems with many remaining unknowns may still begin identifying unknowns in their service line inventory prior to the 2021 LCRR initial inventory deadline in 2024. Thus, this analysis is likely an overestimate the number of unknown service lines which will remain after all systems have completed their initial inventories.

EXHIBIT 3.2: SUMMARY OF REMAINING PERCENTAGE OF SERVICE LINES CLASSIFIED AS "UNKNOWN" FROM THE 2023 EPA NEEDS SURVEY ONE-TIME UPDATE AMONG SYSTEMS REPORTING SERVICE LINE MATERIALS

System Size	Percent Unknown of Median System	Percent Unknown of 75th percentile system	Number of Systems Not Reporting Any Lines
Serving < 10,000 persons (n=1,626)	0%	93%	443[A]
Serving >10,000 persons (n=1,786)	13%	79%	317[B]
All systems (n=3,412)	6.5%	84%	760

[A]An additional 258 systems reported entirely unknown service lines
[B]An additional 234 systems reported entirely unknown service lines.
Data was received in December 2022 and one-time update was collected in fall 2023.

While the median system serving fewer than 10,000 people had identified all of their unknown lines, there were also relatively more systems serving fewer than 10,000 people who reported entirely unknown service lines and who did not report any lines. (Exhibit 3.2). This could be due to the relatively fewer number of lines to identify in systems serving fewer than 10,000 people. In other words, systems serving fewer than 10,000 people were more likely to have finished their programs, however systems serving more than 10,000 people were more likely to have programs that have been started and are currently in progress. Additionally, the percentage of remaining unknowns in Exhibit 3.2 was determined by excluding systems which did not report any service lines but including any systems which reported entirely unknown service lines. This was done to reflect the difference between systems that didn't respond to the survey and those that did respond to indicate they had not yet begun identifying unknowns. In either case however, the

EPA expects that progress will be made prior to the 2021 LCRR initial inventory 2024 deadline and further progress prior to the 2027 LCRI compliance date.

The data show that in all States in which LSL inventories were required (CA, OH, IL, MI, WI), which represent the states with among the highest counts of LSLs in the nation (USEPA, 2024a), no more than 50 percent of all lines in the state were classified as unknown within two years of the requirement (See "Michigan LSLR Analysis.xlsx", "New Jersey LSLR Analysis.xlsx", "Illinois Downloaded Inventory Analysis.xlsx" in EPA-HQ-OW-2022-0801). This suggests that initial records of service line material were robust, and that any service line material investigations that have taken place, have resulted in the majority of service line materials having been identified.

3.3 Systems with Completed LSLR Programs

The EPA is aware of several water systems who have fully replaced LSLs from their distribution systems. Replacing all LSLs requires an inventory where all unknowns have been identified; therefore, analysis of completed LSLR programs can provide information about a feasible timeline that systems were able to identify the material of all unknown service lines in their distribution systems. Exhibit 3.3 includes data about system LSLR programs which have completed their replacement programs and have thus identified all unknown lines.

EXHIBIT 3.3: WATER SYSTEMS WITH COMPLETED LSLR PROGRAMS

City	State	Population	Total Number of LSL/GRR	% of Total SLs	Duration of LSLR Program	Avg. # Replaced Per Year (% of Total LSL/GRR)
Tucson	AZ	675,686	600	0.31%	2016 to 2018	47 (7%)
Newark	NJ	294,274	23,189	64%	2019 to 2022	7,730 (33%)
Spokane	WA	244,817	486	0.60%	2016 to 2018	162 (33%)
Lansing	MI	166,000	12,150	22%	2004 to 2016	1,013 (8%)
Green Bay	WI	107,395	2,028	5%	Jan 2016 to Sep 2020	357 (18%)
Newton	MA	89,103	433	1.7%	2017-2019	144 (33%)
Framingham	MA	72,362	184	1.08%	2004-2016	1 (1%)
Madison	WI	71,160	8,000	9%	2000 to 2011	727 (9%)
Village of Montgomery	IL	28,956	106	1.20%	Fall 2019 to Summer 2020	106 (100%)
Norwood	MA	28,284	200	2.2%	2004-2008	40 (20%)
Winchester	MA	22,800	21	0.29%	Mar 2017 to 2019	7 (33%)
Frankfort	IL	20,296	82	0.70%	2021-2022	41 (50%)
Menasha	WI	14,792	636	12%	2017 to 2023	127 (20%)
Stoughton	WI	13,078	700	14%	2021	700 (100%)
Mayville	WI	5,112	220	12%	2021	220 (100%)

The data shows that a range of systems have completed LSLR programs thus identified all unknowns. The EPA notes that systems such as Tuscon, AZ, and Spokane, WA, despite having relatively few LSLs at the start of their replacement program, are nevertheless strong indicators of inventory feasibility because the total number of service lines in the distribution system is more relevant to completing an inventory than the number of LSLs because the proposed LCRI requires systems to identify the material of all service lines. While Madison, WI, and Lansing, MI, took longer than the10-year deadline to complete both their inventory and replacement program (i.e., approximately 11 years for Madison and 12 years for Lansing), the EPA does not interpret these or other examples of systems completing LSLR in over 10 years as evidence that a 10-year deadline is necessarily infeasible. The agency is not aware that these systems were necessarily replacing service lines in accordance with the SDWA requirement to “prevent known or anticipated adverse health effects to the extent feasible” as is required of the LCRI, per SDWA. Additionally, these systems initiated their LSLR and inventorying simultaneously, while the LCRR initial inventory deadline in 2024 will give systems a head start prior to beginning the LCRI replacement requirements. In addition, the EPA’s inventory guidance (USEPA 2022), BIL funding towards LSL identification and replacement, as well as new and emerging technologies to identify service line materials may contribute to significant inventory development for many systems.

3.4 Additional Opportunities for Inventory Development

In systems with remaining unknown lines to investigate, the EPA notes that routine water system activities or emergency repairs provide opportunities to identify unknowns in the course of normal operations. Water meters are generally replaced after 15 to 20 years (City of Pasadena, n.d.; Stubbart, 2003); although, the EPA has found information suggesting their replacement may be as frequent as eight years (Vollrath 2015). This information suggests that approximately five percent (replacing all meters every 20 years = 100 percent/20 years) to 12.5 percent (100 percent/8 years) of a system’s meters will be replaced annually, which presents a substantial opportunity for service line materials to be encountered and inventoried, although materials are not guaranteed to be encountered during each meter replacement. Replacement of water mains has been documented between 0.8 percent and two percent per year, presenting additional opportunities to identify the material of the connected service lines (Folkman, 2018). This rate could also potentially to increase in coming years, as 82 percent of cast iron water mains are over 50 years old and seeing increasing rates of the need for emergency repairs (Folkman, 2018). Overall, through routine infrastructure work and emergency-repair activities, water systems could be expected to encounter up to six percent to eight percent of their service lines each year. Thus, systems may have the potential to encounter between 60 percent and 80 percent of their service lines within the 10-year replacement deadline, outside of any activities dedicated solely to service line material identification.

3.5 Determination of the Inventory Validation Pool and Minimum Number of Validations Required

For the final LCRI, the EPA requires water systems to validate the methods used to categorize service lines as "non-lead" in their inventories. Water systems must populate a validation pool of non-lead service lines from their inventories, excluding non-lead service lines categorized through (1) records showing the line was installed after June 19, 1986, the date their States or local communities adopted standards or plumbing codes that meet the definition of lead free in accordance with SDWA section 1417, (2) visual inspection of the pipe exterior at a minimum of two points, or (3) previously replaced lead or GRR service lines are excluded from the validation pool.

