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Best Practices for

Identifying Galvanized Service Lines Requiring Replacement

Authors:

Jennifer Liggett (Jacobs)
Tugba Akgun (Jacobs)
Lauren Wasserstrom (Jacobs)
Sheela Lal (BlueConduit)
Ian Robinson (BlueConduit)

Introduction

On December 16, 2021, US Environmental Protection Agency (EPA) announced new steps to strengthen the regulatory framework on lead in drinking water under the Lead and Copper Rule Long-Term Revision (LCRR). One of the major revisions of the LCRR requires all community water systems (CWSs) and non-transient non-community water systems (NTNCWSs), regardless of their size, to conduct inventories of service line materials by October 16, 2024.

If the 90th percentile for the tap compliance sample results exceed the trigger or action levels for lead, the LCRR requires mandatory replacement of two categories of service lines: LSLs, and galvanized requiring replacement (GRR). By the rule definition, GRRs are galvanized steel lines that are or ever were historically downstream of an LSL. Under the current LCRR, water systems are required to presume the galvanized service line (GSL) was downstream of an LSL if unable to demonstrate that the GSL was never downstream of a lead service line. Galvanized piping was commonly installed in homes built between 1880 and 1960. GRRs have been a particular concern because galvanized steel lines are dipped in a protective zinc coating containing lead that can leach into drinking water when corroded after decades of water exposure (Clark, Masters & Edwards, 2015). They also can capture lead from upstream lead sources and release lead if water quality changes or pipes are disturbed.

Disturbance of service lines and premise plumbing can cause short-term, high particulate lead levels even after full LSLR in which the entire lead service has been replaced (Sandvig et al, 2008). In circumstances in which the upstream lead service line was removed years ago, downstream galvanized iron pipes still have the potential to periodically release the trapped lead particulates into the water. The estimates for service line occurrences and replacement figures are LSL-centric and focus mainly on LSLs which could result in undermining the cost of inventory identification, verification, customer outreach regarding potential GRR occurrence, GRR planning costs, and ultimately GRR replacement costs for the water systems.

The estimated occurrence of GSLs and GRRs is highly variable and system-specific. In 2022, the American Water Works Association (AWWA) conducted a Water Industry Technical Action Fund (WITAF) research study with Jacobs Engineering Group, Inc. (Jacobs) to evaluate the impact of including GRRs in the LCRR on service line inventory development and quantity of required service line replacements, including the degree to which the definition of GRRs impacts the number of service lines requiring replacement and the resulting burden associated with other rule requirements (Akgun, 2022). Based on the national survey conducted of thirty (30) water systems, the report findings identified that an average of 2% of service lines are known galvanized iron downstream of lead, and another 2% of are known galvanized iron downstream of unknown service lines based on the service line inventories. The dataset from the survey indicated that the inclusion of GRRs in the LSL inventory increased the number of service line replacements required by 18%, without taking the presence of lead connectors into account. Furthermore, peer-reviewed research data from HomeServe emergency repair service enrollment to assess the durability of different service line materials characterized one-third to be galvanized pipe out of a dataset of 12,000 service lines (Lee and Meehan, 2017).

Determination of GRRs require special considerations and commonly used visual and field identification methods may not be suitable for the burden of proof required for GRRs. The following sections address the main challenges and considerations associated with the identification and validation of GRR service lines, focusing on the historical lead upstream component, and outlines best practices and applicable methods available to help prove whether lead currently is or ever was upstream of a galvanized service line (GSL). Note, within this document the term “State” is used following the EPA’s definition “the agency of the State or Tribal government that has jurisdiction over public water systems” (EPA, 2022).

Main Challenges Associated with GRRs

Recognizing that the EPA's definition of GRR requires water systems to presume the GSL was downstream of an LSL if unable to demonstrate that the GSL was never downstream of a lead service line, many States and Territories have deferred to the EPA's definition. There are currently a few States, listed in Table 1 below, that either provide additional guidance or have more stringent definitions of a GRR. State regulators may continue to update their GRR rules, and water systems are encouraged to check for potential updates periodically.

