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ISSUE BRIEF

GETTING THE LEAD OUT

REMOVING LEAD PIPES WOULD YIELD HUNDREDS OF BILLIONS OF DOLLARS IN HEALTH BENEFITS

The United States built drinking water infrastructure with lead pipes for well over a century, despite being aware of the health risks.[1] As early as 1893, for example, the *Washington Post* reported that experts were urging the local water utility to stop using lead pipes because of the health risks.[2] Yet cities across the country continued to use lead pipes for many decades at the urging of water utilities, local officials, and lead industry lobbyists.[3] Today scientists and health experts agree that there is no safe level of exposure to lead and that we should avoid such unnecessary exposures.[4]

Part of a lead service line removed from outside a home in Chicago, Illinois.

In addition to the long-known risks of lead, including increased risk of developmental delays and certain cancers, a formal Scientific Statement from the American Heart Association in June 2023 emphasized that there is significant evidence that exposure to lead is linked to numerous cardiovascular diseases including stroke and heart attack.[5] The risk of cardiovascular disease is especially high in populations of color and low socioeconomic means, due in part to greater lead exposure.[6] There is also strong evidence that people of color, and particularly Black children, are at substantially higher risk of having elevated blood lead levels than are non-Hispanic white children.[7] And mounting evidence suggests that lead-contaminated water occurs disproportionately in many communities of color.[8] Thus, reducing lead exposure has significant equity implications.

The largest source of lead in our drinking water is lead service lines, the lead pipes that connect homes to the water mains in the street.[9] The only way to be sure that lead will not leach or flake off from these lead service lines is to remove them from use and replace them with non-lead lines.[10] Ideally the replacements should be made of copper.[11]

Removing lead service lines would result in significant cost savings from avoided health impacts. This paper quantifies those savings, both state by state and nationwide, and finds that over the next 35 years the United States could save an estimated $786 billion in health costs.

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THE BENEFITS OF REMOVING LEAD PIPES

Recent analyses by Harvard School of Public Health researchers show that the health and financial benefits of removing all lead service lines and reducing lead levels in tap water through a variety of methods would be staggering, in the hundreds of billions of dollars.[12] Yet many of these benefits have not been widely publicized, are sometimes completely ignored, and are surprising to most policymakers and the public. For example, few people are aware of the strong evidence, as noted by the American Heart Association Scientific Statement, of the major risk to adults of cardiovascular disease, stroke, and even fatal heart attacks from low-level lead exposure, such as occurs from lead-contaminated tap water.[13] Indeed, nearly 90 percent of the monetized health benefits of reducing lead in drinking water derive from reduced cardiovascular disease and deaths, yet the U.S. Environmental Protection Agency's (EPA) most recent rules for lead in tap water fail to quantify these benefits.[14]

These Trump-era Lead and Copper Rule Revisions, issued in January 2021, made limited changes to the nation's regulations governing lead in drinking water.[15] In the revised rule, the EPA quantified only a small sliver of the health and economic benefits of reducing lead levels in tap water, monetizing only the economic benefits of avoided IQ decrements (losses) in children. (We know that lead damages children's brains and later performance, and that lower lead exposures result in higher lifetime earnings.)[16] Despite the limited rule revisions and narrow range of benefits considered in that 2021 rule, both the EPA's and independent analyses still show that large benefits will result from the rule's modest reductions in lead exposure.[17]

In this paper, NRDC builds on the Harvard researchers' efforts to quantify and monetize the full range of health benefits of reducing lead levels in drinking water. In creating state-by-state estimates of potential cost savings of removing lead service lines alone, we find that every state in the United States would reap substantial benefits from removing its lead pipes, from a minimum of hundreds of millions of dollars in states with few of these lead pipes, to as much as $99 billion in states overloaded with them. These benefits were calculated to accrue over 35 years (the assumed lifetime of the homes after the lead pipes are removed.)

The Harvard researchers drew on previously published and peer-reviewed EPA assessments to quantify and monetize a wide array of health benefits of reducing lead levels in drinking water.[18] They found that while there are enormous and crucially important benefits for children in reducing harm to developing brains, fully 88 percent of the monetizable health benefits of reducing lead levels flow from reducing cardiovascular disease and deaths in adults.[19]

These benefits—which are not all covered by the 2021 EPA Lead and Copper Rule Revisions—include:

Benefits for Children

- Reduced short-term damage to cognitive function
- Reduced behavioral problems (such as impulsivity, attention deficits and hyperactivity/ADHD) and reduced conduct problems (such as aggressive conduct disorders)
- Reduced hearing impairment

Benefits for Adults

- Reduced hypertension (high blood pressure)
- Reduced coronary heart disease
- Reduced mortality from cardiovascular disease
- Reduced preterm births
- Reduced harm to the male reproductive system
- Reduced depression, ADHD, and dementia
- Reduced risk of lung cancer

Lifetime Benefits

- Reduced immunological damage and asthma
- Reduced harm to red blood cells/altered heme synthesis leading to anemia
- Reduced developmental problems

One of the Harvard study's authors has extracted from that study data related to the health benefits of removing lead service lines alone.[20] These benefits are separate from the benefits of using corrosion control, which can, for example, reduce damage to water infrastructure and household plumbing. This information about the benefits of removing lead service lines alone is summarized in Table 1 and Figure 1.

