Pause Button and Mass Water Filtration for the City of Milwaukee:

A Not So Modest Proposal to Shape the Lead Water Policy Discussion Moving Forward

Jim Bohl, Alderman, 02.26.18

No one wants our children to drink water contaminated by lead. We naturally find the thought abhorrent and want something, anything, done. So often we want simple solutions and replacing lead service lines seems like an easy answer. The problem is that lead in water is a complex issue and not an easy one. Lead service lines have become public enemy number one in the lead water narrative and the notion that their replacement eliminates the problem of lead in the water is a perception that many hold.

The cost of completed lead line replacement in the city is exorbitant. Early estimates placed the figure at upwards of $750 million for completed service line replacement in current dollars, and a recent estimate by DPW pegs the cost at over $1 billion. The sporadic work conducted across the city in 2017, not having achieved an economy of scale, has been given as $13,100 per line in replacement cost. Given the present annual spending levels and anticipated future replacements over the next few years, it will take the city somewhere between 75-100 years to complete the work. Also, and this is critically important, the replacement of service lines does not come close to eliminating all possible sources of water-delivered lead exposure, which includes significant sources of interior lead in most homes in the city, and may also impact homes never having a lead service line and even homes of more recent construction.

We are creatures of habit. Opinions and minds are shaped by bits of information shared through media, social media, or even health experts; even though these sources are sometimes wrong or more likely paint a far-from-complete picture of the problem at hand. This is compounded when the media jump on the first or perceived obvious source of lead outlined and runs with it. Such is the case with lead service lines. The sensationalism that ran from the tragic episode of Flint, Michigan provides a case study in how knee jerk information and solutions can result from a real and significant problem.

Misinformation and misinformed solutions on lead are not solely a product of an under-informed press or social media hype. Even purported local health experts have a tendency to parrot the policies of federal health agencies which can be decades behind the science in their talking points and action plans. Case in point for this became evident during deliberations of the City of Milwaukee Water Quality Task Force Hearings in 2017. The City of Milwaukee Water Works and Health Department (MHD) were following and encouraging a U.S. Centers for Disease Control and Prevention (CDC) policy urging residents to flush water pipes if they sit stagnant for six or more hours.

During a hearing on this issue, I questioned the lack of logic in that reasoning. I raised the point that, "surely if lead leaches into water during periods of stagnation due to prolonged exposure of chemicals added for water safety, then wouldn't two, three hours, or certainly five hours stagnation time also allow sufficient exposure for significant leaching to occur?"

I brought evidence to the meeting of a 2000 study done by D.A. Lytle and M.R. Schock in the *Journal of Water Supply* titled "Impact of Stagnation Time on Metal Dissolution of Plumbing Materials in Drinking Water." This study revealed that the EPA based its six-hour time frame on a "worst case" lead or copper exposure period. In Schock's review of investigations done, he determined that lead levels in treated drinking water rapidly increased and merely reached an equilibrium at approximate periods of "overnight" stagnation. This corroborated results from an earlier study in which leached copper was shown to have increased to maximum value in some experimental conditions following as little as two to three hours of stagnation.

Fortunately, the argument for revising the recommendation won the day and led to a review and revision of public information being disseminated by the MHD. While positive, this still left some vexing questions. What happens when there isn't someone who can take the time and effort to search, review, thoroughly study and reflect on an issue, and then be afforded a position to try to realistically prescribe and obtain a change in governmental health policy? How could it be that nobody in the MHD questioned the efficacy of this policy? This logic was akin to arguing that cooking a turkey in a 350 degree oven for five hours would yield a fully raw turkey for nearly the duration of cooking time, but that, miraculously, at the six-hour mark, the turkey would instantly transform into a fully-cooked bird.

It is easy to see why this happens. Health department officials follow a chain of command that leads upward to their proverbial Wizard of Oz -- health policy espoused by the CDC. The CDC represents grants for health services and grants are the mother's milk of local health departments.

As someone who takes health policy seriously, I find this blind allegiance disturbing. Further, as was evidenced in Flint, the various Federal health and safety agencies are capable of providing un-sound health advice, supporting questionable policies, ignoring warnings, and mandating efforts to retrench and cover their tails when problems are exposed. The current dilemma of broken information chains and maintaining a "unified front" in health policy currently under investigation in the city of Milwaukee presents another side of this. It shows how some antiquated national health policy is kept in the forefront with few questioning it because after all, "they are the experts."

