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Special Report No. 22 June 1991

Getting the Lead Out: Risks and Costs of Lead in Drinking water

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Lead has been used by humans for centuries; in fact, the English word plumbing comes from the Latin word for lead, plumbum. However, lead is also a highly toxic metal that produces a wide range of adverse health effects. Although there are several sources of lead contamination, lead in drinking water is one of the most serious. Since lead in drinking water is usually tasteless, odorless and colorless, it can go unnoticed and its poisonous effects remain untreated.

Since lead in drinking water is usually tasteless, odorless, and colorless, it can go unnoticed

Lead in drinking water, unlike many other water pollutants, usually comes from plumbing at the tap, rather than from polluted ground or surface waters or from public water treatment plants. This potential for lead contamination in household water makes it essential for citizens to become aware of the possible hazard in their homes.

Does Lead Affect Everyone?

Lead is a common metal in the earth, but it poses little risk to humans until it is distributed in our environment through mining and manufacturing. Although lead has long been recognized as poisonous at high dosages, studies on its health impacts in recent years have shown that it can cause damage at lower blood levels than had been realized, and lead exposure levels considered acceptable have been revised steadily downward.[1]

Some of the effects on adults of lead poisoning include:

- **greater risk of cancer 2**
- **damage to the brain, kidneys, liver, nervous system, and hearing**
- **inhibited red blood cell formation**
- **elevated blood pressure in adults**
- **increased possibility of stroke 3**

In fact, lead can affect anyone, at any age.

Children Are At Greater Risk

Children and infants are at particular risk from lead, since their growing bodies absorb it more rapidly, and their small size means that a dose of lead is more damaging than to an adult. In 1988, the Public Health Service estimated that 10.4 children in this country were exposed to lead in drinking water .[4] The U.S. Environmental Protection Agency (EPA) has named lead as the most serious environmental health hazard to children because it can cause:

- **premature birth and reduced birth weight**
- **anemia, colic, and seizures**
- **nervous disorders and behavioral problems**
- **brain damage and lower IQ levels.[5]**

Lead in water keeps more than 240,000 children from realizing their full intellectual potential

EPA has estimated that exposure to lead in water is keeping more than 240,000 children from realizing their full intellectual potential[s]

What Are the Economic Costs?

Since the diverse biological effects of exposure to lead involve all of the bodily systems and multiple types of health problems, medical costs associated with lead damage can be extensive. In addition to direct medical costs, there are significant social costs from lead poisoning. A 1986 study produced by EPA estimated that:

- $291.9 million each year could be saved nationwide by reducing the exposure of adult males to lead, thus reducing high blood pressure, heart attacks, and strokes
- $27.6 million in medical costs would be avoided each year through lower levels of lead exposure in children
- $81.2 million annually would be saved through reducing the need for compensatory education to help children with learning problems caused by lead exposure
- loss of earnings over the lifetime of children who had been exposed to lead, compared those who had not, would be as much as $268.1 million [7]

How Does Lead Get Into Drinking Water?

There are several sources of lead in the environment (see Table 1), although increased regulations in recent years have greatly reduced exposure to lead from these sources

Drinking water is estimated to contribute 15 to 20 percent of exposure to lead in humans.[8] In addition, lead from water is absorbed more completely than lead from food; 10 to 15 percent of lead in food is absorbed by adults, but 35 to 50 Percent or more, of lead in water is absorbed.

Drinking water may contribute 15 to 20 percent of human exposure to lead

Lead in home drinking water usually comes from solder used to join plumbing pipes or from lead pipes used in some older homes. Amendments to the Safe Drinking Water Act in 1986 banned the use of lead solder, pipes or fittings in public water systems (including those in homes and buildings) after mid-1988.

Significant Sources of Lead — **Table 1**

Leaded Paint
- lead released into the air through weathering and destruction of painted structures
- lead ingested by children from household dust or leaded-paint chips

Leaded Gasoline
- lead released into air from exhaust fumes
- lead released into air during fueling

Stationary Sources
- lead released into air by industrial activity, e.g. smelting, refining, battery recycling
- occupational exposure of factory workers and exposure of children to lead on the clothing of parents