Table 1. Summary of Available Guidance or Requirements for GRRs by State*

EPA GRR Definition: A GSL that is or was at any time downstream of a LSL or is currently downstream of a lead status unknown service line. If the water system is unable to demonstrate that the GSL was never downstream of a LSL, it must presume there was an upstream LSL (40 CFR 141.84(a)(4)(ii)).		
States & Territories	**Specific Guidance or Requirements for GRR that Differs from the EPA**	**Source**
Michigan	Water utilities have a choice. They can assume that locations with galvanized service lines between the main and curb stop contain (or previously contained) a lead connector. Otherwise, they would need to physically verify to demonstrate the absence of a lead connector.	https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Programs/DWEHD/Community-Water-Supply/Lead-Copper/Minimum-Service-Line-Material-Verification-Requirements.pdf
New Jersey	Per C.58:12A-41, section 2, the definition of a lead service line includes galvanized. Under New Jersey law, galvanized materials are presumed to include lead.	Chapter 183, LSL FAQ
Massachusetts	The State of Massachusetts does not set further GRR regulation, but they do provide detailed answers to many questions impacting GRR lines using EPA guidance.	https://www.mass.gov/doc/frequently-asked-questions-about-the-lead-and-copper-rule-revisions-lcrr/download
Nevada	The State of Nevada includes GRR as Tier 3 sampling site for Community Water System testing plans.	https://ndep.nv.gov/uploads/documents/2023-05-12-_RLCR_FAQ_-_Final.pdf
New York	New York State provides explicit guidance on communicating the presence of a GRR service line, which goes beyond the EPA guidance.	https://www.health.ny.gov/environmental/water/drinking/docs/service_line_inventory_guidance_lcrr.pdf
Pennsylvania	The water system must be able to demonstrate that the galvanized service line was never downstream of any portion of a lead service line, lead gooseneck, pigtail or connector, or service line of unknown material. Otherwise, it must be considered galvanized requiring replacement.	https://files.dep.state.pa.us/Water/BSDW/DrinkingWaterManagement/Regulations/LCRR_SLI_Workbook_2023_v4.pdf
Rhode Island	Rhode Island includes the same EPA definition for GRR but also indicates that "service lines with galvanized steel or iron shall be considered lead service lines."	https://webserver.rilegislature.gov/BillText23/HouseText23/H5007.pdf

**Note that this table was developed with available information at time of publication and is subject to change.*

All States recommend, if not require, a thorough historic records review as part of the LCRR's inventory process. However, many public water systems do not have full, trustworthy records about what is currently in the ground; budget to fund the effort while managing other water programming; or the available talent to effectively transcribe, read, or sort historic records. It is important to recognize the huge burden of poorly kept or missing records on already overworked water systems. The EPA guidelines requires documentation of whether a lead line ever existed upstream from a GSL. Given how challenging it is for water utilities to document what is currently in the ground, finding information of what was ever upstream of GSLs may lead many utilities to categorize most customer-side GSL to be GRR. Current investigate techniques for service line material identification are designed to identify material that is currently in the ground. The GRR definition relates to materials that were ever in the ground. This part of the rule relies on robust records of all service line materials ever used at an address or within a water system. Current field investigation techniques are generally not able to identify "historical" lead.

Forthcoming Federal and State regulations such as the LCRI and State-specific guidance documents may clarify the uncertainties regarding the GRRs and provide insight into State approved methods and required burden of proof for identifying GRRs. AWWA WITAF 074 research study indicated that 20% of survey participants faced challenges regarding the understanding of the rule on the GRR portion and 18% of survey participants expressed uncertainty about how to prove there was never lead upstream of a known GSL. Refining the definition of GRR in the forthcoming Federal and State regulations can assist in establishing an achievable standard of care and would facilitate improved rule implementation.

