Lead & Copper

THE CHALLENGE

Lead and copper release to drinking water can be an issue for communities due the fact that drinking water passes through pipes and components made of lead and copper. There is no safe level of lead, and lead exposure has been shown to cause negative impacts to almost every organ and system in the body. Children under six and pregnant women are most susceptible to low levels of lead due to negative neurological impacts. Copper, on the other hand, is required to help our bodies function. However, ingesting higher levels of copper can cause temporary gastrointestinal distress. Copper can also be harmful to people with Wilson's disease—a genetic disorder where copper accumulates in vital organs.

Water leaving the treatment plant is typically free of lead and copper. Lead and copper usually enter drinking water through contact with the service line—the pipe that connects your home to the main in the street—or through contact with household plumbing. The service line and household plumbing can contain both lead and copper. The concentrations of lead and copper in water are regulated by the U.S. Environmental Protection Agency's (EPA) Lead and Copper Rule (LCR).

THE RESEARCH

Since the late 1980s, WRF has funded over 50 research projects related to lead and copper corrosion valued at approximately $20M. This body of research provides an understanding of the issues surrounding lead and copper corrosion and the LCR.

Because of the important public health implications of lead and copper in drinking water, WRF has partnered with EPA, UK Water Industry Research (UKWIR), the American Water Works Association (AWWA), and the National Science Foundation (NSF) on this research.

In addition, WRF is a member of the Lead Service Line Replacement Collaborative, which brings together public health, utility, environmental, consumer, and housing organizations to advocate for full replacement of LSLs through collective local efforts. The Collaborative disseminates information on LSL replacement practices and provides guidance on developing service line inventories, communication resources, policies, and more.

Occurrence and Compliance

In 1991, EPA published the LCR, which is meant to protect public health by minimizing lead and copper levels in drinking water. Since that time, it has undergone several revisions. In January of 2021, the EPA released significant revisions to the LCR. These revisions were then delayed to allow additional stakeholder input. The new effective date for the LCR revisions is anticipated to be set for later in 2021 with a compliance date expected for late 2024. WRF has been at the forefront of this issue, helping water utilities understand the presence of these compounds in our water systems, preventing leaching, complying with current and pending regulations, and ultimately protecting public health.

In 1990, WRF took the proactive step of publishing *Lead Control Strategies* (406). At the time, EPA guidance on LCR

Lead & Copper Regulatory Framework

	Lead	Copper
Action Level	0.015 mg/L (based on treat-ment feasibility)	1.3 mg/L (based on prevention of potential health problems)
Maximum Contaminant Level	N/A	N/A
Maximum Contaminant Level Goal	0	1.3 mg/L (based on prevention of potential health problems)
Secondary Maximum Contaminant Level	N/A	1.0 mg/L (based on aesthetics or taste and staining)

Source: U.S. Environmental Protection Agency. 2008. *Lead and Copper: A Quick Reference Guide*. EPA 816-F-08-018.

treatment plans was lacking, and this guidance manual filled the gap by helping utilities develop lead control strategies. The project identifies potential sources of lead in customer plumbing and variables that control the rate of leaching and lead in water samples, including the age and type of material, workmanship, size of pipe, water quality, size of the water sample, and stagnation time. The manual also provides practical considerations for controlling lead leaching from chemical treatment processes. The research determined that the most important water quality parameters for lead solubility are pH, alkalinity, dissolved inorganic carbonate, and orthophosphate levels. The manual recommends controlling lead with pH adjustment, alkalinity adjustment, and orthophosphate addition.

Lead in drinking water at the customer tap is almost exclusively the result of water contact with lead-containing components in the distribution system or household plumbing. If these lead-containing materials are present in the system, and the water causes corrosion through contact, lead can be released in a soluble or insoluble form, depending on the water chemistry. In 2015, WRF released *Controlling Lead in Drinking Water* (4409), which helps utilities understand why lead is present at the tap and how it can be prevented—breaking down the chemistry of the water that determines both of these factors. The research explores water chemistry parameters (e.g., pH, alkalinity, disinfectant residuals) and describes how they can be manipulated or accounted for in drinking water systems to control lead levels at the customer tap. The most common methods to minimize lead in drinking water are adjusting the water chemistry to produce stable water quality conditions that inhibit lead release, high-velocity flushing (especially inside the home) to remove particulate lead, and removing service lines and plumbing materials that contain lead. The report also describes an example of a lead service line replacement strategy.