Water systems will then validate a subset of non-lead service lines from the validation pool through visual inspection of at least two points of the pipe exterior to reach a 95 percent confidence level, so the results of this inventory validation are representative of the entire validation pool. The determination of the "subset" of service lines (or the sample size) for the validation pool is determined using a similar methodology to the methodology developed by the Michigan Department of Environment, Great Lakes, and Energy (Michigan EGLE, 2021). Specifically, this method utilizes a test of proportions to determine the proportion of a population (in this case, the validation pool size) that meets a given criteria (in this case, that the service line is validated as non-lead) by sampling only some subset of this population. For example, if a system visually inspected 100 non-lead lines, and 98 were confirmed to be non-lead, while the other two lines were found to be lead or GRR service lines, the proportion of lines verified as non-lead would be 98 out of 100. However, if the entire validation pool of that system consisted of 10,000 non-lead lines, then only sampling 100 lines is not be enough to achieve a 95 percent confidence level to ensure that the observed results are representative, and it would be possible that the proportion of lines validated as non-lead could be different if the system instead inspected a larger subset (i.e., 300, 1,000, 5,000) of their 10,000 lines. Therefore, a statistical test is needed to determine the minimum number, out of the 10,000 lines, that the system would need to validate to achieve a 95 percent confidence level, so the proportion of lines validated as non-lead in their sample is representative of the entire validation pool.

The following information is included in this technical support document to provide clarification on the inventory validation calculations, specifically what data was used to determine the expected sample proportion, what the relevant comparison is between the number of validations required and the validation pool (and what is significance of that comparison), and where the agency derived its formulas for determining the appropriate sample size (as well as to provide citations).

To determine the minimum number of validations required for a certain validation pool size, the EPA derived formulas from the methodology used to determine the sample size for estimating means from chapters 5.3, 6.7, and 6.8 in the textbook, "Biostatistics: A Foundation for Analysis in the Health Sciences, tenth edition" (Daniel and Cross, 2013). Online sample size calculators (Select Statistical Services, n.d.) and other EPA materials (USEPA, 1997) have used similar methodologies (Cochran, 1977). The following information walks through the determination of the sample size for estimating means and proportions from the textbook and how the EPA simplified and applied those formulas to the inventory validation calculations.

Determining the sample size for estimating means (chapter 6.7, Daniel and Cross, 2013)
The EPA utilizes a method for determining the sample size, n, required for estimating a population mean, which is applied to the case of sample size determination when the parameter to be estimated is a population proportion.

The objectives in interval estimation are to obtain narrow intervals with high reliability. First, the width of the interval is determined by looking at the components of a confidence interval:

$$(reliability\ coefficient) \times (standard\ error\ of\ the\ estimator)$$

since the total width of the interval is twice this amount. This quantity is referred to as the precision of the estimate or the margin of error. For a given standard error, when reliability is increases, the reliability coefficient becomes larger. However, a larger reliability coefficient for a fixed standard error makes for a wider interval. On the other hand, by fixing the reliability coefficient, the only way to reduce the width of the interval is to reduce the standard error. The standard error is equal to $\sigma/\sqrt{n}$. Since σ (the population standard deviation) is a constant, the only way to obtain a small standard error is to take a large sample. How large of a sample depends on the size of σ, the desired degree of reliability, and the desired interval width. For an interval that extends *d* units on either side of the estimator:

$$d = (reliability\ coefficient) \times (standard\ error\ of\ the\ estimator)$$

For sampling with replacement from an infinite population, or from a population that is large enough to ignore the finite population correction:

$$d = z \times \frac{\sigma}{\sqrt{n}}$$

where *z* is the value for a normal distribution. When solved for *n*:

$$n = \frac{z^2\sigma^2}{d^2}$$

For sampling without replacement from a small, finite population, the finite population correction is required:

$$d = z\frac{\sigma}{\sqrt{n}}\sqrt{\frac{N-n}{N-1}}$$

where *N* is the finite population. When solved for *n*:

$$n = \frac{Nz^2\sigma^2}{d^2(N-1) + z^2\sigma^2}$$

The formulas for sample size require knowledge of σ^2 (or the population variance). However, the population variance is, as a rule, unknown. Therefore, σ^2 must be estimated.

Finite population correction (chapter 5.3, Daniel and Cross, 2013)
As seen above, for sampling without replacement from a finite population, the finite population correction is required. The finite population correction factor is $\frac{(N-n)}{(N-1)}$ and can be ignored when the sample size is small in comparison with the population size. When the population is much larger than the sample, the difference between σ^2/n and $\left(\frac{\sigma^2}{n}\right)\left[\frac{N-n}{N-1}\right]$ will be negligible. The finite population correction is not used unless the sample is more than 5% of the size of the population. That is, the finite population correction is typically ignored when $n/N \leq 0.05$.

Determining sample size for estimating proportions (chapter 6.8, Daniel and Cross, 2013)
The method of sample size determination when a population proportion is to be estimated utilizes the same method that described for estimating a population mean. One-half of the desired interval, *d*, may be set equal to the product of the reliability coefficient and the standard error.

It is assumed that random sampling and conditions permitting approximate normality of the distribution of $\hat{p}$ leads to the following formula for *n* when sampling is with replacement from an infinite population, or when the sampled population is large enough that the finite population correction can be ignored:

$$n = \frac{z^2pq}{d^2}$$

where $q = 1 - p$, and *p* is the sample proportion. If the finite population correction cannot be disregarded, the proper formula for *n* is as follows:

$$n = \frac{Nz^2pq}{d^2(N-1) + z^2pq}$$

Both formulas require knowledge of *p*. Since this is the parameter that the EPA is trying to estimate, it will be unknown. One solution is to take a pilot sample and compute an estimate to be used in place of *p* in the formula for *n*. Sometimes, an investigator will have some notion of an upper bound for *p* that can be used in the formula. If it is impossible to come up with a better estimate, set *p* equal to 0.5, and solve for *n*. Since $p = 0.5$ in the formula yields the maximum value of *n*, this procedure will give a large enough sample for the desired reliability and interval width. However, it may be larger than needed and utilize more resources during sampling than if a better estimate of *p* had been available. This procedure is used only if a better estimate of *p* is unavailable.

Simplifying the determination of the sample size for a finite population when the population proportion is estimated

Start with the formula for sample size *n* for sampling without replacement for a finite population as derived above.

$$n = \frac{Nz^2pq}{d^2(N-1) + z^2pq}$$

Multiply the numerator and denominator by d^2.

$$n = \frac{Nz^2pq}{d^2(N-1) + z^2pq} \times \frac{d^2}{d^2}$$

Substitute *X* (denoted as *X* instead of *n* to reduce confusion) for a sample size for sampling with replacement from an infinite population.

$$n = \frac{NXd^2}{d^2(N-1) + z^2pq}$$

Rearrange the formula.

$$\frac{d^2(N-1) + z^2pq}{d^2} = \frac{NX}{n}$$

Simply the left side of the formula.

$$\frac{d^2(N-1)}{d^2} + \frac{z^2pq}{d^2} = \frac{NX}{n}$$

$$(N-1) + X = \frac{NX}{n}$$

Solve for *n*.

$$n = \frac{NX}{X + N - 1}$$

Where, as mentioned above, *X* is the formula for a sample size for sampling with replacement from an infinite population:

$$X = \frac{z^2pq}{d^2}$$

Connecting the sample size for a finite population when the population proportion is estimated to the minimum number of validations required

To calculate the minimum number of samples required to achieve a 95 percent confidence level, the simplified formula for calculating the sample size *n* for a finite population when the population proportion is estimated is used:

Equation 1. $$n = \frac{N \times X}{X + N - 1}$$

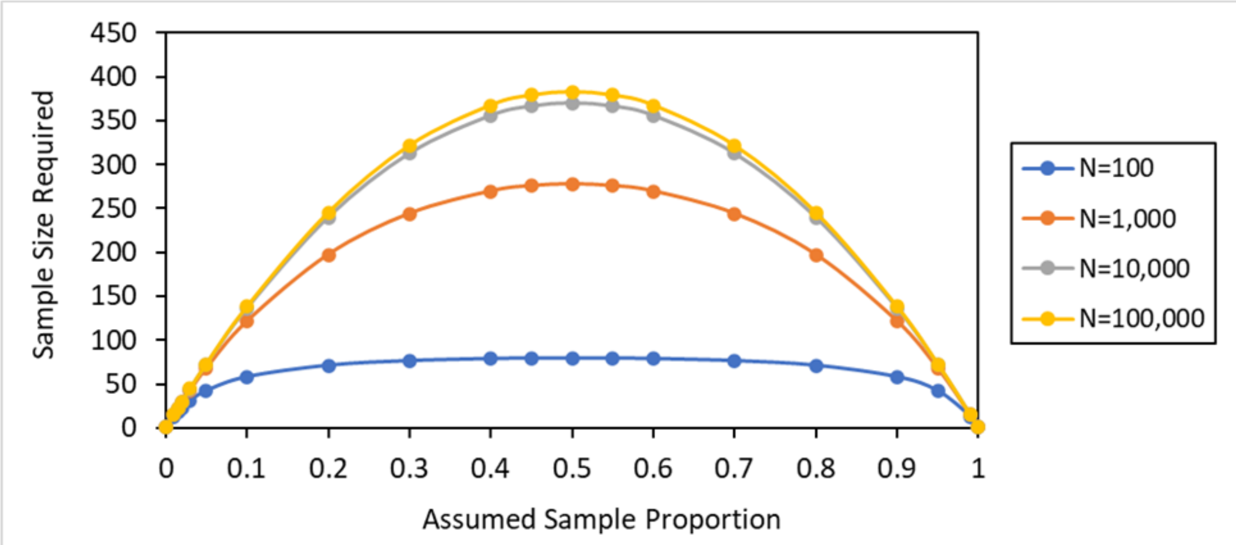
Where *N* is the size of the validation pool, and *X* is the sample size for an infinite population. *X* is further calculated through Equation 2:

Equation 2. $$X = \frac{Z^2_{\frac{\alpha}{2}} \times p \times (1-p)}{(MOE)^2} = 384.16$$

The EPA assumes sampling follows a normal distribution and specifies the confidence level of 95 percent, which means the value from the standard normal distribution at this confidence (*z*) is a constant value of 1.96. The precision of the estimate or margin of error, *d*, (denoted as "MOE") is also already specified at 0.05 (5%), and the validation pool size (*N*) is calculated based on summing the total number of non-lead service lines eligible for validation. Therefore, once the sample pool is established, the only remaining unspecified variable is the estimate of the sample proportion (*p*).

In the Michigan EGLE method, the sample proportion is assumed to be 50%, meaning that 50% of the non-lead service lines investigated are expected to be confirmed as non-lead. In practice, this proportion will most likely be much higher since most non-lead lines will end up being confirmed as non-lead. However, as Daniel and Cross (2013) noted, an assumption of 0.50 provides the most conservative (or largest) sample size, meaning that any system validating this number of lines will be guaranteed to have met or exceeded the minimum number for statistical significance regardless of the true sample proportion. The EPA assumes a sample proportion of 0.50 because the agency does not have sufficient data to estimate a sample proportion specific to discovering a non-lead service line as a lead or GRR service line and, therefore, used a conservative sample proportion to ensure the minimum number of validations required is statistically significant in all systems nationwide regardless of the possibility for a more precise sample proportion at an individual system's level. The procedure of using a sample proportion of 0.5 is used when one cannot arrive at a better estimate (Daniel and Cross, 2013). It is also important to note that, although a sample proportion of 0.5 may overestimate the sample size, since these equations are based on interval estimation and do not take into account power, some of the equations used may also underestimate the necessary sample size (Kupper and Hafner, 1989).

Exhibit 3.4: Sample size required for a system with varying validation pool sizes to achieve 95% confidence in the validation with varying assumptions of the sample proportion.



Flexibility for small systems with the minimum number of validations required

Similar to the Michigan EGLE method, both the proposed and final rules provide a flexibility for systems with fewer than 1,500 non-lead lines in their validation pool to only be required to validate 20 percent of their eligible non-lead lines rather than the number required for statistical significance. This provision is designed primarily for small systems for whom a 95 percent confidence level may not be technically possible given possible staffing limitations and burden associated with simultaneously complying with other parts of the LCRI as well as the increased proportion of validations smaller systems would be required to complete compared to larger systems. For example, at a 95 percent confidence level, a system with a validation pool of 100 lines would be required to validate 80 lines (80 percent of validation pool) to achieve statistical significance, whereas a system with a validation pool of 10,000 lines would be required to validate only 370 of them (3.7 percent) (Exhibit 3.4).

Display of the minimum number of validations required in tabular form

To decrease rule complexity and ease compliance tracking, in the final LCRI, the EPA presents the validation requirements in tabular form rather than as an equation (Exhibit 3.5). In this way, each individual system will not calculate their specific number of validations; they only need to establish the size of their validation pool and conduct the corresponding number of validations specified in the table. The size of increments in the table were chosen to ensure that the number of validations required would be no greater than 10 away from the number required to achieve a 95 percent confidence level. Thus, as the validation pool increases in size, the additional number of validations required increases, and larger differences between rows are employed (i.e., the first row only captures sizes from 1,500 to 2,000, whereas the last rows capture all systems from 10,001 to 50,000 or greater than 50,000).

Exhibit 3.5: Number of validations required based on the validation pool size

Size of Validation Pool	Number of Validations Required
Fewer than 1,500	20 percent of validation pool

Size of Validation Pool	Number of Validations Required
1,500-2,000	322
2,001-3,000	341
3,001-4,000	351
4,001-6,000	361
6,001-10,000	371
10,001-50,000	381
More than 50,000	384

4 Supporting Information for the Lead Action Level Analysis

In the final LCRI, the EPA used data from the 6,551 community water systems of all sizes with known corrosion control treatment (CCT) and lead service line (LSL) status and reported 90th lead percentile values in EPA's Safe Drinking Water Information System (SDWIS) from 2012-2020. The EPA used this data to evaluate a range of action level alternatives for the final LCRI that are generally representative of OCCT (see section IV.F.4 of the final LCRI preamble for details). The EPA updated the number of systems from 6,529 to 6,551 from the proposed to the final LCRI. Under the proposed LCRI, 6,529 systems with known CCT and LSL status and reported 90th percentile values were evaluated but the agency was able to include an additional 22 systems with known LSL status based on additional data through the one-time update to the 7th Drinking Water Infrastructure Needs Survey and Assessment from May 2024.

The LCRI includes new tap sampling requirements that are likely to result in higher 90th percentile lead levels compared to the LCR. To account for differences in the tap sampling requirements under the LCR and the LCRI, the lead 90th percentile data was adjusted using a multiplier approach. Specifically, the EPA adjusted for the requirement for systems with lead service lines to collect all samples at lead service line sites, and to collect and use the higher lead concentration of the first- and fifth-liter samples at each lead service line site in the 90th percentile calculation. The EPA found that these 6,551 systems are representative of water systems nationally. See sections 3.3.3-3.3.5 of the final LCRI Economic Analysis (USEPA, 2024b) for additional information about how the EPA identified these systems and their CCT and LSL status, details about the multiplier approach, representativeness of the data nationally, and the associated uncertainties.
To further inform whether the level of 0.010 mg/L supports the action level's purpose of addressing the technical feasibility for the CCT treatment technique, in the proposed LCRI the EPA estimated what percentage of CWSs are likely to exceed various potential action levels nationally. The EPA conducted this analysis to illustrate the estimated percentages of systems that would be required to make a detailed OCCT demonstrations, which could require more effort and resources from systems, and therefore, States (see Exhibit 3, 88 FR 84941, USEPA, 2023b). For the final LCRI, the EPA is updating the analysis presented at proposal and including

an additional analysis to clarify how these values were calculated and correspond to the analysis presented in the final LCRI preamble (see Exhibit 2 in the final LCRI preamble). The EPA used the 6,551 systems grouped by system size and CCT and LSL status characteristics for these analyses. The additional analysis and updated data presented here do not support an alternate conclusion from the LCRI proposal.