Dust, soil
- paint
- industrial activity
- gasoline

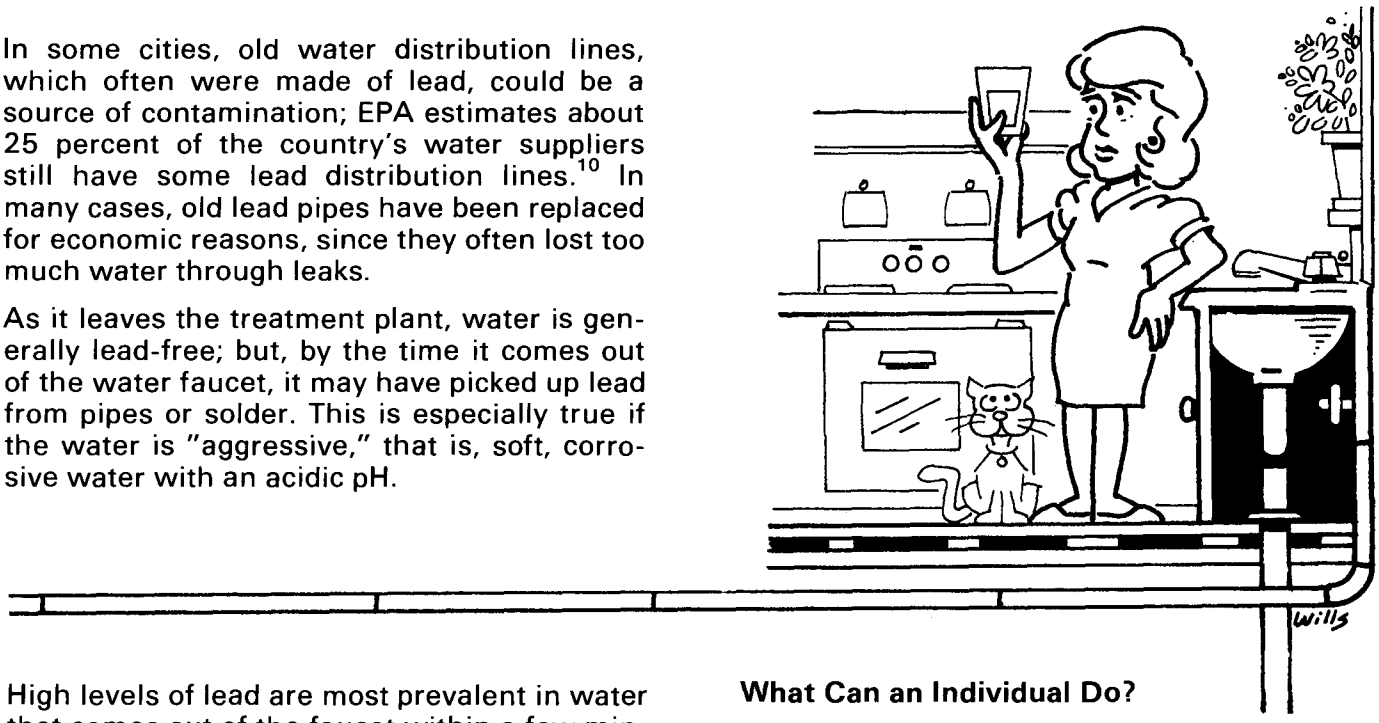
Water
- leaching from lead pipes or solder
- lead in water source

Food
- lead in food items from contaminated water or soil
- lead-soldered food cans
- lead deposited on crops from automobile exhaust or industrial activity
- lead glazes in dishes and pottery

Source: Office of Technology and Assessment, 1990

In some cities, old water distribution lines, which often were made of lead, could be a source of contamination; EPA estimates about 25 percent of the country's water suppliers still have some lead distribution lines.[10] In many cases, old lead pipes have been replaced for economic reasons, since they often lost too much water through leaks.

As it leaves the treatment plant, water is generally lead-free; but, by the time it comes out of the water faucet, it may have picked up lead from pipes or solder. This is especially true if the water is "aggressive," that is, soft, corrosive water with an acidic pH.



High levels of lead are most prevalent in water that comes out of the faucet within a few minutes after it has been turned on, since that water has been standing in the pipe for some time. Where copper pipes are used with lead solder, even relatively noncorrosive water can result in high lead levels when water has been in contact with the pipes for more than a few hours.

High levels of lead are most prevalent in first-flush water

Fresh lead-based solder can release high levels of lead into water,[11] but lead leaching into tap water from solder or lead pipes often decreases after two to five years, since natural reactions in the water can create an insulating layer inside the pipes.[12] Virginia's uniform statewide building code has excluded the use of lead-based solder in plumbing since 1986; thus, any plumbing in buildings constructed before that ban may have had time for some protective coating to form inside the pipes.