Equally as dangerous, however, can be solutions proffered by well-intended policy makers who often respond to the immediacy of events, the whims of media, and public perception shaped from bits of information and sometimes misinformation. Because most are not health experts and because of the complexity of their jobs, policy makers may have done little-to-no self-education on the topic at hand, and may rely on what they read in the paper, hear from constituents, and receive as information from their local health experts. And, when these sources present our policy makers with outdated or incomplete information or solutions, we enter a vicious cycle with the net result being policy that is far from optimal.

Such is our present state and it provides the backdrop of this "not so modest proposal." It represents food for thought to drive deeper debate on our current city lead policy, which, in my opinion, attempts to address the complexity of the lead water crisis, and other sources of lead impacting residents, in a flawed way.

The direction laid out in this proposal may not be the perfect answer. Nobody short of God has that. My attempt is to look for a policy that maximizes both short- and long-term safety of residents, taking into account science and the evidence at hand, and factoring in the realities of the city's present fiscal situation.

The first step in finding an improved policy on lead water reduction efforts involves moving beyond the mistaken notion that replacing service lines is "the solution." It is not. A 2008 EPA/AWWA study on lead sources at the tap identified 40% of the lead mass in water drawn from sequential sampling in one Washington, D.C. study as coming from either an interior faucet or interior premise sources. Similar testing in Madison, Wisconsin showed only 49% of the lead in water as coming from the service line and 38% from interior faucet or premise sources, with the remainder coming from the water main (EPA/AWWA "Contribution of Service Line and Plumbing Fixtures to Lead and Copper Rule Compliance Issues," 2008—figures cited are contained in Ch. 3).

It is not difficult to deduce from this the possibility that some percentage of homes with a lead service line may have greater sources of lead leaching into water sources that are originating from internal sources of lead rather than from a service line. Additionally, some homes that have no service line and even those of newer construction where service lines were not installed may also be at risk of excessive lead exposure.

One example cited in the addendum of this report shows a case of excessive lead water levels in new homes constructed after 1999 in Seattle. Ten of 95 tested homes in a newly constructed subdivision revealed levels of lead exceeding the EPA threshold and the culprit was lead solder used in internal plumbing.

Further evidence can be extracted from the 1,556 tested water fixtures in MPS schools exceeding EPA action levels for lead in 2016. Of importance is that not one of the approximately 169 school buildings tested had a lead service line. One last example cited in the addendum of this paper is water testing done on homes in the city of Madison after service line work was completed, which revealed many homes still drawing excessive levels of lead at the tap. This topic was further addressed at a 2017 hearing of the city's Water Quality Task Force where it was revealed that the city of Madison still encouraged the flushing of water in homes despite the replacement of service lines because lead is not eradicated with that work being completed.

This policy of encouraging flushing after service line removal makes sense in light of the aforementioned EPA study of lead water draws in Madison revealing 51% of the lead drawn at tested taps is coming from sources other than lead service lines.

A good summary of lead water sources can be derived by an interesting article done by Yanna Lambrinidou, PhD. in *Lead Action News* ("Top Ten Myths About Lead in Drinking Water." Lead Action Volume News, Vol. 18, No. 2, Oct., 2017, p.9).
http://www.lead.org.au/lanv18n2/LANv18n2-Truth-about-lead.pdf

The third myth cited by Dr. Lambrinidou is that "lead in drinking water is a 'legacy' problem affecting only homes built before 1986. She cites information derived from the October 2016 E.P.A. Lead and Copper Rule Revisions White Paper
https://www.epa.gov/sites/production/files/2016-10/documents/508_lcr_revisions_white_paper_final_10.26.16.pdf

and a study done by Simoni Triantiafyllidou and Marc Edwards in the journal *Critical Reviews in Environmental Science and Technology* (Vol 21, 2012-Issue 13) on lead in water and its impact. http://www.tandfonline.com/doi/abs/10.1080/10643389.2011.556556

Among the estimates provided by these sources on U.S. homes are the following:

- 6.5 to 10 million homes have lead service lines containing 100% lead by weight.
- 81 million homes have interior lead solder containing 40-50% lead by weight.
- U.S. homes built between 1986 and 2013 have interior plumbing components containing up to 8% lead by weight.

What this shows is that while service lines have the highest content of lead by weight, and in theory present the greatest single potential source of lead, the number of homes with lead solder or other potentially dangerous sources of interior lead far exceeds those with service lines. Further, it would not be a stretch to believe that nearly all homes with service lines contain lead solder and other lead source plumbing components. If the argument commonly made that any amount of lead in a body is dangerous, does it not raise a question about how the mere replacement of the service lines "solves" the lead issue? Additionally, because the focus by media, social media, and misinformed government bodies has been that service lines are "the" source of lead in water, residents that have other potential sources of interior lead and no service line have been led to believe that they are "in the clear." The reality is that while their overall risk may not be as great as if they had a lead service line connected to their homes, they are far from being free of risk.