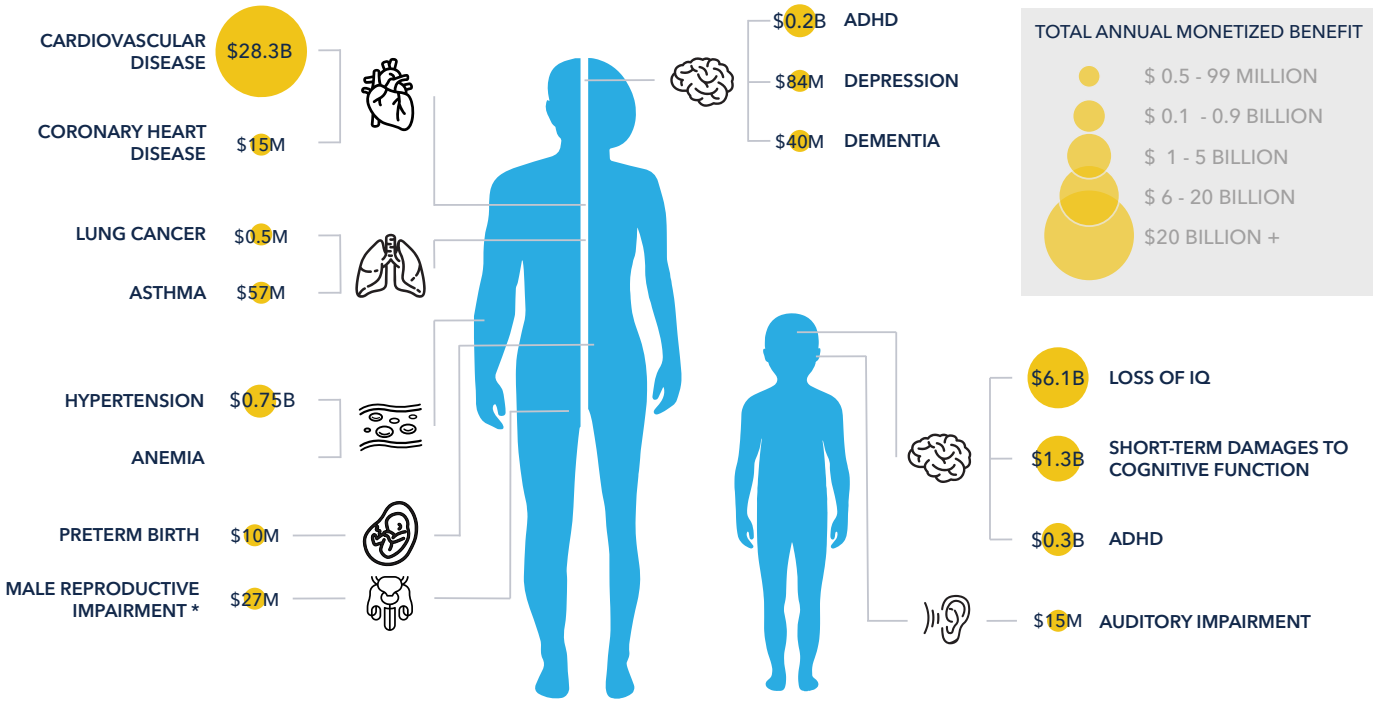
TABLE 1: ESTIMATES OF THE NATIONAL ANNUAL HEALTH BENEFITS OF REPLACING ALL REMAINING LEAD SERVICE LINES (2016 $)

Body system	Component assessed	Population	Aspect monetized	Monetized cost per case (2016 $)	Incidence	Total annual monetized benefit (2016 $)[21]
Nervous	Cognitive function decrements	Children	IQ earnings	$22,503 per IQ point	322,722	$6,136,000,000
	Cognitive function decrements	Children	Short-term damages	$42,208	30,000	$1,266,000,000
	Behavioral and conduct problems	Children	ADHD	$10,021	27,846	$282,000,000
	Sensory function decrements	Children	Auditory impairment	$14,999	970	$15,000,000
	Internalizing behaviors	Children				
	Cognitive function decrements	Adults	Depression	$57,518	1,440	$84,000,000
	Psychopathological effects	Adults	ADHD	$8,972	24,000	$216,000,000
	Psychopathological effects (alternative)	Adults	Dementia	$25,072	1,600	$40,000,000
Cardiovascular	Hypertension	Adults	Hypertension	$4,676	160,000	$752,000,000
	Coronary heart disease	Adults	Coronary heart disease	$15,958	900	$15,000,000
Immune	Immunological damage	Lifetime	Asthma	$45,908	1,250	$57,000,000
Blood	Decreased red blood cell survival and altered heme synthesis	Lifetime	Anemia	$3,000	20	
Reproduction and development	Development	Lifetime				
	Birth outcomes	Childhood & life	Preterm birth	$73,772	130	$10,000,000
	Male reproductive function*	Adult	Male reproductive impairment	$54,756	480	$27,000,000
Cancer	Cancer	Adult	Lung cancer	$239,918	2	$500,000
Mortality	Cardiovascular	Adult	VSL	$8.85 mil	3,200	$28,300,000,000
TOTAL ANNUAL BENEFITS						**$37,200,500,000**

Source: Ronnie Levin, "Full Lead Pipe Replacement Analysis," T.H. Chan School of Public Health, Harvard University,2023, based on Ronnie Levin and Joel Schwartz,
"A Better Cost-Benefit Analysis Yields Better and Fairer Results," Environmental Research 229 (2023)

* Levin & Schwartz did not quantify impacts on female reproduction because of the findings of EPA's Integrated Science Assessment.