Drinking water from water coolers is another possible source of lead. The Lead Contamination Control Act of 1988 required the repair or recall of coolers with lead-lined tanks, and prohibited the manufacture and sale of coolers that have lead in their plumbing. EPA has published guidance on lead in school drinking water, as well as a list of water coolers known to contain lead.[13]

What Can an Individual Do?

Test Your Water: Reducing exposure to lead from household drinking water starts with testing the water to find out if there is some risk in your own residence or workplace. Your local health department or water utility can refer you to qualified laboratories; prices for the test may vary from $15 to $25. A list of laboratories certified by Virginia's Division of Consolidated Laboratory Services (DCLS) is also available, either from your local health department or from DCLS at (804) 786-1155.

If tests show that the amount of lead is around 15 parts per billion or higher[14] in first-flush water, EPA advises that the lead level should be reduced as much as possible, particularly if young children are drinking the water. For comparison, you also may want to test the water that comes out after the first flush.

Reducing exposure to lead starts with testing your water

"Flush" Your Water: An immediate step that can be taken is to avoid using water for drinking or cooking if it has been sitting undisturbed in contact with plumbing pipes for six hours or more. In the morning, or after returning home from work, the cold-water faucet should be flushed by allowing water to run until it has become noticeably colder, usually about one or two minutes (This first-flush

water can be used for rinsing dishes, watering plants, or other nonconsumptive uses.) The water that comes out after flushing the faucet will not have been in extended contact with lead pipes or solder, and can be used safely for drinking or cooking. If more than one tap is used for drinking or cooking water, then the water in each of the taps should be flushed. Once the tap has been flushed, water can be stored in bottles for use later in the day to avoid having to flush the taps again.

Use Cold Water for Cooking or Drinking: Another step is to make sure not to use water from the hot-water tap for cooking or drinking, since hot water can dissolve lead more quickly than cold. This is especially important for making baby formula; only well-flushed water from the cold tap, heated on the stove, should be used.

Investigate Your Plumbing: To determine whether the service line connecting a home to the water main is made of lead, you can either hire a licensed plumber to inspect the line or contact the plumbing contractor who installed it. The name of the contractor usually can be found on the building permit, which should be maintained in the locality's files. The plumber also can check the house's plumbing for lead solder or pipe fittings that contain lead.

Private Wells: if lead levels remain high in a house that is served by a private well, the lines or fittings may need to be replaced by the homeowner. *Public Systems:* in areas served by public water systems, high lead levels may require replacement of the lead pipes by the locality. In Virginia, about 4.9 million people get their tap water from public systems.[15]

Corrosive water can dissolve lead from plumbing pipes and joints

Measure Corrosivity: Since corrosive water can dissolve lead from pipes and joints, it may be a good idea to measure the corrosiveness of the water. As with lead testing, a private laboratory can measure this for you. Public water suppliers now are required to control the corrosivity of the water leaving the treatment plant, but private wells in some areas may be a source of aggressive water.

In some cases, corrosion may be increased if grounding wires from the electrical system are attached to the water pipes. If your water has a tendency to be corrosive, and if the wiring in your home appears to be grounded on the pipes, the wires should be checked and grounded elsewhere. This should be done only by a licensed electrician, as improper grounding can cause electrical shock and fire hazards.

Use Treatment Devices: If the lead level in your household drinking water is not reduced below 15 parts per billion (ppb) after flushing, then the tap water may need to be treated directly to reduce the amount of lead it carries. For example, reverse osmosis or distillation devices, which may cost between $300 and $1500, are used by many homeowners to ensure that their drinking water is free of contaminants. Neutralizing units, such as calcite filters, can be installed to reduce the corrosivity of the water. Other treatment devices on the market may do little to remove lead from the water; all claims of performance should be investigated. The National Sanitation Foundation tests water treatment units, and their seal of approval should be displayed on the device.[6] More information about treatment devices can be found in *What Do the Standards Mean? A Citizen's Guide to Drinking Water Contaminants,* from the Virginia Water Resources Research Center (free to Virginia residents).

What is the Environmental Protection Agency Doing About Lead?

The Safe Drinking Water Act, passed in 1974 and amended in 1986, requires EPA to set standards for specific contaminants, including lead. EPA's rule for lead, which was issued on May 7, 1991, set an "action level" for lead in first-flush water at the tap (that is, where the water is consumed rather than where it is treated) at 15 ppb, which corresponds to a 5 ppb average in drinking water.