To further inform the selection of an action level that is representative of OCCT, the EPA evaluated the 6,551 systems grouped by CCT and LSL status and estimated the percentage of systems that would meet each level (see Exhibit 2, section IV.F.4 of the final LCRI preamble). For the final LCRI, the EPA evaluated the 6,551 systems grouped by LSL and CCT status to clarify how the estimates of percentages of systems that would be required to conduct CCT demonstrations correspond to Exhibit 2 in the final LCRI preamble (Exhibit 4.1).

Exhibit 4.1: Percent of CWSs in Each Size Category Estimated to Have 90th Percentile Lead Levels Exceeding 0.015 mg/L, 0.010 mg/L, and 0.005 mg/L by System Size Under the Final LCRI

P90[1]	System Size	LSL and CCT Status				Total (n=6,551)[1]
		No LSL/ CCT (n=2,062)[1]	**LSL/ CCT** (n=1,277)[1]	**No LSL/ No CCT** (n=2,731)[1]	**LSL/ No CCT** (n=481)[1]	
0.015 mg/L	< 3,300 (40,113 systems)[2]	4.1%	4.5%	4.3%	8.9%	4.6%
	3,301– 10,000 (5,026)[2]	0.7%	5.5%	0.2%	6.0%	1.8%
	10,001 – 50,000 (3,374)[2]	0.0%	9.9%	0.1%	5.4%	2.4%
	> 50,000 (1,016)[2]	0.1%	6.7%	0.0%	0.0%	1.4%
	TOTAL (49,529)[2]	**5.0%**	**26.7%**	**4.6%**	**20.4%**	**10.2%**
0.010 mg/L	< 3,300	6.0%	5.4%	8.3%	14.8%	7.5%
	3,301– 10,000	1.3%	8.5%	0.7%	10.4%	3.1%
	10,001 – 50,000	0.3%	16.4%	0.2%	10.4%	4.2%
	> 50,000	0.2%	9.7%	0.0%	0.0%	2.0%
	TOTAL	**7.9%**	**40.1%**	**9.3%**	**35.6%**	**16.8%**
0.005 mg/L	< 3,300	10.8%	7.1%	18.5%	23.3%	14.2%
	3,301– 10,000	3.7%	13.2%	2.6%	18.9%	6.2%
	10,001 – 50,000	2.2%	25.1%	1.0%	21.0%	7.5%
	> 50,000	1.5%	17.1%	0.0%[3]	0.0%[3]	3.8%
	TOTAL	**18.1%**	**62.5%**	**22.2%**	**63.2%**	**31.8%**

Notes:
[1] Data from 6,551 community water systems with known CCT and LSL status used in the analysis. See "Analysis of reported 90th percentile values from 2012-2020 for final LCRI.xlsx" in EPA-HQ-OW-2022-0801. Systems categorized based on their highest P90 value reported (SDWIS 2012–2020).
2Total number of CWSs in each size category nationally as reported to SDWIS in fourth quarter 2020. See USEPA, 2024b, Chapter 3, Exhibit 3-2. The data used in the analysis was determined to represent systems nationally (see USEPA, 2024b, Chapter 3, section 3.3.5.1.3). The total number of systems in each size category is included to inform the impact to all systems in each size category.
[3]Systems serving > 50,000 people without CCT must have 90th percentile levels below 0.005 mg/L in accordance with § 141.82(b)(3) under the LCR.

Exhibit 4.1 shows the percent of systems in each LSL and CCT status category estimated to have 90th percentile values (P90) exceeding the evaluated levels of 0.015 mg/L, 0.010 mg/L, and 0.005 mg/L as adjusted for the final LCRI tap sampling requirements. The LSL and CCT status headings include the number of systems in each of the categories evaluated. The number of systems in each size category nationally are also provided for reference to inform the potential national impact of each of the action levels evaluated (see above discussion on the representativeness of the data evaluated nationally). The bolded values in the rows labeled "total" represent the percent of systems in each column that exceed the various P90 values. For example, 26.7 percent of LSL and CCT systems exceed 0.015 mg/L. This is the inverse of the percentage of CCT and LSL systems that meet 0.015 mg/L in Exhibit 2 in section IV.F.4 of the LCRI preamble after rounding (73.3 percent). Exhibit 4.1 shows the percent of systems within a specific LSL and CCT size category that exceed a P90 and are systems of a given size (e.g., X percent of systems with CCT and LSLs exceed 0.005 mg/L and are systems serving < 3,300 persons). In other words, within each LSL and CCT status category, the percent of systems that are expected to exceed the action levels evaluated and belong to a system size category are shown. Therefore, the percentage of exceedances across system sizes for each P90 level evaluated adds up to the total exceedance percentage for each CCT and LSL status category (i.e., the bolded values). These non-bolded percentages can be used to identify which system size categories have the greater number of system exceedances in each LSL and CCT status group. The EPA presented a similar analysis to Exhibit 4.1 in the LCRI proposal using the same data but based on system size category instead of CCT and LSL status (Exhibit 3, 88 FR 84941, USEPA, 2023b). The EPA included this analysis at proposal because the discussion of technical factors related to CCT feasibility are explained based on system size rather than LSL and CCT status. While the EPA is including Exhibit 4.1 in the final LCRI to clarify interpretation of the data relative to Exhibit 2 in the final LCRI preamble, the EPA also updated the analysis presented in the proposed LCRI using the 6,551 systems for completeness and transparency. Exhibit 4.2 does not offer different conclusions to Exhibit 4.1, but the values differ because the percentages are based on the number of systems in each system size category rather than LSL and CCT status group. Exhibit 4.2 shows the percentage of each system size category estimated to have P90 values exceeding the evaluated levels of 0.015 mg/L, 0.010 mg/L, and 0.005 mg/L by LSL and CCT status as adjusted for the final LCRI tap sampling requirements. Similar to Exhibit 4.1, the number of systems evaluated in each size category are included along with the number of systems in each size category nationally for reference. Each bolded row shows the percent of systems in each size category that exceed each P90. Within each size category, the percent of systems that are estimated to exceed the action levels evaluated and have a specific CCT and LSL status are shown. As in Exhibit 4.1, the EPA is clarifying that the non-bolded values do not represent the percentage of the subset of systems exceeding each P90 value by CCT and LSL status (e.g., X percent of the systems serving < 3,300 persons that exceed 0.005 mg/L are CCT and LSL systems, but rather X percent of systems serving < 3,300 persons exceed 0.005 mg/L and are CCT and LSL systems). Therefore, the percentage of exceedances across each LSL and CCT status group for each P90 level evaluated adds up to the total exceedance percentage for each system size category (i.e., the bolded values).