If these examples of the risk inherent in interior sources of plumbing are not persuasive, a recent University of Michigan study of the Flint lead water crisis adds more credence. In their assessment of the lead water issue there, the Michigan researchers concluded, "Despite the huge media attention focused on the service lines, one of the major takeaways from our analyses is that these service lines may not be the major driver of the lead in Flint's drinking water." Their analysis showed the difference between service line and interior sources of lead to be negligible (http://theconversation.com/how-big-data-and-algorithms-are-slashing-the-cost-of-fixing-flints-water-crisis-62525).

Collectively, these examples should raise questions about the effectiveness of lead service line replacement as a complete solution, and furthermore should cast doubt on information being disseminated that only homes/properties with lead service lines present risk.

Interior sources of lead in plumbing include lead solder and flux utilized to connect and seal fixtures, lead pipes in very old homes, galvanized steel piping that utilize a zinc-lead coating as a rust inhibitor, and brass fixtures and parts that utilize heavy portions of lead in its construction. Most faucets purchased prior to 1997 were constructed of brass or chrome plated brass which contain up to eight percent lead (http://www.mwra.state.ma.us/04water/html/Lead_Faucets.htm). Additional information is included in the Addendum below.

An "all hands on deck" approach to water safety is a must from day one. The only tried and tested way short of a complete overhaul to both interior and exterior sources of plumbing is through effective use of filtered, lead-free water from a NSF/ANSI standard 53 water filtration device.

If the mere removal of lead service lines is not a complete answer for the lead water conundrum, the question to ask then is, "Is there a more thorough and affordable answer to this problem?" The answer to this, whether it is viewed as a short or long term solution, lies with lead removing water filtration devices. Yet in answering one question we merely move to another issue-- how to get to water filter use in a comprehensive way to significantly reduce the risk in neighborhoods where we know children are testing at high rates of lead?

We must establish a standard for use of lead water filtration like seatbelt laws where the accepted norm in society is to buckle up when you get into your car. Residents must know that lead is not solely confined to service lines. They must be informed that the likelihood of bottled water purchased from grocery stores have no mandate to be filtered using a lead-free filtration process and that the federal standard for bottled water is not zero lead but 5 parts per billion. They must know that homes have various sources of lead, including numerous interior sources in indoor plumbing, and that all these sources present a real and significant risk to lead exposure. They need to know that removing lead service lines, while remedying one potential source of lead in water, does not automatically eliminate the risk. They need to know that if they live in a home of newer housing stock, built well beyond the years of lead service line use, that they still can be exposed to high levels of lead due to lead solder, residual lead matter in

galvanized steel pipes, or lead-brass water fixtures. They need to know that just because their home's water source may be safe from lead, that drinking or eating from a contaminated water fixture at a school, a workplace, a daycare, a visit to grandmother or a friend's home, or even a restaurant could present a lead risk.

Purchasing environmentally safe water bottles and filling and bringing filtered water with you should become the new norm.

Clarification of these points and a massive campaign sharing this information should become the focus of the MHD, MWW, city leaders, and the media. The narrative of this campaign needs to be an end of the fiction that lead in water comes merely from service lines, including the narrative that if you don't have one connected to your home or have one that was removed, you are safe. In short, the only guaranteed safe water is that from a lead removing water filter. Further, all homes, schools and businesses should have and utilize filters.

Given this, city policy should be shifted where resources go to providing water filtration devices in large numbers, emphasizing dissemination particularly to households in high exposure, low-income census tract zip codes and neighborhoods.

Water filters should be provided first for properties with a known lead service line, but public information should continue to be shared that service line removal and/or homes without a lead service line are also encouraged to obtain and use proper filters. The city should immediately seek flexibility from the state legislature to utilize water works' revenues to support a mass campaign of providing water filters and replacement cartridges. The goal over the next four years should be to reach 50,000 households with free city filters with the push in reaching all low income and high lead incident rate areas in the city. After this figure is achieved and a new norm is established in the community over the use of filters, a campaign emphasizing continued purchase of filter cartridges can be weighed. During the ensuing four year filter program, those residents in the community who are able to purchase and use filtration devices should strongly be encouraged to do so.

Rather than add spending to escalate lead service line removal, which maximizes costs to the city, mass dissemination and habitual use of lead free water filters to low income areas should be emphasized. Healthy habits are not formed overnight and only by the city undertaking a significant initiative, whereby homes are not only provided with lead removing devices but also replacement filters, will this importance be conveyed.