FIGURE 1: ANNUAL HEALTH BENEFITS OF REMOVING ALL LEAD SERVICE LINES (2016$)



*Based on the EPA assessments, Levin & Schwartz did not include impacts on female reproductive function
Icons created by Fran Couto and Supanut Piyakanont from Noun Project
Visualization created by Susan Lee

Using calculations summarized in detail in endnote 22, the Harvard researcher estimated the total benefits of removing all lead service lines at $37 billion per year (Table 1).[22] The EPA recently conducted a nationwide survey of many water utilities and state officials and estimated that there are about 9.2 million lead service lines nationwide.[23] Dividing the $37 billion figure by the EPA-estimated 9.2 million lead service lines yields estimated benefit of about $4,000 per lead pipe removed per year. Assuming a 35-year lifetime of a home with its lead service line removed, the analysis estimated that the health benefits will be about $85,500 per lead service line, when discounted to present value. The analysis concluded that the total national benefits amount to $786 billion, discounted to present value (Table 2).

INDIVIDUAL STATES STAND TO SAVE BILLIONS OF DOLLARS

To better inform state and federal lead in drinking water policies and highlight the enormous benefits of removing lead service lines, NRDC estimated the financial benefits in avoided health costs in each state.

The EPA estimates that the average cost of the removal of a lead service line is about $5,000.[24] The American Water Works Association (AWWA) puts this figure at about $6,100. But this is a one-time cost, as opposed to the benefits that will continue for as long as the non-lead service line is used.

A 50-state NRDC survey completed in 2021 estimated that there are a minimum of 6.2 million lead service lines in the nation.[25] This is considerably less than the more recent EPA estimate of 9.2 million, but considering that many service lines of "unknown material" are probably lead, NRDC assessed that there are more likely from 9.7 million to 12.8 million lead service lines.[26] Table 2 presents a range of possible numbers of lead service lines (LSLs) in each state, based on NRDC's low state estimates and EPA's more recent state estimates, along with the corresponding estimated health benefits.[27] These figures are graphically presented in Figure 2.

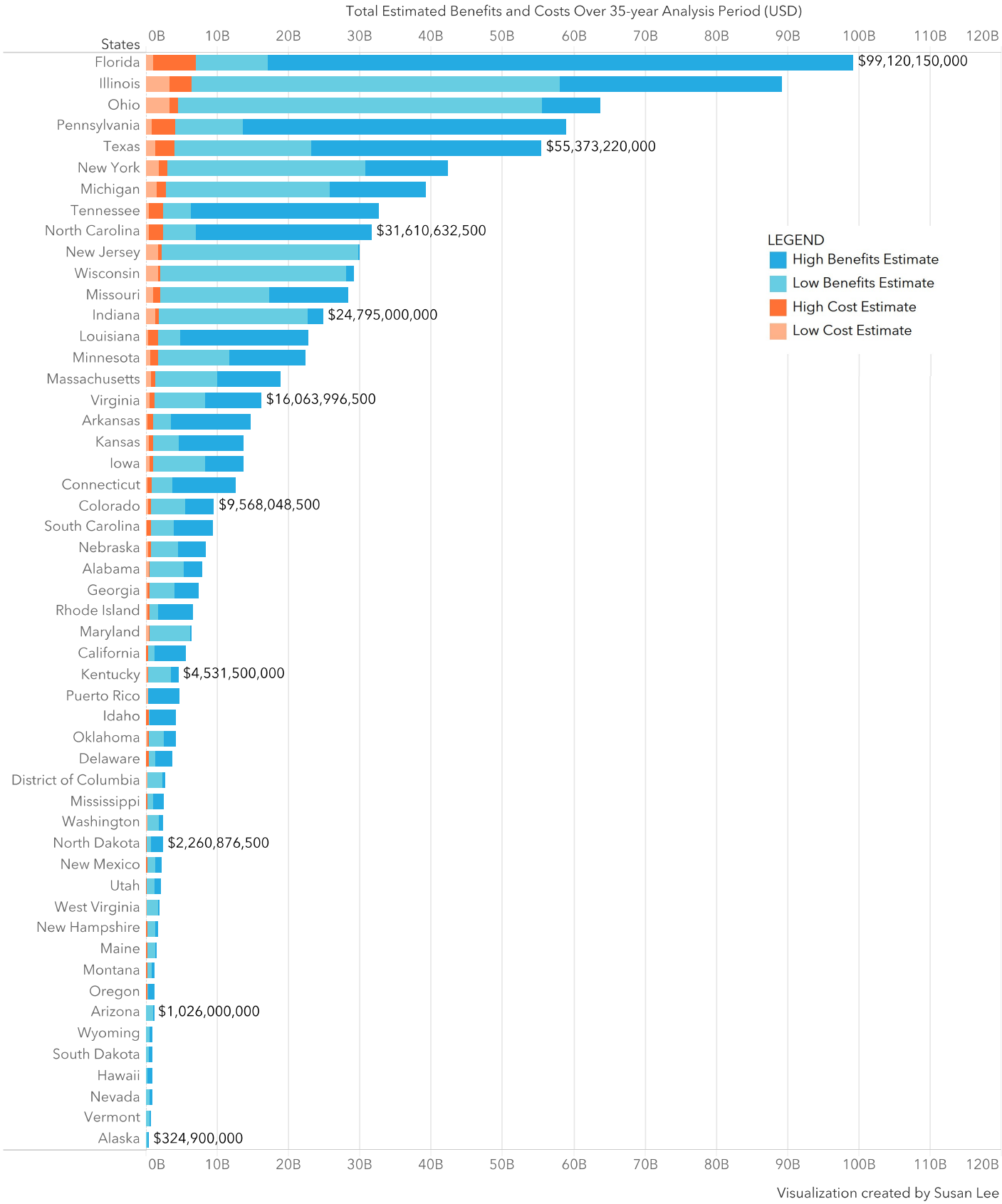
Benefits for individual states range from $124 million for Alaska on the low end, to $89–99 billion in Illinois and Florida at the high end. Of course, if the NRDC's or EPA's estimates are low (i.e., if there are more lead service lines in a state than estimated), the total benefits will go up accordingly, and vice versa.