EXHIBIT 4.2: PERCENT OF CWSS IN EACH SIZE CATEGORY ESTIMATED TO HAVE 90TH PERCENTILE LEAD LEVELS EXCEEDING 0.015 MG/L, 0.010 MG/L, AND 0.005 MG/L BY LSL AND CCT STATUS UNDER THE FINAL LCRI

P90	LSL and CCT Status	System Size				Total n=6,551[1] (49,529 systems)[2]
		< 3,300 n=3,798[1] (40,113 systems)[2]	3,301–10,000 n=1,121[1] (5,026 systems)[2]	10,001–50,000 n= 1,099[1] (3,374 systems)[2]	> 50,000 n=533[1] (1,016 systems)[2]	
0.015 mg/L	No LSL/No CCT	3.1%	0.5%	0.2%	0.0%	1.9%
	No LSL/CCT	2.2%	1.3%	0.1%	0.6%	1.6%
	LSL/No CCT	1.1%	2.6%	2.4%	0.0%	1.5%
	LSL/CCT	1.5%	6.2%	11.6%	16.1%	5.2%
	TOTAL	**8.0%**	**10.7%**	**14.2%**	**16.7%**	**10.2%**
0.010 mg/L	No LSL/No CCT	6.0%	1.7%	0.5%	0.0%	3.9%
	No LSL/CCT	3.3%	2.4%	0.6%	0.9%	2.5%
	LSL/No CCT	1.9%	4.5%	4.5%	0.0%	2.6%
	LSL/CCT	1.8%	9.7%	19.1%	23.3%	7.8%
	TOTAL	**13.0%**	**18.3%**	**24.8%**	**24.2%**	**16.8%**
0.005 mg/L	No LSL/No CCT	13.3%	6.4%	2.5%	0.0%[3]	9.2%
	No LSL/CCT	5.9%	6.8%	4.1%	5.6%	5.7%
	LSL/No CCT	2.9%	8.1%	9.2%	0.0%[3]	4.6%
	LSL/CCT	2.4%	15.1%	29.1%	40.9%	12.2%
	TOTAL	**24.5%**	**36.4%**	**44.9%**	**46.5%**	**31.8%**

Notes:

[1] Data from 6,551 community water systems with known CCT and LSL status used in the analysis. See "Analysis of reported 90th percentile values from 2012-2020 for final LCRI.xlsx" in EPA-HQ-OW-2022-0801. Systems categorized based on their highest P90 value reported (SDWIS 2012–2020).

[2] Total number of CWSs in each size category nationally as reported to SDWIS in fourth quarter 2020. See USEPA, 2024b, Chapter 3, Exhibit 3-2. The data used in the analysis was determined to represent systems nationally (see USEPA, 2024b, Chapter 3, section 3.3.5.1.3). The total number of systems in each size category is included to inform the impact to all systems in each size category.

[3] Systems serving > 50,000 people without CCT must have 90th percentile levels below 0.005 mg/L in accordance with § 141.82(b)(3) under the LCR.

Appendices

Appendix 1.0: List of references for service line replacement data from Exhibit 2.1

City	State	Citation in References
Cleveland	OH	City of Cleveland LCRI Public Comment
Denver	CO	Denver Water, 2023a
Fort Worth	TX	Fort Worth, n.d.
Louisville	KY	Louisville Water Company LCRI Public Comment
Cincinnati	OH	Greater Cincinnati Water Works, 2023
Detroit	MI	City of Detroit, n.d.
Tucson	AZ	City of Tucson, 2019
Washington	DC	DC Water, 2023
Pittsburgh	PA	Pittsburgh Water and Sewer Authority, n.d.
Central Arkansas Water	AR	Sweeney, 2020
Saskatoon	Canada	City of Saskatoon, n.d.
Newark	NJ	City of Newark, n.d.
Grand Rapids	MI	City of Grand Rapids, 2022
Spokane	WA	Feist, 2018
Trenton	NJ	Trenton Water Works, n.d.
Aurora	IL	IEPA, 2022
Sioux Falls	SD	Kelley, 2017
York	PA	The York Water Company, 2023
Kalamazoo	MI	City of Kalamazoo, 2023
Lansing	MI	Lansing Board of Water and Light, n.d.
Lancaster	PA	City of Lancaster LCRI Public Comment
Elgin	IL	IEPA, 2022
Green Bay	WI	Green Bay Water, n.d.
Quincy	MA	MWRA, 2023
Flint	MI	City of Flint, n.d.
Newton	MA	MWRA, 2023
Somerville	MA	City of Somerville, n.d.
Evanston	IL	IEPA, 2022
Framingham	MA	MWRA, 2023
Madison	WI	City of Madison, 2014
St. Clair Shores	MI	City of St. Clair Shores, n.d.
Revere	MA	City of Revere, 2023
Bozeman	MT	City of Bozeman, 2020
NA	VT	Vermont DWGPD LCRI Public Comment
Bloomfield	NJ	Bloomfield Water Department, 2021
Battle Creek	MI	Battle Creek, 2023
Marlborough	MA	MWRA, 2023
Galesburg	IL	IEPA, 2022
Village of Montgomery	IL	Village of Montgomery, n.d.
Norwood	MA	MWRA, 2023
Sandusky	OH	City of Sandusky, 2021

City	State	Citation in References
Winchester	MA	MWRA, 2023
Birmingham	MI	City of Birmingham, n.d.
Frankfort	IL	IEPA, 2022
Menasha	WI	Menasha Utilities, 2023
Stoughton	WI	City of Stoughton Utilities Committee, 2022
Mayville	WI	City of Stoughton Utilities Committee, 2022
Evart	MI	City of Evart, 2020

Appendix 2.0: Examples of types of documents available to provide additional guidance to water systems beginning or implementing their service line replacement programs

- LSLR Collaborative-Established in 2017 following the Flint Water Crisis, the Collaborative is a joint effort of 28 national public health, water utility, environmental, labor, consumer, housing, and State and local government organizations to accelerate full removal of lead pipes. The Collaborative has provided a roadmap for starting a service line replacement program, an ongoing webinar series focused on service line replacement, and links to additional related resources. The Collaborative also notes that service line replacement practices "may evolve with new information" and that they will continually update resources to reflect any changes in technology or processes over time. (LSLR Collaborative, n.d.).
- Principles for Lead Service Line Replacements-Released in 2022, NRDC and colleagues proposed a set of basic principles for replacing LSLs based upon their experience with efforts to replace pipes from Flint and Benton Harbor, MI, Newark, NJ, Pittsburgh, PA, Washington, DC, and many other locations. The principles cover varying aspects of a LSLR program, from community involvement to consent of property owners, to the approach and methods used for replacement. (Alliance of Nurses for Healthy Environments et. al., n.d.).
- Denver Water Lead Reduction Program-Since the first year of Denver Water's replacement program in 2021, Denver has released semi-annual reports detailing the progress of the replacement program, inventory updates, lead sampling, and distribution and sampling of water filters. These reports include a section "Learning by Doing" in which the system reflects and shares lessons learned the previous year including adjustments to their procedures or policies to increase efficiency and effectiveness of their program. (e.g. Denver Water, 2023b).
- Central Arkansas Water's Lead Service Line Replacement Program: Investigation, Communication, Implementation-Published in April 2020, Central Arkansas Water shares a service line replacement protocol developed in 2016 and details the success of the protocol and challenges faced in their replacement program after conducting approximately 100 replacements in October 2017. (Sweeney, 2020).
- Halifax Water's Lead Service Line Replacement Program Gets the Lead Out-Published March 2022, Halifax Water details their process for service line replacement, including a research partnership with nearby Dalhousie University and insights resulting from this partnership. This paper details customer outreach and funding strategies and the evolution of the LSLR program in recent years. (Krkosek et. al., 2022).

- Safety and Affordability are Vital for LSLR-Published in August 2020, an Ohio water utility describes their process to make service line replacement affordable for its customers and safe for field crews. (Niranjan and McCarthy, 2020).
- Lead in Drinking Water: A Permanent Solution for New Jersey-Published in October 2019, Jersey Water Works convened a 30-member task force of representatives from local, State, and Federal governments, water utilities, academia, environmental, smart growth and community advocates, and public health organizations to determine practical, cost-effective, equitable, and permanent solutions to virtually eliminate lead in drinking water within 10 years. (Jersey Water Works, 2019).
- Identifying Information Gaps to Help Communities Navigate Lead Service Line Replacement-Published in June 2024, The Joyce Foundation and the Federal Reserve Bank of Chicago jointly convened 25 regional and national leaders in LSLR and published a summary of key information and research gaps, including LSLR cost drivers, financing needs, and how to address common equity issues. (Anderson et. al., 2024).