This policy should end notions of expanding service line replacement beyond completing the lines and child care centers and ongoing emergency service line replacements for leaks in the short term. Only after we have established progress of lead safe water filtration use should coordinated projects in neighborhoods where sewer mains are scheduled or other viable cost-effective and farther-reaching options like lining of pipes, be weighed. Pushing a temporary pause button on a full service line removal policy short of emergency leak replacement will not only ensure a larger portion of the population is insulated from lead water risk, it will provide time to explore other options and may also provide the city with leftover funding for lead paint remediation efforts. The primary role of lead in paint as a vector for lead exposure has seemingly been lost in the lead water frenzy post-Flint.

Several discussions, including a current bill before the Council, have sought to force immediate replacement of service lines for city-acquired *In Rem* properties. Not only would this drive up the cost of service line replacement by eliminating the demonstrated effective cost containment achieved in coordinated projects, but its significant cost on a per unit basis will quickly eat up revenue sources that could be used to purchase and deliver the best-known way to provide a safe water source to low income families-- lead-removing water filters. Case in point for this policy problem comes from a discussion I had with the city's Water Works Superintendent, Jennifer Gonda in early fall and which was reiterated at a recent Common Council committee hearing. Ms. Gonda spoke of a single property with a lead service line leak at an unusually long juncture from an oddly-placed water main that had a cost of $28,000 alone for the replacement of its service line. The cost of this single replacement could have provided not only this home, but likely over 250 others with water filter systems for a year. To take on additional costs by seeking to add non-coordinated projects to the mix of service line replacements, including city-owned housing, makes no fiscal or health safety sense beyond the appearance of seeking a policy for its own sake. Unfortunately, after this policy was suggested, it initiated a demand from a small, vocal advocacy group in the community which called for its enactment under

threat of lawsuits against the city. What they did not seem to grasp is that the cost of replacing service lines in sporadically located city In Rem homes is much costlier than tackling service lines in a coordinated project on the same block. This has been proven in communities like Madison, Lansing, and other communities who have done service line replacement work. In essence, while the community group rightfully wants to maximize lead service line removal to reduce the lead water risk, they were advocating a policy that drastically drives up costs and thus would reduce the number of homes getting service lines replaced. A mass filtration program by the city fixes this problem.

After a four-year period of filter dissemination and mass public relations campaign, the city will hopefully have reached a critical mass of residents using lead-free filters. While some will argue that it is not the role of a local government to provide filters to families, unless an entity like city government steps in to provide them, it is doubtful if the public will take the issue of water seriously enough for it to change personal habits. While I have no hard numbers to quantify this, I would argue the social, economic and institutional costs of lead poisoning in a significant number of our children far outweighs any costs of establishing regular filter use. An added benefit is that the more cost-effective filter strategy would allow more money to be brought to bear to address lead paint remediation. Again, this important and often cited leading aspect of lead poisoning cannot be lost in the mix.

Under the proposal being made here, the city would ramp up filter distribution over a four year period and then afterward could ramp down while providing replacement filters to certain households, while establishing a means test system for ongoing purchase for certified low-income households. It would also "buy time" for the city to explore holistically the problem of environmental lead contamination.

One technology that holds promise for lead water remediation is pipe lining. The city has been lining return sewerage main lines and private side sewer laterals for a number of years now. Similar lining technology for water system delivery has been used in places like the United Kingdom for a couple decades. Additionally the technology also may be used to add a protective layer to interior plumbing, therefore mitigating both exterior and interior lead plumbing risks. One company that provides the technology touts a 50-year life expectancy on the product and 30-40% lower cost than traditional service line replacement. (https://pipelt.com/pipelining/)
Another firm advertises a 20-50% cost savings over replacement costs. (http://sandiegopipelining.com/pipelining-costs/)

Pipe lining has merit as it can be done without disturbing existing plumbing. While used in a number of other countries for a couple decades, it will need to be sufficiently tested for safety and durability here in the U.S. before commitment is made to it as a long-term alternative strategy.

In regard to water filtration efforts, I believe the city could realistically achieve dissemination to approximately 50,000 households in four-year's time. For calculating this, I've utilized $3.9 million being spent on the program annually over that four-year time frame, having derived the figure as the amount of revenue sources into lead service line removal from non-state grant levied funds in 2017.