As the water systems are building their service line inventory based on historical records review, desktop analysis, and field investigations, there are additional considerations and nuances related to the suspected occurrence of GSL. The lack of clarity regarding what is required as proof creates more uncertainty as the water systems depend on the guidance provided by their State primacy agency. For those water systems that have limited or no historical records of service lines, it presents a major challenge to prove the previous materials on the upstream side and prove that there was no prior replacement of lead on the upstream. In order to be as conservative as possible, water systems can benefit from eliminating all GSL from their distribution system regardless of upstream or downstream location.

Best Practices & Methodology for Determination of GRRs

Best practices for determining GRRs include following available EPA and/or primacy agency guidance, determining the identification methods that will be most advantageous, digitizing records and data, identify challenges of working on private property, taking a conservative approach and leveraging existing funding options.

Follow Available Federal and State Primacy Agency Guidance

The EPA published the Guidance for Developing and Maintaining a Service Line Inventory in August 2022 and provides various methods and best practices for identification of service line materials. The guidance references Hensley et. al (2021), Bukhari et. al (2020), Liggett et. al (2022) for a list of available tools and methods available to water systems as well as examples from water systems. The tools and methods listed by the EPA include:

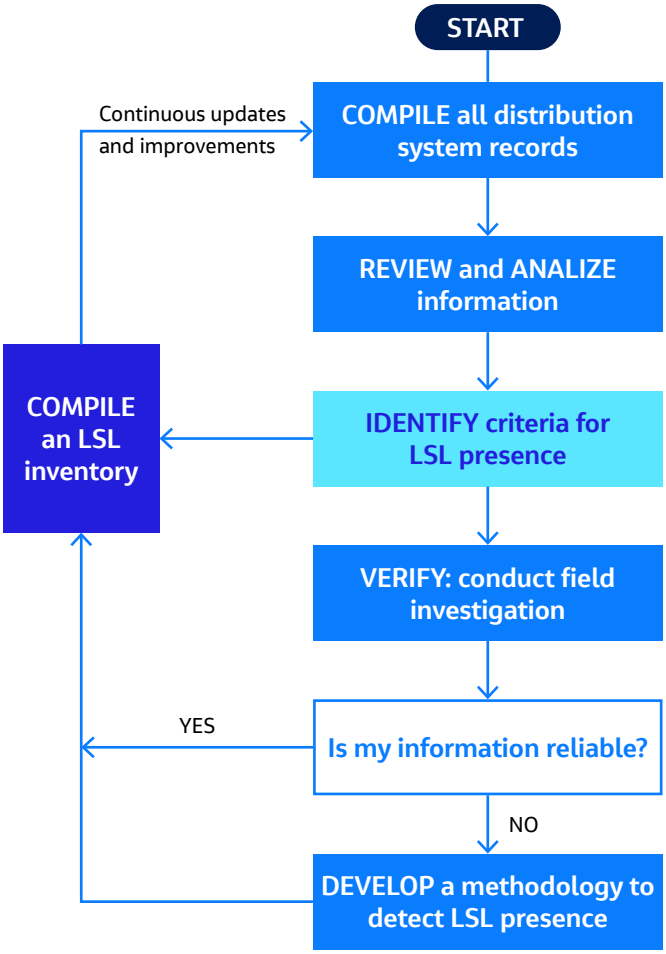
- Historical records review
- Visual inspection of service line materials
- Water quality sampling
- Excavation
- Predictive modeling
- Emerging methods such as ground penetrating radar, electrical resistance testing, stress wave propagation

It is also of note that the LCRR requires the historic records review, and the EPA defers to the individual primacy agencies or States for acceptance of the other tools and methods listed above. Additionally, water systems may use an iterative approach to identifying service line materials as illustrated in Figure 1. This iterative approach can be coupled with more than one of the tools and methods listed above. However, many of these tools and methods are broad and more focused on identifying lead service lines. There is limited guidance on specific methods for identifying GRR service lines as well as lead connectors, goosenecks or pigtails.

The EPA defers to the primacy agency and recommends water systems comply with any additional requirements from their primacy agency. As listed Table 1, some primacy agencies have more specific definitions of GRR and include identification of any lead containing component or require designation of GRR for any GSL. Further, Michigan and Pennsylvania provide requirements or guidance on multi-step verification of service line materials.