Corrosion Control Strategies

To control corrosion and minimize lead levels in drinking water, utilities have several treatment strategies to choose from, including treating with phosphate-based chemicals and adjusting pH/alkalinity. However, water quality differences can significantly impact the effectiveness of these strategies.

Evaluation of Flushing to Reduce Lead Levels (4584) assesses the impact of high-velocity flushing (HVF) on the removal of lead from service lines and premise plumbing, and the subsequent impact on at-the-tap lead concentrations. The goals of the project were not only to see if HVF could successfully reduce lead levels at the tap, but also to see how frequently flushing needs to be repeated to maintain lead reduction. The research includes guidance to help utilities perform in-home tap flushing following a service line disturbance (i.e., a partial or full service line replacement). It also addresses flushing duration, frequency, and different options depending on the type of lead being released (dissolved or particulate).

The research shows that HVF is not recommended for houses without a preceding disturbance (e.g., lead service line replacement or other triggering disturbance), under the conditions tested in this study, since HVF creates disturbed conditions that would otherwise not be present. HVF is, however, recommended following partial or full lead service line replacement. The data from this study indicate that the use of HVF after these types of disturbances results in lower lead levels at consumer faucets, but not always right away—some time may elapse before improvements in lead levels are detected. Therefore, consumers should be instructed to take precautionary measures until the data indicate that lead levels have been reduced.

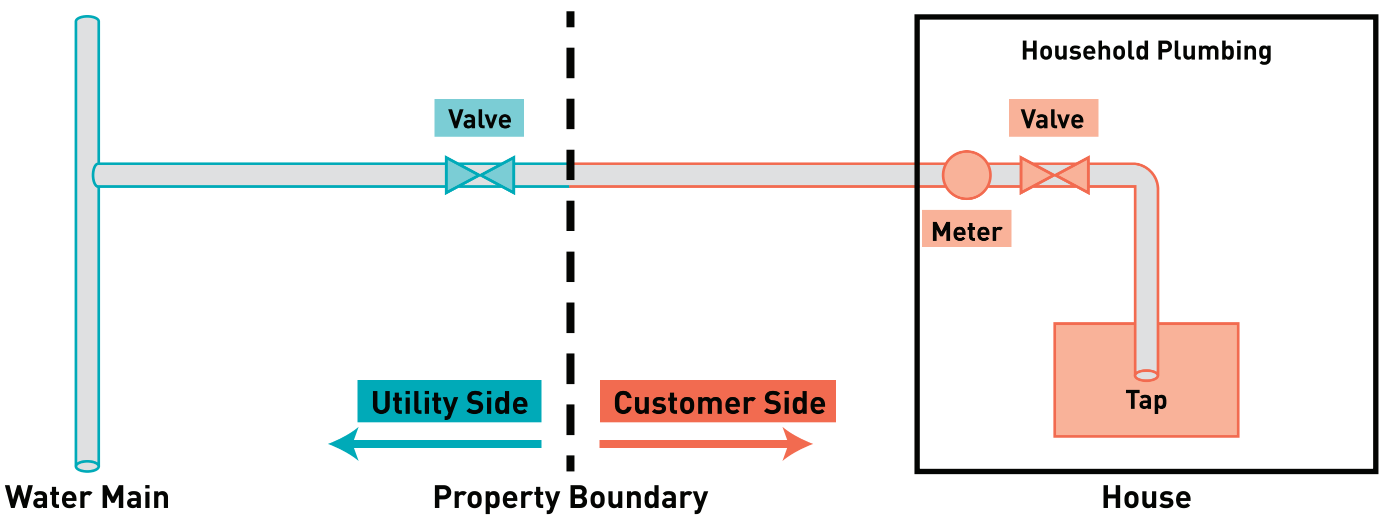
Many utilities rely on phosphate treatment strategies to protect against corrosion and lead leaching into distribution systems, but drinking water utilities are beginning to realize that the use of these chemicals can have unintended consequences for wastewater treatment plants downstream. In 2017, WRF published *Optimization of Phosphorus-Based Corrosion Control Chemicals Using a Comprehensive Perspective of Water Quality* (WERF2C14/4586). This project assesses the impact of phosphates on the environment and on waste-water treatment facilities after the phosphates have left the drinking water system. The findings emphasize a comprehensive perspective for control of distribution system water quality issues, including lead and copper release. In this perspective, all distribution system water quality issues are interrelated; they are all manifestations of the complex interactions between a complex solution of water and a complex composition of pipe wall accumulations.