The calculations below are based upon a single low cost unit that was obtained over the internet and verified by independent sources for effectiveness in lead removal. The unit is merely one example of a functional, cost-effective lead removing filter system. The city has many options such as expanding its partnership with the hometown A.O. Smith Corporation to provide Aquasana filtration systems to residents. Whatever filtration system is chosen, the purchase of mass quantities should enable some type of realized savings on units and filters by the city.

https://www.walmart.com/ip/ZeroWater-30-Cup-Dispenser-with-Free-TDS-Meter-Total-Dissolved-Solids-ZD-030RP/954669897?wmlspartner=wlpa&selectedSellerId=0&adid=22222222227105897029&wmlspartner=wmtlabs&wl0=&wl1=g&wl2=t&wl3=219761581676&wl4=pla-357049808615&wl5=9018847&wl6=&wl7=&wl8=&wl9=pla&wl10=8175035&wl11=online&wl12=954669897&wl13=&veh=sem

$35.99 for a 30 cup shelf unit lead free water dispenser.

https://slickdeals.net/f/10384580-zerowater-replacement-filter-for-pitchers-12-pack-zr-012-67-33-w-s-s

$114.99 for 12 replacement filters, but this figure was found at $67.33 with a subscribe and save deal.

Actual cost for the full unit and 12 replacement filters for year-round use: $36 +$68 = $104.

For reference here, I have rounded up to $120 the purchase of a single 30 unit pitcher with 12 replacement filters annually, and used $80 for future 12 replacement units annually as a cost estimate that may be achievable with a large quantity purchase. Also, if smaller, lower priced units are utilized, the number of potential homes provided with functional year round filtration systems could be increased.

Providing an ongoing source of replacement filters is inconsistent with the current city practice of distributing

a small number of water filtration systems annually but not issuing long-term replacement filters. This presents a problem. If you were a physician and you wanted your patient to take their medicine, you must ensure they have access to the medicine in the first place. Without the city providing some form of ongoing commitment to replacement filters, I just do not see enough families continuing filtration efforts under this scenario for the process to pay off.

YEAR 1:
$3.9 million divided by $120 = 32,500 households.

Total filtered homes = 32,500

YEAR 2:
32,500 existing households x $80 replacement units = $2.6 million
With $1.3 million left from the $3.9 million starting figure:
$1.3 million divided by $120 = 10,833 new households added.

Total filtered homes = 43,333

YEAR 3:
43,333 existing households x $80 replacement units = $3,466,640
With $433,360 left from the $3.9 million starting figure:
$433,360 divided by $120 = 3,611 new households added.

Total filtered homes = 46,944

YEAR 4:
46,944 existing households x $80 replacement units = $3,755,520
With $144,480 left from the $3.9 million starting figure:
$144,480 divided by $120 = 1,204 new households added.

Total filtered homes = 48,198

With $3.9 million spent annually in each of four years, the total number of households provided filters in four-year's time is 48,198 using conservative calculations. This is compared to 3,200 homes with conventional service lines removed using the rate of removal included in the 2018 budget where 800 homes are targeted for service line construction efforts (using even higher estimates of cost) if extrapolated over four years.

Further, if the city were to only rely on a policy of having 3,200 service lines being replaced, those homes would likely still have interior sources of water lead exposure, rendering the needed use for filters to still provide optimized safety. Such a policy could be carried out by having devices and replacement filters delivered to homes via a delivery service such as Amazon and thus limit city staffing needed to get supplies out to a sizable number of homes.

Any savings realized by putting a pause on service line replacement could be earmarked to supplement lead paint remediation efforts.

The proposal for providing a mass push toward private water filtration in homes is more thorough, less costly approach and can provide immediate impact to a significant number of households as opposed to the partially effective but expensive lead service line removal process. This is not to say something shouldn't be done with lead service lines. From a lead water perspective, they are an albatross in waiting. The city may opt for continued long-term service line removal or could shift to lining or some other approach to deal with the laterals. Whatever long-term approach is ultimately chosen, it should not deter city leaders from considering a short-term partial pause on proactive service line removal (with the exception of continuing work on day cares and emergency breaks) while a massive short-term "surge" in providing water filtration devices and replacement filters to high lead-affected households and areas is enacted. The multi-year hiatus on proactive service line replacements with scheduled sewer main work, though not ideal, will enable us to provide a more all-encompassing approach to water safety through filtration, while at the same time allowing us to move beyond frenzied approach to remediating lead. Our method in dealing with lead needs to be comprehensive and holistic and needs to function on remediating primary sources of lead in homes-- devoting sufficient city resources and using science, and not popular misconception, to drive our policy.