Figure 1.

Iterative Methodology to Determine Service Line Material



Source: Liggett, J., et al. (2002). Identifying Service Line Material. Journal AWWA. https://doi.org/10.1002/awwa.1841

Determine Best Identification Methods for Your Water System

The specific methods and tools recommended for identifying GRRs are further described below. As previously noted, there is not a one-size fits all approach, and the specific methods for determining service line materials will vary for each water system. It is anticipated that systems will use a combination of evidence-based records, and methods, to determine GRRs.

Historical Records Review

The LCRR specifies the types of historical records water systems must review as part of the initial inventory (EPA 2021; 2022). Since the availability and accuracy of records will vary for each system, it is important to track and include the specific records used to identify service line materials for both the public and private portions of the service line.

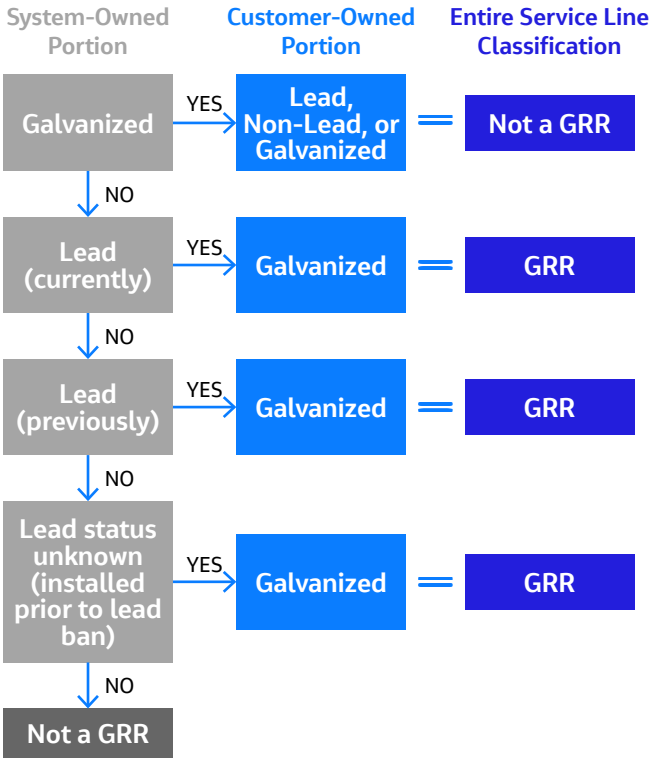
In addition to recording the service line material information, if/when available, capturing the following data is recommended to further target suspected GRRs and identify locations for field investigation, as well as to support other LCRR requirements (such as, identification and selection of compliance tap sampling sites):

- Building construction date
- Service line diameter
- Building type
- Lead connectors, lead solder, or other leaded components/fittings

Determining the building construction date and comparing to the State and/or local lead ban date, provides a valid, cost-effective strategy regardless of the water system's records. Figure 2 illustrates the GRR decision logic to determine whether the entire service line is classified as GRR or non-GRR based on the public and private material. Additional data, such as the service line diameter and building type, can help further determine the likelihood of LSLs particularly for the system-owned portion since LSLs are typically 2 inches or less in diameter and primarily serve single family or small multi-family residences (EPA, 2022). As such, service lines with those attributes and/or unknown service lines that were installed prior to the lead ban date, can be targeted for field identification.

It is also recommended that systems subclassify GRRs to indicate if the galvanized pipe is (1) known to be currently downstream of an LSL, (2) was previously downstream of an LSL, or (3) unable to demonstrate it was never downstream from an LSL. This may help systems to prioritize replacements, as well as support additional field investigation methods that are described in the sections below.

Figure 2. GRR Decision Logic



Visual Inspection of Service Line Materials

Since water systems typically lack records on the private portion of the service line, visual inspection of the customer-owned portion may be needed to identify the material. As discussed in the records review section above, LSLs and/or lead status unknown service lines identified for the system-owned portion can be prioritized to confirm if galvanized is present on the customer owned portion as well as to determine or verify the material on the system-owned portion.