With the passage of this new rule, treatment plants across the country must begin new monitoring and treatment programs. All drinking water treatment plants are required to:

- monitor tap water in certain high-risk homes (those with lead pipes, lead service lines, or lead solder installed after 1982)
- submit results to the state agency overseeing drinking water standards (in Virginia, the Department of Health)

Large water treatment plants-those serving more than 50,000 people-are required by the new rule to:

- begin monitoring lead levels at the tap by January 1992
- monitor for other water quality parameters throughout the distribution system (pH, for example), to identify an optimal corrosion control treatment
- begin treatment to control the corrosivity of the public water supply by January 1997

Medium-sized or small treatment plants are given more time before they must begin monitoring. The test results determine whether the plant must take action: if 10 percent of the tests show lead in amounts above the action level of 15 ppb, then these plants also must begin corrosion control treatment. In addition, any public drinking water system that exceeds the lead action levels in tap water samples must carry out a public education program in the community. Table 2 (on the next page) shows the schedule for monitoring and corrosion control programs.

Approximately 600 public water systems in Virginia may exceed the recommended level

EPA estimates that these new regulations will:

- reduce the exposure of approximately 130 million people to lead in drinking water
- result in an additional 570,000 children having lead in their blood reduced to a safe level
- reduce medical costs estimated between $2.9 and $4.5 billion annually
- reduce corrosion in the nation's water supply pipes, making the pipes last much longer, thus saving about $500' million each year
- add a cost per household estimated to range between $1 each year for households served by large systems to between $2 and $20 each year for households served by smaller systems

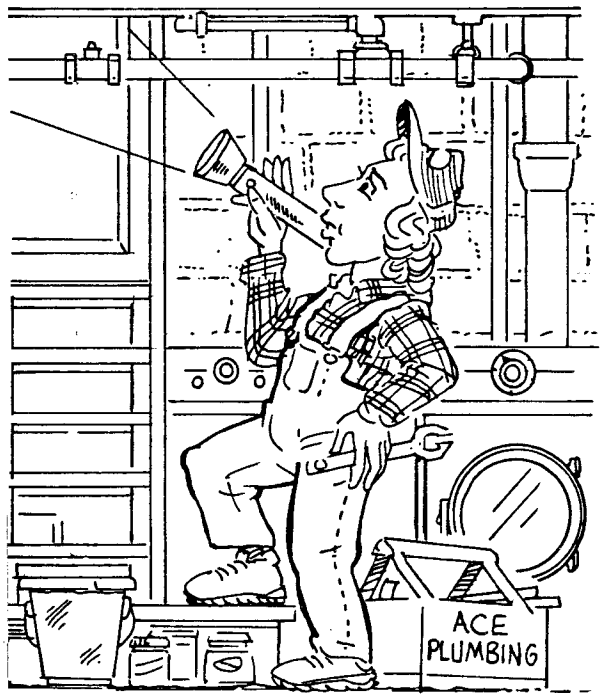
Virginia's Public Water Systems

Virginia's Department of Health estimates that approximately 600 water systems in the state may exceed the action level of 15 ppb.[17] The state's largest water treatment plants, which will be required to install corrosion control treatment, serve 80 percent of those who receive water from public systems. Although corrosion control in public drinking water was not required by law in the past, 137 systems in Virginia have corrosion-control treatment in place because they are in areas with particularly aggressive water. Other plants raise the pH of their water, which decreases corrosivity, for non-lead-related reasons.[18]

Take individual action in testing and treating your home tap water

It's Up to You

EPA's new regulations give treatment plants more responsibility over controlling lead contamination, and will result in a substantial reduction in the number of people exposed to lead in drinking water. However, the best way to ensure personal protection is to take individual action in testing-and treating, if necessary-your home tap water.



Regulatory Schedule Table 2

Large Systems (> 50,000 people

Date	Activities (system activities denoted by bold type)
May 1991	National Primary Drinking Water Regulations (NPDWP) for lead promulgated
January 1992	**Begin tap water and distribution system monitoring**
November 1992	**Treatment technique requirements take effect**
January 1993	**Complete tap water and distribution system monitoring**
July 1994	**Complete corrosion control studies and recommend treatment to state**
January 1995	State designates optimal corrosion control treatment
January 1997	**Complete installation of corrosion control treatment**
January 1998	**Complete follow-up monitoring and submit results to state**[1]
July 1998	State designates water quality parameters

[1] Systems that continue to exceed action level begin 15-year lead service line replacement program.