TABLE 2. STATE-BY-STATE ESTIMATES OF BENEFITS OF FULL LEAD SERVICE LINE REPLACEMENT (2016 $, DISCOUNTED TO PRESENT VALUE)				
States	NRDC 2021 estimate of LSLs (not including unknows that may be lead)	Estimated Benefits in $USD of LSL removal using NRDC estimate of LSLs	EPA 2023 estimate of LSLs	Estimated benefits in $USD of LSL removal using EPA estimate of LSLs
Alabama	63,000	5,386,500,000	91,544	7,827,012,000
Alaska	3,800	324,900,000	1,454	124,317,000
Arizona	12,000	1,026,000,000	11,429	977,179,500
Arkansas	40,000	3,420,000,000	171,771	14,686,420,500
California	65,000	5,557,500,000	13,476	1,152,198,000
Colorado	64,650	5,527,575,000	111,907	9,568,048,500
Connecticut	43,000	3,676,500,000	146,574	12,532,077,000
Delaware	16,000	1,368,000,000	42,479	3,631,954,500
District of Columbia	31,974	2,733,777,000	27,058	2,313,459,000
Florida	200,000	17,100,000,000	1,159,300	99,120,150,000
Georgia	86,000	7,353,000,000	45,985	3,931,717,500
Hawaii	2,800	239,400,000	9,589	819,859,500
Idaho	6,200	530,100,000	49,434	4,226,607,000
Illinois	679,292	58,079,466,000	1,043,294	89,201,637,000
Indiana	290,000	24,795,000,000	265,400	22,691,700,000
Iowa	160,000	13,680,000,000	96,436	8,245,278,000
Kansas	160,000	13,680,000,000	54,107	4,626,148,500
Kentucky	53,000	4,531,500,000	40,207	3,437,698,500
Louisiana	56,000	4,788,000,000	266,984	22,827,132,000
Maine	15,000	1,282,500,000	18,057	1,543,873,500
Maryland	74,000	6,327,000,000	71,166	6,084,693,000
Massachusetts	220,000	18,810,000,000	117,090	10,011,195,000
Michigan	460,000	39,330,000,000	301,790	25,803,045,000
Minnesota	260,000	22,230,000,000	136,873	11,702,641,500
Mississippi	29,000	2,479,500,000	11,098	948,879,000
Missouri	330,000	28,215,000,000	202,112	17,280,576,000
Montana	10,000	855,000,000	14,125	1,207,687,500
Nebraska	97,000	8,293,500,000	53,230	4,551,165,000
Nevada	5,200	444,600,000	9,048	773,604,000
New Hampshire	20,000	1,710,000,000	14,819	1,267,024,500
New Jersey	350,000	29,925,000,000	349,357	29,870,023,500
New Mexico	26,000	2,223,000,000	15,453	1,321,231,500
New York	360,000	30,780,000,000	494,007	42,237,598,500
North Carolina	82,000	7,011,000,000	369,715	31,610,632,500
North Dakota	8,200	701,100,000	26,443	2,260,876,500

TABLE 2. STATE-BY-STATE ESTIMATES OF BENEFITS OF FULL LEAD SERVICE LINE REPLACEMENT (2016 $, DISCOUNTED TO PRESENT VALUE)				
States	NRDC 2021 estimate of LSLs (not including unknows that may be lead)	Estimated Benefits in $USD of LSL removal using NRDC estimate of LSLs	EPA 2023 estimate of LSLs	Estimated benefits in $USD of LSL removal using EPA estimate of LSLs
Ohio	650,000	55,575,000,000	745,061	63,702,715,500
Oklahoma	48,000	4,104,000,000	28,679	2,452,054,500
Oregon	14,000	1,197,000,000	3,530	301,815,000
Pennsylvania	160,000	13,680,000,000	688,697	58,883,593,500
Puerto Rico		0	51,490	4,402,395,000
Rhode Island	20,000	1,710,000,000	75,749	6,476,539,500
South Carolina	44,000	3,762,000,000	108,177	9,249,133,500
South Dakota	10,000	855,000,000	4,141	354,055,500
Tennessee	74,000	6,327,000,000	381,342	32,604,741,000
Texas	270,000	23,085,000,000	647,640	55,373,220,000
Utah	23,000	1,966,500,000	14,293	1,222,051,500
Vermont	7,400	632,700,000	5,263	449,986,500
Virginia	97,000	8,293,500,000	187,883	16,063,996,500
Washington	27,000	2,308,500,000	22,030	1,883,565,000
West Virginia	20,000	1,710,000,000	20,259	1,732,144,500
Wisconsin	329,866	28,203,543,000	341,023	29,157,466,500
Wyoming	6,300	538,650,000	10,477	895,783,500
TOTAL	**6,179,682**	**528,362,811,000**	**9,188,545**	**785,620,597,500**

A piece of lead pipe removed during a service line replacement in Flint, Michigan.