Appendix 3.0: Examples of types of documents available to provide additional guidance to water systems beginning or implementing their service line identification programs

- Planning and Developing a Service Line Inventory-EPA has released comprehensive inventory guidance along with a LSL identification webpage housing all EPA guidance, case studies, templates, fact sheets, and webinars related to service line identification. (USEPA, 2022).
- Developing and Maintaining a Service Line Inventory: Small Entity Compliance Guide-EPA released the Small Entity Compliance Guide in 2023 to support water systems, particularly small water systems, in complying with the LCRR initial inventory requirements. This guide explains the inventory-related actions small community and non-transient non-community water systems are required to take under LCRR. (USEPA, 2023c).
- Lead service line identification: A review of strategies and approaches-Published in June 2021, scientists at the EPA's ORD summarized the current industry LSL identification methods, including records screening, basic visual examination of indoor plumbing, water sampling, excavation, and predictive data analyses. This analysis was used to develop a stepwise approach to identify unknown service lines using a combination of different available methods. (Hensley et. al., 2021).
- Service Line Material Identification: Experiences from North American Water Systems-Published in January 2022, an AWWA subcommittee interviewed 10 water systems to learn about their processes for LSL inventory creation, material identification, customer communication, and other aspects of their experiences. In this way they have compiled lessons learned from various utilities into one article to peruse to aid in preparing water utilities with what to expect in their own identification efforts. (Ligget et. al., 2022)
- Predictive Modeling in Service Line Inventory Development-Published in December 2023, this article documents States which permit the use of predictive modeling and discusses in detail various uses and applications of predictive modeling to the development of a service line inventory. (Deheer et. al., 2023).
- Identifying Lead Service Lines with Field Tap Water Sampling-Published in 2021, researchers at the University of Pittsburgh worked with the PWSA to analyze historical tap sampling data by utilizing a random forest statistical model. This study gauged the

accuracy of the random forest model and considered sampling strategies which could lead to even more accurate models. (Blackhurst, M., 2021).

- Developing and Verifying a Water Service Line Inventory-Published in April 2021, Pittsburgh Sewer and Water Authority (PWSA) discusses how they learned from the efforts of similar utilities to inform their development of a service line inventory, even when data and records have not been consistently collected and maintained in the past. PWSA documented their inventory process and which inventory method were used, and overall lessons learned to assist future utilities. (Duffy and Pickering, 2021).
- Planning for Service Line Material Identification and Lead Service Line Replacement Costs-Published in 2023, the study team from CDM Smith sent a survey to more than 4,500 utilities to obtain information about what service line identification methods are being used and various associated costs of them at utilities nationwide. The summary of costs provides utilities with realistic estimates for what to expect in terms of the cost of their service line identification and replacement programs to aid in long-term planning and financial assessments. (Kutzing et. al., 2023).
    - Full associated report from CDM Smith is also publicly available
- Development and optimization of a systematic approach to identifying lead service lines: One community's success-Published in 2023, Engineers working with Bennington, VT worked with EPA scientists to document the accuracy of various service line identification methods during their development of a service line inventory. Service line identification strategies arising from this information were developed and mapped for future water systems (Smart et. al., 2023).

References

Alkafaji, R. (2023, June 29). *Lead pipe survey flaws reveal that states may not be getting their fair share*. Environmental Defense Fund. Retrieved July 31, 2023 from https://blogs.edf.org/deepdives/2023/06/29/lead-pipe-survey-flaws/

Alliance of Nurses for Healthy Environments, Beyond Plastics, Clean Water Action, Earthjustice, Environmental Advocates NY, Environmental Policy Innovation Center, Environmental Protection Network, Gulf Coast Center for Law & Policy, Healthy Babies Bright Futures, League of Conservation Voters, Little Village Environmental Justice Organization, MI Welfare Rights Organization, Natural Resources Defense Council, New Jersey Future, Newark Education Voters Caucus, New York League of Conservation Voters, People's Water Board Coalition, Waterway Advocates, WE ACT for Environmental Justice. (n.d.). Principles for Lead Service Line Replacements. Retrieved July 17, 2024 from https://www.nrdc.org/sites/default/files/principles-for-lead-service-line-replacements-20220228.pdf

American Association for Public Opinion Research (AAPOR), 2023. Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys. Retrieved 9-9-2024 from https://aapor.org/wp-content/uploads/2023/05/Standards-Definitions-10th-edition.pdf

Anderson, N., Castro, M., Cisar, E., Cuenca, K., Saxena, S. (2024, June). Identifying Gaps to Help Communities Navigate Lead Service Line Replacement. *Federal Reserve Bank of Chicago-Chicago Fed Insights.* Retrieved July 17, 2024 from https://www.chicagofed.org/publications/chicago-fed-insights/2024/lead-service-line-replacement-information-gaps

Battle Creek, Michigan (2023, Mar. 29). Works to replace existing lead service lines throughout city resumes. Public Works/Road Work News Flash. Retrieved August 9, 2023, from https://www.battlecreekmi.gov/CivicAlerts.aspx?AID=1698

Blackhurst, M. (2021, Aug. 4). Identifying Service Lines with Field Tap Water Sampling. *ACS ES&T Water.* Vol. 1, Issue 8, pp 1983-1991. Retrieved July 17, 2024 from https://pubs.acs.org/doi/full/10.1021/acsestwater.1c00227#

Bloomfield Water Department (2021). Important information about lead in your drinking water. Retrieved August 9, 2023 from http://bloomfieldtwpnj.com/DocumentCenter/View/7734/Bloomfield-Lead-Update---February-2021-PDF

California Legislature (2017). Health and Safety Code, Division 104-Environmental Health, Part 12-Drinking Water, Chapter 5-Water Equipment and Control. Retrieved July 31, 2023 from https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=116885.

City of Birmingham (n.d.). Turn on the Tap-Residential Water Testing. Water and Sewer Department. Retrieved August 9, 2023, from https://www.bhamgov.org/about_birmingham/city_departments/public_services/water___sewer/lead_testing.php

City of Bozeman (2020). 2019 Water Quality Report. Bozeman Water Treatment Plant. Retrieved August 9, 2023, from https://www.bozeman.net/home/showpublisheddocument/9965/637169227578900000

City of Chicopee (n.d.). Lead Service Line Inventory. City of Chicopee Water Department. Retrieved August 19, 2023 from http://chicopeema.gov/1031/Lead-Service-Line-Inventory

City of Detroit (n.d.). Capital Improvement Program. Detroit Water and Sewerage Department. Retrieved August 9, 2023, from https://detroitmi.gov/departments/water-and-sewerage-department/dwsd-projects/capital-improvement-program

City of Evart (2020, Mar. 31). City of Evart Lead & Copper Program. Retrieved August 9, 2023, from https://storymaps.arcgis.com/stories/2be961871eb444629a87e8f7d70b6d95 28

City of Flint. (n.d.). Progress Report on Flint Water. Michigan. Retrieved July 25, 2023, from https://www.cityofflint.com/progress-report-on-flint-water/

City of Grand Rapids (2022, Nov.). Private Lead Service Line Replacements. Water System. Retrieved August 9, 2023, from https://www.grandrapidsmi.gov/Government/Departments/Water-System/Lead-in-Drinking-Water/Private-Lead-Service-Line-Replacements#section-4

City of Kalamazoo (2023). City of Kalamazoo Lead Service Line Replacement Project. Retrieved August 9, 2023, from https://cityofkalamazoo.maps.arcgis.com/apps/dashboards/765de573218b406d8a9062d67286e0e3

City of Madison (2014, Nov. 7). EPA seeks details of Madison's Lead Service Line Replacement Program. Madison Water Utility. Retrieved August 9, 2023, from https://www.cityofmadison.com/water/insidemwu/epa-seeks-details-of-madisons-lead-service-replacement-program

City of Newark, New Jersey (n.d.). Lead Service Line Replacement Program. NewarkLeadServiceLine.com Retrieved July 25, 2023, from https://www.newarkleadserviceline.com/replacement