Utilities contemplating the use of a phosphate-based corrosion-control chemical should begin a dialogue with the associated wastewater treatment facility personnel. The report lists steps for evaluating the impact of corrosion-control strategy on meeting phosphorus discharge limits. Utilities should consider the impact of the phosphate on the receiving body of water, especially using the phosphorus discharge limits determined by regulatory agencies.

Service Lines and Plumbing Fixtures

Lead service lines (LSLs) and plumbing fixtures are a topic of high interest for utilities, and a top priority for WRF research. Completed in 2021, *Full Lead Service Line Replacement Guidance* (4713) evaluated strategies to reduce lead exposure after conducting full lead service line replacements (FLSLRs). The research provides easily understood guidance and reference materials for staff at any U.S. or Canadian water system to use when planning and implementing FLSLRs. The research team conducted a literature review of current information related to limiting lead release following lead service line disturbances and evaluated the effectiveness of flushing to reduce lead exposure following FLSLRs at single-family homes. The research identified lessons learned from utilities that have monitored lead release following FLSLRs. Participating utilities conducted field studies at over 100 locations during this project.

The most effective way to reduce the total mass of lead measured at the tap is to replace the entire lead service line, followed by replacing lead sources in the premise plumbing, the faucet, and then the meter. Replacement



Source: Adapted from Hayes, C. (ed.) 2010. Best Practice Guide on the Control of Lead in Drinking Water. London, UK: IWA Publishing. With permission from the copyright holders, IWA Publishing.

The ownership of service lines between the utility (public space) and homeowner (private property) presents a challenge to full service line replacement.

of faucets and end-use fittings may or may not improve lead levels at the tap; however, it may be appropriate at sites without lead service lines that experience elevated lead levels in first-draw samples. Elevated lead levels may occur immediately after lead source replacement and may persist for longer periods, dependent on the materials and water quality at each site, and the amount of disturbance during replacement.

Under the current LCR, water systems that are unable to reduce their lead levels after implementing various treatment techniques are required to replace at least 7% of LSLs in their distribution system annually. A water utility is only required to replace sections of service lines that it owns. If a system does not own the entire LSL, then the system is not required to replace the privately owned portion. This results in a partial lead service line replacement (PLSLR). Figure 1 highlights the discrepancy between utility and privately owned service lines. In this example, service line ownership changes at the property line. This is a simplified representation and the actual ownership can vary by utility.

WHAT'S NEXT?

In 2017, WRF initiated a research priority area specifically dedicated to lead and copper management. This research will continue to evaluate service line disturbance challenges, explore corrosion control methods, and provide resources for utilities to communicate with their stakeholders on lead and copper issues.

While it is well known that lead exposure at customer taps can come from lead pipes, leaded solder, and brass fittings and fixtures, galvanized iron pipes (GP) can also contribute to lead exposure at customer taps. Recent studies have shown the potential for GPs to be a source of lead, especially if the GPs are downstream of a source of lead. However, even if there is no upstream lead source, GPs can contain up to 2% lead in the zinc coating and contribute to lead in drinking water levels. In addition, accumulated lead can remain in GPs after the removal of any upstream lead sources. Funded in 2018, *Evaluating Key Factors that Affect the Accumulation and Release of Lead from Galvanized Pipes* (4910), will develop cutting-edge tools to evaluate links between GPs and lead release. The research team will scientifically assess customers' concerns related to GP corrosion and possible association with lead in water, characterize the nature of iron and lead release to drinking water from known sources, and examine iron and lead release from GP using bench-scale testing. In addition, public education materials will be developed related to GP and lead release.

Lead and copper will continue to be concerns as long as drinking water pipes and fittings contain those materials.

Utilities need to better understand when and how to conduct corrosion control studies. Changes in source water, water quality, action level exceedances, and other events can trigger the need for a corrosion control study. Funded in 2019, *Analysis of Corrosion Control Treatment for Lead and Copper Control* (5032) will provide guidance based on science and utility experience for state regulators and water systems recommending when and how to conduct a corrosion control study in anticipation of a treatment change, water quality change, or a requirement/desire to lower lead levels.

The proposed LCR includes language that requires utilities to conduct corrosion control studies using a pipe loop. Pipe loops can take many forms and be different for every utility. Starting in 2021, *Guidance for using Pipe Loops to Inform Lead and Copper Corrosion Control Treatment Decisions* (5081) will provide "fit for purpose" guidance for corrosion control pipe loop construction, operation, sampling, and data interpretation to inform pipe loop implementation for corrosion control studies.

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