FIGURE 2: TOTAL BENEFITS AND COSTS OF FULL LEAD SERVICE LINE REPLACEMENT



BENEFITS OUTWEIGH COSTS 14 TO 17 -FOLD

Nationally, the benefits of removing lead service lines dwarf the costs by an enormous margin. Taking the EPA and AWWA cost estimates of about $5,000 to $6,100 per lead service line removal, multiplied by the EPA estimate of 9.2 million lead service lines across the United States, the total national cost of removing all lead service lines would be in the range of **$46 billion to $56 billion.**[28] Compare that with the total health benefits of **$786 billion** based on the Harvard researcher's calculations using EPA's estimate of 9.2 million lead service lines (Table 2).

As summarized in Table 3, the benefits of removing lead service lines are 14 to 17 times greater than the costs of removing lead service lines.[29]

TABLE 3: SUMMARY OF COSTS AND BENEFITS OF LEAD SERVICE LINE REPLACEMENT

COST of lead service line removal, per LSL	$5,000 (EPA)–$6,100 (AWWA)
COST of lead service line removal, U.S. total*	$46 billion–$56 billion
BENEFIT per lead service line	$4,000 per year $85,500 total for a 35-year house lifetime
BENEFIT, U.S. total*	$786 billion
BENEFIT TO COST RATIO*	**14-fold to 17-fold more benefits than costs**

*Using EPA estimate of 9.2 million lead service lines.

RECOMMENDATIONS

For decades, tens of millions of Americans have been drinking water from what amounts to a lead straw, putting the health of both children and adults at grave risk. This analysis highlights the significant health and dollar benefits we would obtain by removing lead service lines—and, conversely, the dangers and health risks of doing nothing. The Biden–Harris administration, the EPA, states, and water utilities must make complete removal of every lead service line a top priority and should require water utilities to pay for the full replacement. Not only will nationwide lead service line removal protect the health of all Americans, but it will create an estimated 56,000-plus well-paying, living-wage jobs lasting a decade. That's more than 560,000 job-years of work.[30]

As a first step, the EPA's improvements to the Lead and Copper Rule should include a requirement that all lead service lines be fully replaced by the water utilities. Indeed, the agency recently promised in a federal court filing that it will propose a stronger Lead and Copper Rule that includes this requirement.[31] The EPA should use the analysis in this paper and the Harvard researchers' detailed studies to help document the extraordinary economic and public health benefits of reducing lead in drinking water and removing all lead service lines across the country. These analyses make it clear that the benefits of these actions would far outweigh the costs.

The EPA rule should require the water utilities to cover all costs of full lead service line replacement to ensure that low-income homeowners and renters get safe water. Many water utilities have insisted that homeowners pay for removal

Workers unrolling new copper line outside a home in Chicago, Illinois.

of the portion of a lead service line that lies under private property. This can cost thousands of dollars. Utilities often take this stance even though they fully control these service lines and in the past often required or strongly encouraged and approved the use of lead pipes. When utilities insist on having private owners pay for lead pipe removal, low-income homeowners and landlords often are unable or unwilling to pay for replacement. This disproportionately affects low-income communities and communities of color, leaving these consumers at higher risk of lead exposure from their water.[32] Dangerous partial lead service line replacements can actually increase lead exposure, at least over the short term and possibly longer.[33]

The Biden–Harris administration's Bipartisan Infrastructure Law makes a $15 billion down payment explicitly for states to help water systems pay for lead service line replacements.[34] Additional funding also is available through that law and through the American Rescue Plan Act to help communities, especially disadvantaged communities, pay to replace their lead service lines.[35] State and local governments should access this funding as quickly as possible to help water systems, especially those serving disadvantaged communities, to begin seeing the health benefits and cost savings outlined here. This federal funding will help many water systems begin to pay to resolve their lead service line problem, but water utilities will need to cover any gap in funding by seeking other federal or state funds and through bonds, rates, and other innovative sources of revenue.[36] To avoid exacerbating problems of water affordability for low-income consumers, utilities should seek all available government and other funding and adopt water affordability programs, many of which are outlined in NRDC's and the National Consumer Law Center's Water Affordability Advocacy Toolkit.[37]

Every household, no matter its zip code, income, race, or ethnicity, must be provided safe drinking water. It is a basic human right. We must protect our children's and our own health and reduce serious cardiovascular and other diseases and deaths by finally eliminating the menace of lead-contaminated tap water.

ENDNOTES

1 Werner Troesken, *The Great Lead Water Pipe Disaster* (Cambridge, MA: MIT Press, 2008).

2 *Washington Post*, "Lead Pipes Unsatisfactory: Looking For A Good Sanitary Pipe for Supplying Water," June 9, 1893.

3 Richard Rabin, "The Lead Industry and Lead Water Pipes 'A Modest Campaign,'" *American Journal of Public Health* 98, no. 9 (September 2008): 1584–92, https://doi.org/10.2105/AJPH.2007.113555.