Visual inspection can be performed by water system staff and through enlisting residents to self-report service line materials. EPA's inventory guidance provides an overview of the common approach to visually determine materials using a scratch and magnet test (EPA, 2022). To increase confidence in the data, submission of photograph(s) to document the service line material is recommended.

While data from the records review can help prioritize locations to target for visual inspection, systems are encouraged to concurrently employ this technique. Identifying and tracking service line material when encountered during normal operations can be immediately implemented if systems have not already done so. Capturing service line material data during this time is the most cost-effective method for systems and it is also required under the LCRR. In addition, effectively engaging the community in the process will help enhance transparency and public trust and increases the likelihood for residences to participate in future replacement efforts if GRRs or LSLs are identified.

> **Per the LCRR (40 CFR 141.84(a)(5)), water systems are required to identify and track service line materials during normal operations. This is an opportunity to not only identify materials but also to confirm materials and potentially confirm presence of lead gooseneck and connectors.**

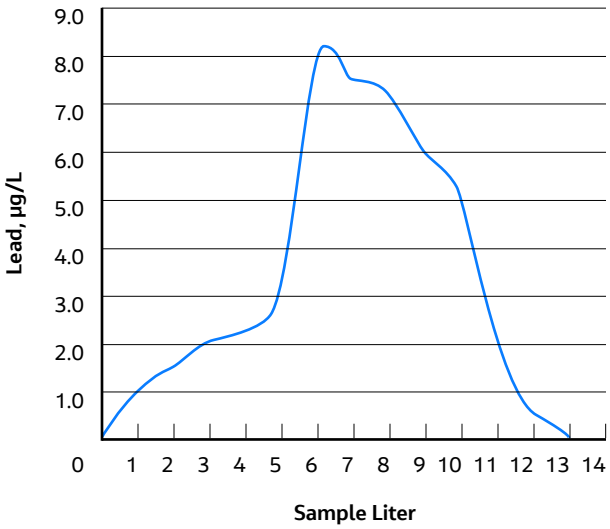
It is important to note that visual inspections may not be an approved method by the primacy agency, may require multiple points of verification, and excavations may be needed to inspect for lead goosenecks, pigtails or connectors that cannot be seen easily from within the meter box.

Water Quality Sampling

For systems with unreliable or minimal water system records, water quality sampling can be explored in combination with the above methods. In particular, sequential sampling or profiling can be a valuable approach to identify sources of lead in plumbing and service lines (Lytle, 2019; EPA, 2022). This sampling protocol involves collecting a series of consecutive samples from the tap after a stagnation period (typically 6 hours or more). The specific sample volumes and number of samples to collect depends on the length and diameter of the premise plumbing and service line materials. This protocol is described in depth in Lytle et al. (2019) and EPA's inventory guidance (2022). Figure 3 is an example of a sequential profile for a lead service line.

Figure 3.

Example Sequential Profile for a Lead Service Line



Sequential sampling is particularly useful when evaluating a suite of metals in the samples. In the context of GRRs, this includes but is not limited to lead and iron. Sample results for the metals can then be related to plumbing volumes. The presence of iron with an appreciable concentration of lead for the premise plumbing samples would suggest there is or was a lead service line or leaded-component upstream. Water systems will need to first establish baseline metals concentrations at sites with known plumbing and service line materials to further evaluate this method.

Predictive Modeling

In the absence of complete information, robust statistical modeling can be used to help fill in the gaps. Many utilities have found these methods useful in developing their service line inventories and planning efficient replacement programs, public communication, and regulatory compliance. These models can indicate the likely material on the private and public side of the service line. They use information that is verified within a service area to generate predictions about other places within that service area where information is not known. With the right input data, predictive modeling can also help utilities navigate the tricky question of GRR.

The best practice to ensure the right data input into a predictive model is to gather data at a representative, random set of homes. Combining the results of this representative set of homes with characteristics of those addresses (e.g., age of home, neighborhood, zoning info, etc.) allows a water system to calculate the probability of finding an LSL or GRR among other service lines with unknown materials (Figure 4).