ADDENDUM

WHY FILTERS ARE NEEDED:
Examples of Interior Sources of Lead that Provide Evidence to Service Line Removal Not Being an End-All Policy

Milwaukee Public School Water Fixture Testing:

In 2016 - 1,556 fixtures tested in 169 school buildings registered above a 15ppb Environmental Protection Agency (EPA) standard of excessive lead, including 82 fixtures in one school building alone. Of those 1,556 fixtures that exceeded the 15ppb EPA limit, 183 were drinking fountains, colloquially referred to as "bubblers." Some of the lead readings were off the charts in terms of contained level of lead toxin. What is more, the 15ppb level is not a baseline acceptable level in science such as the American Academy of Pediatrics but an arbitrary line used by the EPA. Not one of the MPS schools tested had a lead service line. Not one! These were all examples of fixtures that drew lead based upon solder, flux, or brass fixtures as sources of lead.

http://fox6now.com/2017/01/11/which-mps-schools-had-the-most-sources-of-lead-in-water-fox6-investigators-have-the-list/

https://localtvwiti.files.wordpress.com/2017/01/pdf-of-schools-list.pdf

https://www.wpr.org/testing-results-show-majority-milwaukee-public-schools-water-fountains-meet-epa-standards

https://www.wisconsinwatch.org/2016/12/regulatory-vacuum-exposes-wisconsin-children-to-lead-in-drinking-water-at-schools-day-care-centers/

University of Michigan Testing of Flint Concluding Interior Sources of Lead May Be The Largest Lead Contributor in Homes

(Excerpts quoted directly from the source cited below the excerpts)

A report from the University of Michigan found home lead service lines may not be the largest contributor of lead in Flint, despite the push by the city to replace them all.

Large spikes of lead occur in homes with and without lead service lines, according to the study's initial findings released online Thursday.
This suggests a large fraction of the dangerously high lead readings are probably not being driven by the service line material but instead by other factors," Jacob Abernethy, assistant professor of electrical engineering and computer science, and Eric Schwartz, an assistant professor of marketing, wrote in an online posting on an academic website called The Conversation Thursday morning.

"Civil engineers who study these problems report that lead can leach from several sources, including the home's interior plumbing, faucet fixtures and aging pipe solder."

The city could have more than 10,000 pipes composed of either lead or galvanized steel contaminated by lead that need to be replaced, according to preliminary estimates. Lead flakes can build up on the walls of corroded galvanized steel pipes and the slough off into the water supply.

Pipes made of copper or plastic are generally considered to be safe.

"What we can conclude is that citizens as well as policymakers may need to widen their focus beyond the service line materials and consider alternative efforts to address other sources of lead," the professors wrote. "Service line replacement is certainly a necessary part of the solution, but it will not be sufficient."

https://www.freep.com/story/news/local/michigan/flint-water-crisis/2016/09/08/study-flint-lead-contamination-goes-beyond-service-pipes/89994636/

University of Michigan Study: Home service lines may not be the largest contributor of lead

(Excerpts quoted directly from the source cited below the excerpts)

Despite the huge media attention focused on the service lines, one of the major takeaways from our analyses is that these service lines may not be the major driver of the lead in Flint's drinking water. Yes, it is the case that those homes with copper service lines have lower lead levels, on average, than those with lead in their service line. But when you look closely at the water testing data, the differences are much smaller than you might think.

While it is difficult to determine with certainty due to the spotty records, what we have found is that large spikes of lead occur in homes with and without lead service lines. This suggests a large fraction of the dangerously high lead readings are probably not being driven by the service line material but instead by other factors.

Environmental engineers who study these problems report that lead can leach from several sources, including the home's interior plumbing, faucet fixtures, and aging pipe solder.

We can look at homes that, based on records and home inspections, appear to have copper-only service lines versus those containing some lead. We plot the distribution of the lead readings for water samples from these two home categories.

What we can conclude is that citizens as well as policymakers may need to widen their focus beyond the service line materials and consider alternative efforts to address other sources of lead. Service line replacement is certainly a necessary part of the solution, but it will not be sufficient.

http://theconversation.com/how-big-data-and-algorithms-are-slashing-the-cost-of-fixing-flints-water-crisis-62525

Evidence of Newly Constructed Homes with Excessive Lead Water Levels

10 of 95 new homes built after 1999 in Seattle that were tested after suspected lead contamination of a child in one home showed signs of lead poisoning revealed excessive lead levels based upon EPA standards. The source was found to be lead solder used in the plumbing as none of the new homes had any plumbing lines that utilized lead.

https://www.businesswire.com/news/home/20040708005684/en/Contamination-Lead-Solder-Household-Water-Pipes-Toxic

Madison Shows Spikes in Lead of Homes with Lead Service Lines Removed

(Excerpts quoted directly from the source cited below the excerpts)

"The federal rule doesn't take into account the complex nature of drinking water systems, which can deliver hazardous, temporary spikes in lead levels that aren't detected by infrequent federally mandated sampling," Cantor said.

When samples show too much lead in more than 10 percent of samples, the EPA calls for adding chemicals that create a coating on pipe interiors that prevents water from absorbing the poisonous metal. Cantor said it works well on new lead pipes.