City of Pasadena, Texas (n.d.). *Frequently Asked Questions-Water Meters.* Water Services Department. Retrieved August 1, 2023 from https://www.pasadenatx.gov/DocumentCenter/View/2093/Frequently-Asked-Questions---Water-Meters-PDF#:~:text=meters%20being%20replaced%3F-,The%20typical%20useful%20life%20for%20a%20water%20meter%20is%2015,more%20prone%20to%20maintenance%20issues

City of Revere (2023). Water and Sewer Department. Retrieved August 9, 2023, from https://www.revere.org/departments/water-and-sewer

City of Sandusky (2021). 2021 Annual Report. Retrieved August 9, 2023, from https://cms6.revize.com/revize/sanduskyoh/docs/City%20of%20Sandusky%20Annual%20Report%202021.pdf

City of Saskatoon (n.d.). Lead Water Pipes. Saskatoon Power, Water, & Sewer. Retrieved August 9, 2023, from https://www.saskatoon.ca/services-residents/power-water-sewer/drinking-water/lead-water-pipes

City of Somerville (n.d.). Lead Service Line Replacement Program. Engineering Department. Retrieved August 9, 2023, from https://www.somervillema.gov/departments/programs/lead-service-line-replacement-program

City of St. Clair Shores (n.d.). SCS Lead Safe. Water Maintenance Division. Retrieved August 9, 2023, from https://www.scsmi.net/892/SCS-Lead-Safe#:~:text=about%20this%20issue%3F-,The%20City%20of%20St.,and%20send%20to%20the%20DPW 29

City of Stoughton Utilities Committee (2022, Aug. 15). Official Notice and Agenda. Meeting Agendas. Retrieved August 9, 2023, from https://www.stoughtonutilities.com/documents/ucpackets/2022-08-15-uc-packet_r.pdf

City of Tucson (2019, Jan. 18). Lead and Copper. Water Quality Monitoring. Retrieved August 9, 2023, from https://www.tucsonaz.gov/Departments/Water/About-Your-Water-Quality/Water-Quality-Monitoring/Lead-and-Copper

Cochran, W. G. (1977). Sampling techniques. John Wiley & Sons.

Daniel, W. W., and Cross, C. L. (2013). Biostatistics: a foundation for analysis in the health sciences. Tenth edition. John Wiley & Sons.

DC Water (2023, June 30). DC Water Releases Lead Free DC Plan Update and New Lead Inventory Map. News. Retrieved August 9, 2023, from https://www.dcwater.com/whats-going-on/news/dc-water-releases-lead-free-dc-plan-update-and-new-lead-inventory-map

Deheer, K., Epstein, K., Cummings, J. (2023, December, 6). Predictive Modeling in Service Line Inventory Development. *Journal AWWA.* Vol. 115, Issue 10, pp 8-18. Retrieved July 17, 2024 from
https://awwa.onlinelibrary.wiley.com/doi/full/10.1002/awwa.2193

Denver Water (2023a). Annual Report-2022. Denver Water Lead Reduction Program. Version 1.0: February 10, 2023. Retrieved July 25, 2023, from:
https://www.denverwater.org/sites/default/files/lead-reduction-program-annual-report-2022.pdf

Denver Water (2023b). Denver Water Lead Reduction Program-Learning by Doing-2022. Version 1.0: February 10, 2023. Retrieved July 19, 2024 from:
https://www.denverwater.org/sites/default/files/lead-reduction-program-learning-by-doing-2022.pdf

Duffy, D., Pickering, W. (2021, April 1). Developing and Verifying a Water Service Line Inventory. *Journal AWWA.* Vol. 113, Issue 3, pp 6-13. Retrieved July 17, 2024 from
https://awwa.onlinelibrary.wiley.com/doi/10.1002/awwa.1686

Feist, M. (2018, July 27). City Eliminates Remaining Lead Service Lines. Spokane City News. Retrieved August 9, 2023, from https://my.spokanecity.org/news/releases/2018/07/27/city-eliminates-remaining-lead-service-lines/

Folkman, S. (2018). *Water Main Break Rates in the USA and Canada: A Comprehensive Study.* Utah State University-Buried Structures Laboratory. Retrieved July, 25, 2023, from:

https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1173&context=mae_facpub&source=post_page

Fort Worth (n.d.). Fort Worth's action plan. Water Department. Retrieved August 9, 2023, from https://www.fortworthtexas.gov/departments/water/lead/protection

Garner, D (2022, May 17). Leetonia to receive portion of state grants to update water lines. *Morning Journal.* Retrieved August 19, 2024 from https://www.morningjournalnews.com/news/local-news/2022/05/leetonia-to-receive-portion-of-state-grants-to-update-lead-water-lines/

Greater Cincinnati Water Works (2023). See Progress in your neighborhood. Retrieved August 9, 2023, from https://la.mygcww.org/neighborhoods/

Green Bay Water (n.d.). Fresh drinking water from Lake Michigan. Retrieved August 9, 2023, from https://www.gbwater.org/services#gsc.tab=0

Hensley, K., Bosscher, V., Triantafyllidou, S., Lytle, D. (2021, June 10). Lead service line identification: A review of strategies and approaches. *AWWA Water Science.* Vol. 3, Issue 3, pp e1226. Retrieved July 17, 2024 from https://awwa.onlinelibrary.wiley.com/doi/full/10.1002/aws2.1226

Illinois Environmental Protection Agency (IEPA) (2022). Lead Service Line Information. Public Water Users. Retrieved June 24, 2024 from https://epa.illinois.gov/topics/drinking-water/public-water-users/lead-service-line-information.html

Illinois General Assembly (2021). HB3739 Lead Service Line Replacement. 102nd General Assembly. Retrieved July 31, 2023, from https://ilga.gov/legislation/BillStatus.asp?DocNum=3739&GAID=16&DocTypeID=HB&LegID=132788&SessionID=110&SpecSess=&Session=&GA=102

Illinois Municipal Code (2017). Public Act 099-0922. Retrieved July 31, 2023 from https://www.ilga.gov/legislation/publicacts/99/099-0922.htm

Jersey Water Works. (2019, October). Lead in Drinking Water: A Permanent Solution for New Jersey. *Report of the Jersey Water Works Lead in Drinking Water Task Force.* Retrieved July 17, 2024 from https://cms.jerseywaterworks.org/wp-content/uploads/2019/10/JWW-Lead-Report.pdf

Kelley, C. (2017, Aug. 2022). Sioux Falls Replaces Final Lead Water Pipe. Retrieved August 9, 2023, from https://www.keloland.com/news/sioux-falls-replaces-final-lead-water-pipe/

Krkosek, W., Healey, M., Sampson, C., and McKnight, A. (2022). Halifax's Lead Service Line Replacement Programs Gets the Lead Out. *Journal AWWA.* Vol 114, Issue 2, Pg 10-19. Retrieved July 17, 2024 from https://awwa.onlinelibrary.wiley.com/doi/full/10.1002/awwa.1862

Kupper, L. L., and Hafner, K. B. (1989). How Appropriate Are Popular Sample Size Formulas? *The American Statistician*, *43*(2), 101–105. https://doi.org/10.2307/2684511

Kutzing, S., Murray, N., Sayre, A., Gawlik, E. (2023, July 5). Planning for Service Line Material Identification and Lead Service Line Replacement Costs. *Journal AWWA.* Vol. 115, Issue 6, p 22-33. Retrieved July 17, 2024 from https://awwa.onlinelibrary.wiley.com/doi/full/10.1002/awwa.2123

Lansing Board of Water and Light (n.d.). Lead Information. Water Resource Center. Retrieved August 9, 2023, from https://www.lbwl.com/customers/water-resource-center/lead-information

Leischner, M. (2022, May 31). City of Mosinee Receives Funding for Lead Service Line Replacement. *WSAU Radio.* Retrieved August 19, 2024 from https://wsau.com/2022/05/31/city-of-mosinee-receives-funding-for-lead-service-line-replacement/