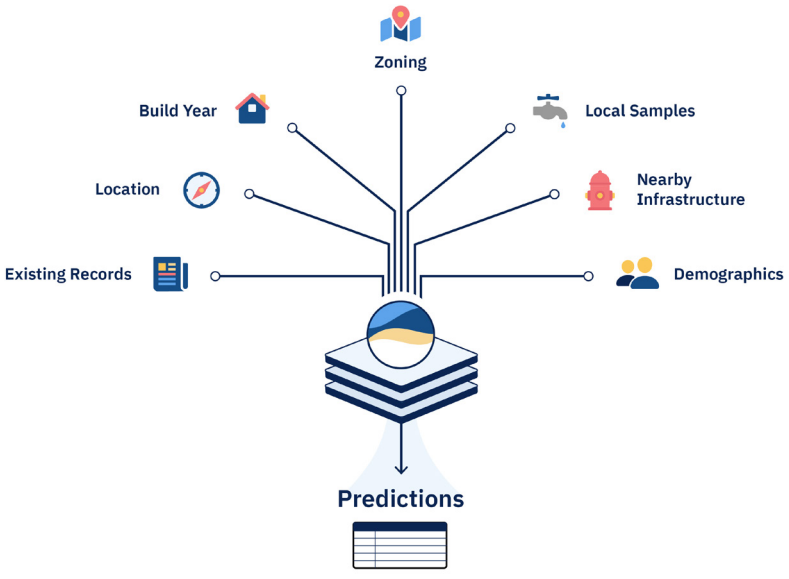
In the case of using predictive modeling to support decisions on GRR, it is important to note where predictions can be most useful. For example, in the case that the utility segment of the service line is known non-lead but the customer segment is unknown, predictive modeling can help in understanding the likelihood of galvanized versus non-lead on the customer segment of the line. By getting more clarity on the downstream materials (ie. customer segment of the service line), water utilities would use predictive modeling to classify service lines for their inventory based on the upstream service line material history (ie. utility segment of the service line).

The output data from the predictive model can then be used to inform prioritization in a service line replacement plan. By gaining clarity on the likely location of GRR and lead service lines across a water system, utilities allocate resources to areas of greatest need. The predictions are an important input into prioritization decisions, but they are not the only one. Including socioeconomic information about different communities within a water system can ensure equitable service line replacement. Integrating that information with other utility projects can identify other efficiencies. Predictive modeling is an option for water utilities with many unknown service line segments because it can fill in the gaps. Smaller water systems with relatively few service lines might find that verifying every service line or taking a conservative approach to classifying GRR to be the most efficient approach.

Many water utilities do not have records of LSLs or galvanized were ever being used in their service area. Statistical modeling can be a powerful tool for those water systems to demonstrate the likely absence of LSL or galvanized from their service areas. A recent blog post by BlueConduit dives into this question.

For more information on the best practices for use of predictive modeling for service line inventories, Association of State Drinking Water Administrators (ASDWA), Michigan Environment, Great Lakes and Energy (EGLE), and New Jersey Department of Environmental Protection (NJDEP) have created useful white papers and guidance to support utilities through the process.

Figure 4: Overview of Predictive Modeling Inputs and Process



Create Digital Records and Data

Additional best practices include digitizing service line inventory data for accuracy and data visualization. This includes following industry best practices for data quality control and assurance and the functionality to update the inventory in near real time. Data digitization will be a dual benefit to water systems that will be or are replacing service lines as well. Available products include functionality such as a data collector app that can be used in the field to identify exposed service line materials. Further, water systems can leverage opportunities to inform the service line inventory such as capital improvement projects and scheduled operations and maintenance activities for sampling and visual inspections. This may require cross collaboration across different departments within the water system such as engineering, operations and maintenance, and customer care.