"But the problem is the pipes in this nation are not nice clean new lines," Cantor said. "They are filled with a lot of precipitants ... what I call a soup of metals and microbiological issues."

Even after Madison replaced most of its lead pipes, spikes in lead content were discovered. The city countered the problem, but it illustrated one of scores of complex, difficult-to-predict interactions that occur in water supplies.

http://host.madison.com/wsj/news/local/environment/years-before-flint-s-scandal-madison-did-unusual-costly-lead/article_92caa8ab-5d0e-5c01-a48a-210d72828240.html

Experts, Including Marc Edwards and Haizhou Liu, Opine on Flint Study

(Excerpts quoted directly from the source cited below the excerpts)

"Some people think, 'If I get rid of the lead pipes, there's no lead in my water,'" Edwards says. "[That's] not true." Definitively solving the lead pipe crisis will require more drastic efforts than just replacing existing pipes—it will require an expensive, time-consuming rehaul of the city's entire plumbing system.

Flint is now in the midst of an effort to replace the city's thousands of lead pipes, but it's unclear how long it will take or how much it will end up costing.

Haizhou Liu, an environmental engineer at the University of California at Riverside who studies corrosion and water quality, praised the study's "careful sampling," and said it shows how crucial phosphates are to controlling corrosion in water systems. More importantly, he says, it portends the future America faces with outdated water systems in the 21st century. "In my opinion, the Flint story reveals the challenges to maintain our aging water infrastructure nationwide," says Liu, who was not involved in this study.
While not a new revelation to experts, Edwards says this study exemplifies how lead from main service pipes can build up in the galvanized iron pipes used inside and outside of many American houses built before 1987, and leach from those pipes into the water even after the lead pipes are gone.

Using samples taken by Walters in January 2015 and sections of the iron pipe that connected Walters' house to the lead service pipe, Edwards was able to pinpoint the contamination patterns."

https://www.smithsonianmag.com/science-nature/chemical-study-ground-zero-house-flint-water-crisis-180962030/

Study Shows Lead from Interior Galvanized Steel Pipes Significant Long-term of Lead

(Excerpts quoted directly from the source cited below the excerpts)

"When unsafe levels of lead are found in drinking water, the culprit has typically been lead pipes or lead-containing brass and bronze fittings, but in a new study researchers clearly show that lead present in the zinc coating of galvanized steel pipes can be a very significant long-term source of lead in water. Copper piping installed upstream of a galvanized steel pipe can worsen lead release from the steel's zinc coating, according to the study published in *Environmental Engineering Science*.

In "Lead Release to Drinking Water form Galvanized Steel Pipe Coatings," Brandi Clark, Sheldon Vaughn Masters, and Marc Edwards, Virginia Tech, Blacksburg, VA, analyzed water samples from homes with galvanized steel pipes in several cities across the U.S. In some cases the lead levels were greater than 100 µg/L. In simulated laboratory tests the concentration of lead in water found through galvanized steel pipes reached a maximum of 172 µg/L, which is more than 10 times the action level set by the U.S. Environmental Protection Agency."

Read more at:
https://phys.org/news/2015-07-source-galvanized-steel-pipe-coatings.html#jCp

https://phys.org/news/2015-07-source-galvanized-steel-pipe-coatings.html

https://www.researchgate.net/publication/279278498_Lead_Release_to_Drinking_Water_from_Galvanized_Steel_Pipe_Coatings

ADDITIONAL DOCUMENTATION
On the Risk of Galvanized Steel Interior Plumbing

https://www.bigberkeywaterfilters.com/blog/lead/galvanized-steel-pipes-leach-lead-into-drinking-water/

http://www.thetimesherald.com/story/life/2016/02/13/galvanized-pipes-home-cause-lead/80360854/

(Excerpts quoted directly from the source cited)

'But here is the catch. There are still many older homes that have the old-fashioned galvanized steel water lines. Galvanized piping has the tendency to accumulate lead deposits over time. As galvanized steel pipes corrode within and form rust, lead that has accumulated over decades is likely to be found deep in the interior walls of those rusty pipes.

Simply changing the outside water mains that provide the water to the house may only be a part of the solution. Domestic municipality water lines run the water to the house, provide a "stop box" (a large shut off valve) and then from that point on the water pipes are installed by whoever built the house. It becomes the responsibility of the homeowner. If you have a well instead of domestic city water, it is important to have the water from a well-type system tested because that water is put into the pipes directly from the well."

https://www.thecleanplumbers.com/know-galvanized-steel-pipes/

(Excerpts quoted directly from the source cited)

Why Is Galvanized Steel Piping No Longer in Widespread Use?