Medium-size Systems (3,300 to [3] 50,000 people)

Date	Activities (system activities denoted by bold type)
May 1991	National Primary Drinking Water Regulations (NPDWP) for lead promulgated
July 1992	**Begin tap water monitoring**
November 1992	Treatment technique requirements take effect
January 1993	**Recommend optimal corrosion control treatment to state'**
January 1994	State requires system to conduct corrosion control studies[2]
July 1994	State designates optimal corrosion control treatment[3]
July 1995	**Complete corrosion control studies and recommend treatment to state**
January 1998	State designates optimal corrosion control treatment for system conducting treatment studies[2]
July 1996	**Complete installation of corrosion control treatment**[3]
July 1997	**Complete follow-up monitoring and submit results to state** [3,4]
January 1998	**Complete installation of corrosion control treatment**[2] State designates water quality parameters[3]
January 1999	**Complete follow-up monitoring and submit results to State 2,4**
July 1999	State designates water quality parameters[2]

' Assumes system exceeds lead action level during first monitoring period.
[2] Medium-size system required to conduct comparative treatment studies.
[3] Medium-size systems for which state specifies optimal treatment without studies.
[4] Systems that continue to exceed action level begin 15-year lead service line replacement program.

(Source for tables: *Fact Sheet: National Primary Drinking Water Regulations for Lead and Copper,* Office of Ground Water and Drinking Water, USEPA, May 1991)

Small Systems(<3,300 people)

Date	Activities (system activities denoted by bold type)
May 1991	National Primary Drinking Water Regulations (NPDWP) for lead promulgated
November 1992	Treatment technique requirements take effect
July 1993	**Begin tap water monitoring**
January 1994	**Recommend optimal corrosion control treatment to state'**
January 1995	State requires system to conduct corrosion control studies[2]
January 1996	State designates optimal corrosion control treatment[3]
July 1996	**Complete corrosion control studies and recommend treatment to state[2]**
January 1997	State designates optimal corrosion control treatment [2]
January 1998	**Complete installation of corrosion control treatment[3]**
January 1999	**Complete installation of corrosion control treatment[2]** **Complete follow-up monitoring and submit results to state [3,4]**
July 1999	State designates water quality parameters[3]
January 2000	**Complete follow-up monitoring and submit results to State [2,4]**
July 2000	State designates water quality parameters[2]

[1] Assumes system exceeds lead action level during first monitoring period.
[2] Small systems required to conduct comparative treatment studies.
[3] Small systems for which State specifies optimal treatment without studies.
[4] Systems that continue to exceed action level begin 15-year lead service line replacement program.

Information Sources

1. Strategy for Reducing Lead Exposures. USEPA, February 21, 1991.

2. *Congressional Record,* February 7, 1991, S 1798

3. *The Water Reporter, Vol. 12, Number 8, page 55*

4. U.S. Department of Health and Human Services, Public Health Service. "Childhood Lead Poisoning in the United States: A Report to Congress by the Agency for Toxic Substances and Disease Registry, "Morbidity and Mortality Weekly Report 37:481-485, 1988.
5. Environment Reporter, Vol. 19, Number 50, page 2603.

6. Reducing Lead in Drinking Water: A Benefit Analysis. USEPA, Office of Policy Planning and Evaluation, December 1986. EPA-230-09-86-019.

7. Reducing Lead in Drinking Water: A Benefit Analysis, USEPA, Office of Policy Planning and Evaluation, December 1986. EPA-230-09-86-019. Monetary estimates in the study use the value of the dollar in 1985.

8. Get the Lead Out! Lead in Drinking Water: A Guide for Pregnant Women and Families. USEPA, Office of Water, January 1989.

9. The Nature and Extent of Lead Poisoning in Children in the United States: A Report to Congress. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, 1988.

10. Reducing Lead in Drinking Water: A Benefit Analysis. USEPA, Office of Policy Planning and Evaluation, December 1986. EPA-230-09-86-019.

11. Ibid.

12. Water News, Virginia Water Resources Research Center, Vol. 17, No. 12, December 1986.

13. Lead Contamination Control Act (LCCA), brochure by USEPA Office of Water, EPA 570/0-89 AAA. List of coolers: Federal Register, April 10, 1989 (54 FR 14320).

14. Test results usually show this as 0.015 milligrams per liter (mg/1).

15. Information from Allen Hammer, Director, Division of Water Supply Engineering, Virginia Department of Health, 5-28-91.

16. National Sanitation Foundation, 3475 Plymouth Road, P.O. Box 1468, Ann Arbor, Michigan, 48106. (313) 769 8010.

17. Draft impact statement, Division of Water Supply Engineering, Virginia Department of Health, May 1991

18. Information from Allen Hammer, Director, Division of Water Supply Engineering, Virginia Department of Health, 5-13-91.