4 See, for example, American Academy of Pediatrics, Council on Environmental Health, "Prevention of Childhood Lead Toxicity," *Pediatrics* 138, no. 1 (July 2016): e20161493, https://doi.org/10.1542/peds.2016-1493; errata in *Pediatrics* 140, no. 2 (August 2017): e20171490, https://doi.org/10.1542/peds.2017-1490, and *Pediatrics* 145, no. 6 (June 2020): e20201014, https://doi.org/10.1542/peds.2020-1014; U.S. Environmental Protection Agency (EPA), "Basic Information on Lead in Drinking Water," updated January 27, 2023, https://www.epa.gov/ground-water-and-drinking-water/basic-information-about-lead-drinking-water; Centers for Disease Control and Prevention, "Health Effects of Lead Exposure," reviewed September 2, 2022, https://www.cdc.gov/nceh/lead/prevention/health-effects.htm; World Health Organization, "Lead Poisoning," August 11, 2023, https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health#:~:text=There%20is%20no%20level%20of,Lead%20exposure%20is%20preventable.

5 Gervasio A. Lamas et al., "Contaminant Metals as Cardiovascular Risk Factors: A Scientific Statement from the American Heart Association," *Journal of the American Heart Association* 12, no. 13 (July 4, 2023): e029852. https://doi.org/10.1161/JAHA.123.029852.

6 Ibid.

7 Andrea E. Cassidy-Bushrow et al., "Burden of Higher Lead Exposure in African-Americans Starts in Utero and Persists into Childhood," *Environment International* 108 (November 2017): 221–227, https://doi.org/10.1016/j.envint.2017.08.021; Deniz Yeter, Ellen C. Banks, and Michael Aschner, "Disparity in Risk Factor Severity for Early Childhood Blood Lead among Predominantly African-American Black Children: The 1999 to 2010 US NHANES," *International Journal of Environmental Research and Public Health* 17, no. 12 (February 28, 2020): 1552, https://doi.org/10.3390/ijerph17051552d.

8 See Justin Williams and Tara Jagadeesh, "Data Points: The Environmental Injustice of Lead Lines in Illinois," Metropolitan Planning Council, November 10, 2020, https://www.metroplanning.org/news/9960/Data-Points-the-environmental-injustice-of-lead-lines-in-Illinois; Karen J. Baehler et al., "Full Lead Service Line Replacement: A Case Study of Equity in Environmental Remediation," *Sustainability* 14, no. 1 (2022): 352, https://doi.org/10.3390/su14010352; Abt Associates, *Environmental Justice Analysis for the Proposed Lead and Copper Rule Revisions*, EPA Contract # EP-W-17-009, Revised Draft, October 22, 2019, https://downloads.regulations.gov/EPA-HQ-OW-2017-0300-0008/content.pdf; Erin McCormick, Aliya Uteuova, and Taylor Moore, "Revealed: The 'Shocking' Levels of Toxic Lead in Chicago Tap Water," *The Guardian*, September 21, 2022, https://www.theguardian.com/us-news/2022/sep/21/lead-contamination-chicago-tap-water-revealed.

9 EPA, "Basic Information on Lead in Drinking Water," updated January 27, 2023, https://www.epa.gov/ground-water-and-drinking-water/basic-information-about-lead-drinking-water; EPA, Office of Water, *Lead and Copper Rule Revisions White Paper*, October 2016, https://www.epa.gov/sites/default/files/2016-10/documents/508_lcr_revisions_white_paper_final_10.26.16.pdf.

10 Removal of a lead service line eliminates the biggest source of lead contamination in drinking water for most homes, but sometimes lead in tap water can also come from indoor pipes containing lead, lead solder, and leaded brass fixtures inside homes; this is called "premise plumbing." Water utilities can use corrosion control to reduce this source of contamination. However, lead in tap water can be 100 percent eliminated only if lead-containing premise plumbing is replaced along with lead service lines. In this study we evaluate the benefits of removing lead service lines only.

11 See NRDC et al., "Principles for Lead Service Line Replacement," 2022, https://www.nrdc.org/sites/default/files/principles-for-lead-service-line-replacements-20220228.pdf.

12 Ronnie Levin, "Full Lead Pipe Replacement Analysis," T.H. Chan School of Public Health, Harvard University, submitted to EPA May 17, 2023; Ronnie Levin and Joel Schwartz, "A Better Cost-Benefit Analysis Yields Better and Fairer Results: EPA's Lead and Copper Rule Revision," *Environmental Research* 229 (2023): 115738, https://doi.org/10.1016/j.envres.2023.115738. .

13 See Lamas et al., "Contaminant Metals as Cardiovascular Risk Factors"; Bruce P. Lanphear et al., "Low-Level Lead Exposure and Mortality in US Adults: A Population-Based Cohort Study," *Lancet Public Health* 3, no. 4 (April 2018): e177–e184. https://doi.org/10.1016/S2468-2667(18)30025-2; Levin and Schwartz, "A Better Cost:Benefit Analysis"; EPA, Office of Research and Development, *Integrated Science Assessment for Lead*, EPA/600/R-10/075F, June 2013, https://ordspub.epa.gov/ords/eims/eimscomm.getfile?p_download_id=518908.

14 See discussion of benefits monetized in Levin and Schwartz, "A Better Cost:Benefit Analysis."

15 EPA, "National Primary Drinking Water Regulations: Lead and Copper Rule Revisions," *Federal Register* 86, no. 10 (January 15, 2021): 4198–4312, https://www.federalregister.gov/documents/2021/01/15/2020-28691/national-primary-drinking-water-regulations-lead-and-copper-rule-revisions.