Ligget, J., Baribeau, H., Deshommes, E., Lytle, D., Masters, S., Muylwyk, Q., Triantafyllidou, S. (2022, Jan. 18). Service Line Material Identification: Experiences from North American Water Systems. *Journal AWWA.* Vol. 114, Issue 1, pp 8-19. Retrieved July 17, 2024 from https://awwa.onlinelibrary.wiley.com/doi/full/10.1002/awwa.1841

LSLR Collaborative (n.d.). About the Lead Service Line Replacement Collaborative. Retrieved July 17, 2024 from https://www.lslr-collaborative.org/about-us.html

Massachusetts Water Resources Authority (MWRA). (2023, June 16). Lead Service Line Replacement Loan Program or Lead Loan Program (LLP), an Enhancement to the Local Water System Assistance Program (LWSAP) for Member Communities. MWRA Online. Retrieved July 17, 2023, from https://www.mwra.com/comsupport/llp/llpprogram.html

Menasha Utilities (2023, May 2). Menasha Completes Replacement of all Lead Water Laterals. Retrieved August 9, 2023 from https://www.menashautilities.com/sites/menashautilities.com/files/Menasha%20Lead%20Lateral%20Replacement%20Complete.pdf

Michigan Department of Environment, Great Lakes, and Energy (2020). Michigan Service Line Materials Estimates-Preliminary Distribution System Materials Inventories. Retrieved August 1, 2023 from https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Programs/DWEHD/Community-Water-Supply/Sampling/pdsmi-summary.pdf

Michigan Department of Environment, Great Lakes, and Energy (2021). *Minimum Service LineMaterial Verification Requirements.* EGLE Drinking Water and Environmental Health Division. Retrieved August 1, 2023 from https://www.michigan.gov/egle/-

/media/Project/Websites/egle/Documents/Programs/DWEHD/Community-Water-Supply/Lead-Copper/Minimum-Service-Line-Material-Verification-Requirements.pdf

Niranjan, D., McCarthy, C. (2020, August). Safety and Affordability Are Vital for Lead Service Line Replacement. *Opflow.* Vol. 46, Issue 8, pp. 10-13. Retrieved July 17, 2024 from https://ui.adsabs.harvard.edu/abs/2020Opflo..46h..10D/abstract

Pittsburgh Water and Sewer Authority (n.d.). Community Lead Response. Retrieved August 9, 2023, from https://lead.pgh2o.com/

Public Service Commission of Wisconsin (2021). *2020 Number of Service Lines by Material Type for Wisconsin Utilities.* Lead Service Line (LSL) Replacement Line. Retrieved August 1, 2023 from https://psc.wi.gov/Pages/ServiceType/Water/LeadServiceLine.aspx

Rhodes, B. (2023, Jan. 25). Cheshire to have Special Town Meeting March 6. *iBerkshires.com*. Retrieved August 19, 2024 from https://www.iberkshires.com/story/70702/Cheshire-to-have-Special-Town-Meeting-March-6.html

Schulwitz, S. (2022, April 25). Nearly 300 residents to have water lines inspected for contaminants. *The Alpena News.* Retrieved August 19, 2024 from https://www.thealpenanews.com/news/local-news/2022/04/nearly-300-residents-to-have-water-lines-inspected-for-contaminants/

Select Statistical Services. (n.d.) Population Proportion – Sample Size. Accessed July 2, 2024, from https://select-statistics.co.uk/calculators/sample-size-calculator-population-proportion/

Smart, P., McRae, L., Formal, C., Lytle, D. (2023, Nov. 1). Development and optimization of a systematic approach to identifying lead service lines: One community's success. *Water Research.* Vol. 246. Retrieved July 17, 2024 from https://www.sciencedirect.com/science/article/pii/S004313542301165X

Stubbart, J., (2003). *When Should Meters Be Replaced?* American Water Works Association-Opflow Question of the Month. Retrieved August 1, 2023 from https://awwa.onlinelibrary.wiley.com/doi/epdf/10.1002/j.1551-8701.2003.tb01715.x

Sweeney, S. (2020, April 6). Central Arkansas Water's Lead Service Line Replacement Program: Investigation, Communication, Implementation. Journal AWWA. 112(4), 32-38. Doi: https://doi.org/10.1002/awwa.1479

Trenton Water Works (n.d.) TWW LSLR Program Progress Metrics. TWW Lead Service Line Replacement Program. Retrieved August 9, 2023, from https://www.twwleadprogram.com/progress-3

USEPA. (1997). Techniques for tracking, evaluating, and reporting the implementation of nonpoint source control measures: Forestry. Office of Water. EPA 841-B-97-009. https://www.epa.gov/system/files/documents/2022-12/Tracking_Full%20Doc.pdf

USEPA. (1998). National Primary Drinking Water Regulations: Consumer Confidence Reports; Final rule. *Federal Register*. 63 FR 44524. August 19, 1998.

USEPA. (2000). Federal Register. Vol. 65. No. 87. National Primary Drinking Water Regulations: Public Notification Rule; Final Rule. (Thursday. May 4, 2000), 25982-26049 (65 FR 25982).

USEPA. (2022). Guidance for Developing and Maintaining a Service Line Inventory. EPA Headquarters. Office of Water. Document No. EPA 816-B-22-001. Retrieved July 17, 2024, from https://www.epa.gov/system/files/documents/2022-08/Inventory%20Guidance_August%202022_508%20compliant.pdf

USEPA. (2023a). Drinking Water Infrastructure Needs Survey and Assessment-7th Report to Congress. Retrieved July 17, 2024, from https://www.epa.gov/system/files/documents/2023-09/Seventh%20DWINSA_September2023_Final.pdf

USEPA. (2023b). National Primary Drinking Water Regulations for Lead and Copper: Improvements (LCRI). Proposed Lead and Copper Rule Improvements. *Federal Register.* 88 FR 84878. December 6, 2023.

USEPA. (2023c). Developing and Maintaining a Service Line Inventory: Small Entity Compliance Guide. Retrieved July 17, 2024, from https://www.epa.gov/ground-water-and-drinking-water/planning-and-developing-service-line-inventory

USEPA. (2023d). Economic Analysis for the Proposed Lead and Copper Rule Improvements. EPA 815-R-23-005.

USEPA. (2024a). EPA's 7th Drinking Water Infrastructure Needs Survey and Assessment. https://www.epa.gov/dwsrf/epas-7th-drinking-water-infrastructure-needs-survey-and-assessment

USEPA. (2024b). Economic Analysis for the Final Lead and Copper Rule Improvements.

USEPA. (2024c). Final Lead and Copper Rule Improvements.

Vasko, M. (2022, March 28). A Resolution authorizing the submission and support of an application to State of Ohio Environmental Protection Agency and declaring an emergency. Council of the Village of Swanton. Retrieved August 19, 2024 from https://villageofswantonohio.us/wp-content/uploads/2022/04/VILSWAN-2022-09-03282022.pdf

Village of Montgomery (n.d.). Lead-Free. Public Works Department. Retrieved August 9, 2023. from https://www.montgomeryil.org/711/Lead-Free

Vollrath, M., (2015). *Water Utilities Change AMR/AMI Systems More Frequently than Previously Thought.* Badger Meter. Retrieved August 1, 2023 from https://www.prweb.com/releases/2015/05/prweb12748042.htm

Voltzer, H., Grim, J., George, A. (2016). Sub. H.B. 512. 131st General Assembly. Ohio Legislative Service Commission. Retrieved July 31, 2023 from https://www.legislature.ohio.gov/download?key=5591&format=pdf

Walker, E., Jacquette-Morrison, A. (2019). *State-Driven Lead Service Line Inventories.* 120 Water. Retrieved July 31, 2023 from https://120water.com/wp-content/uploads/2020/10/Whitepaper-State-Driven-Lead-Service-Line-Inventories-1-1.pdf

The York Water Company (2023). Lead Information. Retrieved August 9, 2023. from https://www.yorkwater.com/lead-information/