Identify Challenges to Work on Private Property

Many water systems have an added challenge of ordinances or local laws prohibiting a public utility to work on private property. Therefore, it is important to identify if these prohibitions exist, determine the likelihood of GRRs, and then work with local officials to update or rewrite these prohibitions. Some States such as New Jersey have implemented State-wide laws to allow public utilities to complete LSL/GRR work on private property.

Track All Leaded Components

There are also many benefits of recording all leaded components in the service line inventory to be prepared for any forthcoming changes to the LCRR. EPA has considered the possibility of adding the presence of a lead connector (current or potentially historically) upstream of a galvanized service to the definition of GRR. Furthermore, each State primacy agency can adopt a varying definition of LSL based on the presence of leaded components such as lead goosenecks, connectors, and pigtails. Those water systems that have already eliminated LSLs entirely from their distribution system but have suspected or confirmed GSLs may need to perform additional work to document any remaining leaded components from the water main to the building inlet.

Take a Conservative Approach

Water systems that are not located within States with available guidance or requirements (Table 1) may use published requirements and guidance from other primacy agencies to develop a conservative approach. However, it is important to balance the cost of the approach in terms of overall labor and regulatory burden of assuming more service lines are GRR and would be replaced if there was a trigger or action level exceedance. If a water system does not have sufficient historic records and is unable to deploy any of the primacy agency approved tools and methods, the water system can likewise take a conservative approach. This would assume that any GSL is a GRR or any unknown service line is a lead service line. The EPA recommends using sub-categories of "Lead status unknown – unlikely lead" or "lead Status unknown-likely lead" (EPA, 2022). As stated above, this approach may have a higher overall cost for replacements and notifications to customers.

Leverage Existing Funding Opportunities

Water systems are encouraged to use the available and applicable funding opportunities, such as Bipartisan Infrastructure Law (BIL), State Revolving Fund (SRF) loans, Water Infrastructure Finance and Innovation Act (WIFIA) loans, municipal bonds, etc., for the identification and replacements of GRRs. However, there are concerns about existing local and state laws/ordinances preventing the use of public funds for private property LSLR activities. Those water systems with the local and state laws preventing the use of public funds on private property may face challenges with the identification and replacement on galvanized services on the upstream side due to the lack of funding opportunities. The forthcoming LCRI may provide further clarification on issues related to the service line ownership and funding; and until then water systems may evaluate other funding mechanisms.

Conclusions

The LCRR requires all water systems to determine service line materials, regardless of ownership. Galvanized service lines that are or were downstream of lead service lines or lead components can sorb lead and thus become a source of lead. The EPA definition of a GRR may be different than a stricter definition by the primacy agency. It is important to confirm GRR definitions and requirements with the primacy agency and to re-confirm as regulatory requirements including the LCRI are forthcoming.

In addition to following available Federal and State guidance with respect to GRRs, water systems can determine the best identification methods for their purposes. More than one of these methods may be employed and the process is iterative. It is also important to document the methods used and digital records and data can assist with overall inventory management. There will be challenges to working on private property that need to be taken into consideration for any method that requires access to the private premises. A conservative approach can be taken assuming all GSLs are GRRs, but this approach may increase overall costs. Additional considerations include recording all lead bearing components when developing the service line inventory, though not currently required by the LCRR, and applying for available Bipartisan Infrastructure Law, State Revolving Fund loans, Water Infrastructure Finance and Innovation Act loans, or municipal bonds, for the identification and replacements of GRRs. As GRRs can be a source of lead, identification and removal will reduce the overall risk of lead exposure.

About Jacobs

For more than 30 years, Jacobs has been responsible for planning and implementing Lead and Copper Rule-related strategies which protect millions of people in the U.S. and Canada. Our work includes enhanced water quality monitoring strategies, sampling plan development, harvested pipe-scale analysis, lead service line inventories and replacement plans, corrosion control studies and the incorporation of equity and environmental justice considerations into compliance programs.

About BlueConduit

BlueConduit is an Ann Arbor-based water infrastructure analytics company specializing in predictive analytics for lead service line identification and replacement and utilizes intelligent data insights and predictive machine learning methods to support cities and their engineering partners to inventory and replace lead service lines.

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