16 Ibid.

17 See EPA, Office of Water, *Economic Analysis for the Final Lead and Copper Rule Revisions*, EPA 816-R-20-008, December 2020, https://downloads.regulations.gov/EPA-HQ-OW-2017-0300-1769/content.pdf; Levin and Schwartz, "A Better Cost:Benefit Analysis."

18 See, Levin and Schwartz, "A Better Cost-Benefit Analysis," citing EPA, Office of Research and Development, Integrated Science Assessment for Lead, 2013, https://ordspub.epa.gov/ords/eims/eimscomm.getfile?p_download_id=518908.

19 The Harvard researchers monetized the value of a statistical life (VSL) using the EPA's standard methodology. Levin and Schwartz, table 5. Placing a value on a human life is highly controversial and poses significant moral questions. (See, e.g., Frank Ackerman and Lisa Heinzerling, "If It Exists, It's Getting Bigger: Revising the Value of a Statistical Life," Global Development and Environment Institute Working Paper No. 01-06, October 2001, http://frankackerman.com/publications/costbenefit/Value_Statistical_Life.pdf.) In this paper we use the EPA and Levin and Schwartz estimates for illustrative purposes.

20 Levin, "Full Lead Pipe Replacement Analysis."

21 The average monetized cost per case times the incidence does not always result in the total annual monetized benefit because some adverse effects are not linear, so the benefits can vary for each case.

22 Ibid. Table 1 presents Levin's analyses of the benefits of lead service line replacement, which used the same health endpoints and the same approaches, methods, and assumptions as Levin and Schwartz to calculate the annual health benefits of reduced lead exposures associated with lead service line replacement. Levin and Schwartz used the EPA's assumptions about current and anticipated water lead levels related to treatment changes, blood lead distributions before and after exposure, the health effects that are causally tied to lead exposure, and how to monetize specific health endpoints. Restricted to published literature, Levin and Schwartz monetized 16 of the health endpoints that the EPA determined are causally related to lead exposure. The analysis also included one health endpoint that EPA did not determine was causally related to lead exposure: birth outcomes, which the EPA concluded were only suggestive of causality. Birth outcomes were included because the EPA had used them in an earlier rulemaking. To monetize excess mortality, the analysis used the EPA's value of a statistical life. Table 3 in Levin and Schwartz summarizes the monetized health components included in their analysis. Levin noted that the EPA's estimate of changes to blood lead levels relies on its existing blood lead modeling, but also that the EPA has acknowledged the model underestimates the drinking water contribution to exposure. To estimate the impact of the 2021 changes to the Lead and Copper Rule, the EPA estimated the changes in water lead levels associated with the anticipated

changes in utility behavior in response to the revised rule; these are presented for the High Cost Scenario used in Exhibit 6-14 of EPA, Office of Water, *Economic Analysis,* 6–24. Levin and Schwartz used the EPA's modeled blood lead levels (BLLs) based on the NHANES data (presented in Exhibit 6-29) and changes in BLLs (Exhibit 6-26) and in adult BLLs (Exhibit 6-32) related to the rule. To these the researchers applied the slope coefficients, effect modifiers, etc. that the EPA cites in Appendix D; where the EPA's discussion was insufficient to extract a slope coefficient or other risk estimate, it used the National Toxicology Program's analysis, upon which the EPA based its assessment. It used the U.S. Social Security Administration's estimate of the average U.S. wage in 2016 ($21/hour) to estimate time losses. The changes in lead exposure associated with corrosion control (i.e., the benefits of corrosion control) will continue throughout the period it takes to replace the lead service lines and thereafter. While far more people are impacted by the changes in corrosion treatment, the impact on the people benefiting from lead service line replacement is considerably larger. Dividing the total annual health benefits ($37.2 billion) by the total number of LSLs (about 9.2 million) yields the per-LSL estimate of $4,000/LSL/year in benefits. The benefits accrue every year after the LSL is replaced.

23 EPA, *7th Drinking Water Infrastructure Needs Survey and Assessment*, April 2023, https://www.epa.gov/system/files/documents/2023-04/Final_DWINSA%20Public%20Factsheet%204.4.23.pdf.

24 EPA, *Strategies to Achieve Full Lead Service Line Replacement*, EPA 810-R-19-003, October 2019, https://www.epa.gov/sites/default/files/2019-10/documents/strategies_to_achieve_full_lead_service_line_replacement_10_09_19.pdf; this report provides an estimate of $4,700 as average cost per lead service line replacement. As noted in EPA, Office of Water, *Economic Analysis,* in 2020 American Water Works Association (AWWA) used a 2019 EPA economic analysis of the cost for full lead service line replacement of $4,923 per service line. Here we use $5,000 as a rounded-up value for the two 2019 EPA estimates.G. Tracy Mehan, American Water Works Association, Comments on National Primary Drinking Water Regulations, Proposed Lead and Copper Rule Revisions, Feb. 5, 2020, https://www.regulations.gov/comment/EPA-HQ-OW-2017-0300-1018.

25 Erik D. Olson and Alexandra Stubblefield, "Lead Pipes Are Widespread and Used in Every State," NRDC, July 8, 2021, https://www.nrdc.org/resources/lead-pipes-are-widespread-and-used-every-state.