Despite galvanized steel piping's ability to withstand corrosion, it is inevitable the protective zinc layer will erode due to constant exposure to moisture. Most of the zinc erosion takes place inside galvanized pipes first, and this leads to an ever-increasing buildup of corrosion byproducts. These byproducts are not harmful to human health, but they greatly restrict the flow of water.

Another concern with the use of galvanized piping for water transport is a process known as a galvanic corrosion. All metals transfer ions to neighboring metals, and dissimilar metals transfer ions much more quickly. Galvanic corrosion results in the eventual destruction of the zinc as its ions are transferred to the steel and other metals that may contact it.

This problem is particularly accelerated whenever galvanized pipes are joined to fittings made from brass, copper, or other metals. Leaks are prone to occur at these locations as a consequence.

http://americanvintagehome.com/advice-for-older-homes/need-swap-galvanized-pipes/

(Excerpts quoted directly from the source cited)

Do galvanized pipes contain lead?

The galvanized pipes installed on water lines between 1880 and 1960 were dipped in molten, naturally occurring zinc. Naturally occurring zinc is impure, so these pipes were bathed in zinc that also contained lead and other impurities. The zinc coating elongated the life of the steel pipes, but added small amount of lead and other substances that could potentially harm inhabitants.

Additionally, if your galvanized pipes were ever connected to lead plumbing (including service lines) there is more cause for concern. The corrosion inside galvanized steel pipes could have trapped small pieces of the lead. Even if the lead piping was removed years ago, the galvanized steel pipes could still periodically release the trapped lead into the water flow. Chicago didn't stop using lead pipes for service lines until 1986, and an estimated 400,000 lead service lines are still in use in Chicago alone.

The only way to ensure that lead is not mobilized from plumbing to tap in a given home is to fully replace the galvanized plumbing and any lead service lines.

https://www.squareoneinsurance.com/galvanized-steel-plumbing

(Excerpts quoted directly from the source cited)

Is there a risk of lead contamination?

The service lines, which connect your home's plumbing with the water main, are normally made of copper. However in older cities in the Eastern parts of the US and Canada, may still have service lines made of lead. Many homes have had this lead service pipe removed and upgraded with modern plumbing material, however for homes that had galvanized plumbing while their lead service lines were in-place there exists another area of concern. Galvanized piping has been found to accumulate lead that has leeched into the water from the old lead service lines. As the galvanized plumbing corrodes (as it inevitably will do), it releases this built up lead back into the water.

http://www.essentialchemicalindustry.org/metals/zinc.html

(Excerpts quoted directly from the source cited)

Uses of zinc:

Zinc is used as coating to protect iron and steel from corroding in the atmosphere, water and soil. This is because zinc reacts preferentially to iron in most environments to form protective layers of oxide, carbonate or other zinc reaction products that are resistant to subsequent corrosion by the atmosphere. Even if the coating is scratched it continues to corrode preferentially and protect the iron. Zinc is the sacrificial metal.

There are various methods of coating iron and steel with zinc. One is to dip the article into a bath of molten zinc, a process known as *hot dip* galvanizing.

Manufacture of zinc:

Nearly all zinc is obtained from sulfide ores, which also usually contain lead, cadmium and other metals such as iron and silver. The most commonly occurring ores are sphalerite, also known as zinc blende (ZnS), and another variety of sphalerite called marmatite which contains significant quantities of iron sulfides."

https://www.lenntech.com/periodic/elements/pb.htm

(Excerpts quoted directly from the source cited)

Lead In the Environment:

Native lead is rare in nature. Currently lead is usually found in ore with zinc, silver and copper and it is extracted together with these metals."

http://www.williamhunter.co.uk/ZINC/relationshipznpb.htm

(Excerpts quoted directly from the source cited)

Zinc:

"The standard zinc product is Special High Grade zinc, with an assay of 99.995% zinc, i.e. it can contain a maximum of 50 parts per million of impurities. There is also a much lower grade of 98.5% zinc, the main impurity being lead, and this used to be the standard grade, called GOB (Good Ordinary Brand) in Europe or PW (Prime Western) in North America. The predominance of this grade as the one used in applications when the production of zinc first became established came about because it was a very suitable quality for general galvanising *and* because it was the natural grade produced by thermal smelting processes. The complete separation of lead from zinc was not easy."

http://www.metalbulletin.com/events/download.ashx/document/speaker/7916/a0ID000000X0kGUMAZ/Presentation

Prime Western Zinc coating of Galvanized Steel which may be used in a number of older homes has a zinc content of 98.5% and a lead content of 1.5%.