26 The EPA's estimate was based on the agency's polling of many public water systems and states, but some of the results have been questioned by experts because of the method used to extrapolate the number of actual lead service lines from the number of service lines reported as being of "unknown" material. NRDC's survey and a previous AWWA survey (which NRDC's 2021 survey cited and built upon) estimated far fewer lead service lines in certain states such as Florida and Texas. Those two states reported large numbers of service lines of unknown material, many of which EPA assumed were lead. But both these states had large population and homebuilding surges well after the heyday of using lead pipes. A few states, like Michigan, that have done a good job of trying to estimate number of lead service lines are essentially penalized by the method the EPA used for its estimates. But the EPA's estimates are the official government numbers. NRDC's estimates date from 2021 but are closer to what industry and other experts historically have believed are correct for a few states, like Florida and Texas.

27 In table 2 we have used Levin's estimates of the benefits of lead service line removal (Levin, "Full Lead Pipe Replacement Analysis"), which is derived from Levin and Schwartz, "A Better Cost:Benefit Analysis." Levin's analysis and table 2 consider only the health benefits of lead service line replacement, not the benefits of other mitigation measures such as using corrosion control treatment, which the Levin and Schwartz paper evaluated. We also break out the benefit estimates by state, using NRDC's estimates of the number of lead service lines as well as the EPA's estimates.

28 Using NRDC's lowest estimate of the number of lead service lines of 6.2 million, which unrealistically assumes none of the reported service lines of unknown materials are lead, the costs would be even lower—about $31 billion to $38 billion, and the benefits of course would be lower—about $530 billion.

29 For comparison, the benefit-cost ratio estimated by the Minnesota Department of Health was 5.8:1 to 18.7:1, though the department considered only impacts on children's IQ and their lifetime productivity and did not consider cardiovascular disease impacts. Minnesota Department of Health, *Lead in Minnesota Water: Assessment of Eliminating Lead in Minnesota Drinking Water*, February 2019, updated March 8, 2019: 20–21, https://www.health.state.mn.us/communities/environment/water/docs/leadreport.pdf.

30 Environmental Entrepreneurs and United Association of Union Plumbers and Pipefitters, *Getting the Lead Out: Employment & Economic Impacts from Replacing America's Lead Service Lines*, 2021. https://e2.org/reports/economic-impacts-of-lead-service-line-replacement/.

31 EPA and U.S. Department of Justice, "Respondents' Consent Motion for Voluntary Remand," *Newburgh Clean Water Project et al. v. U.S. EPA*, No. 21-2019 and consolidated cases, Document #1977031, filed December 9, 2022: 10.

32 See Baehler et al., "Full Lead Service Line Replacement"; Childhood Lead Action Project et al., "Complaint Under Title VI of the Civil Rights Act of 1964, 41 U.S.C. § 2000d, 40 C.F.R. Part 7 against Providence Water," filed with EPA January 5, 2022, https://drive.google.com/file/d/1aWpYMiHYFnpVi2SuFAeUvwZ5S2s6og41/view?pli=1.

33 EPA Science Advisory Board, *SAB Evaluation of the Effectiveness of Partial Lead Service Line Replacements*, EPA-SAB-11-015, September 28, 2011, https://www.epa.gov/sites/default/files/2015-09/documents/sab_evaluation_partial_lead_service_lines_epa-sab-11-015.pdf; Rebecca Renner, "Reaction to the Solution: Lead Exposure Following Partial Service Line Replacement," *Environmental Health Perspectives,* 2010 May;118(5):A202-8. https://doi: 10.1289/ehp.118-a202..

34 Erik D. Olson, "Bipartisan Infrastructure Law Means Big Investments in Safe Water and Lead Pipe Removal," *NRDC Expert Blog*, March 29, 2022, https://www.nrdc.org/bio/erik-d-olson/bipartisan-infrastructure-law-means-big-investments-safe-water-and-lead-pipe.

35 See Department of the Treasury, "Coronavirus State and Local Fiscal Recovery Funds: Final Rule," 87 *Federal Register* 87, no. 18 (January 27, 2022): 4451, https://www.govinfo.gov/content/pkg/FR-2022-01-27/pdf/2022-00292.pdf, explicitly authorizing ARPA funds to be used for full lead service line replacements and prohibiting the use of such funding for partial lead service line replacements.

36 For example, Newark New Jersey paid for much of its lead service line replacement program by using funds from lease agreements with the local port authority to pay back bonds floated by the city and surrounding county. Missy Rebovich, City of Newark, "Newark's Lead Service Line Replacement Program is a Model for the Nation," June 12, 2020, https://www.newarknj.gov/news/newarks-lead-service-line-replacement-program-is-a-model-for-the-nation. In another innovative approach, Madison Wisconsin paid for lead service line replacements in part by using funds raised by allowing phone companies to put cell towers on water utility water towers. City of Madison Water Utiliity, "Information for Utilities on Lead Service Replacement," https://www.cityofmadison.com/water/water-quality/water-quality-testing/lead-copper-in-water/information-for-utilities-on-lead-service-replacement.

37 Larry Levine, Sam Whillans, Olivia Wein, Karen Lusson, and Berneta Haynes, "Water Affordability Advocacy Toolkit," *NRDC Expert Blog* and *NRDC and National Consumer Law Center Report,* September 16, 2022, https://www.nrdc.org/resources/water-affordability-advocacy-toolkit.