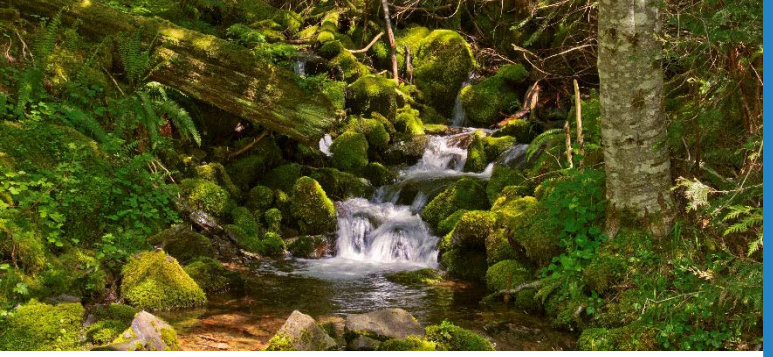
Parsons, Susan

From: Dee White <deewhite1@mindspring.com>
Sent: Monday, March 06, 2017 2:21 PM
To: Moore-Love, Karla
Subject: 5 Agenda item 215/235 for March 8 PWB contract with Confluence
Attachments: 4-21-16 EPA-OHA-PWB LCR Mtg(2).pdf; 121296 EPA Document Lead Hazard Reduction Program Portland OR Dec 1996.pdf; 222 Scientist - The New York Times).pdf; 00657 Lead & Copper _ Data Online _ Oregon Drinking Water Services.pdf; Lead and Copper Rule _ Drinking Water Requirements for States and Water Systems _ US EPA.pdf; 508_lcr_revisions_white_paper_final_ 10.26.16.pdf; 226 Standards and Regulations _ US EPA).pdf; Was Portland's lead crisis preventable_ _ OregonLive.pdf; 186513 Black & Veatch Corporation Water Quality Corrosion Study exhibit(1).PDF; 186513 Black & Veatch Corporation Water Quality Corrosion Study contract additional documents(1).PDF

Karla,

Please include these documents in the record for this agenda item. Please also send me a receipt that you have received. THANKS so much.

Dee White



PORTLAND WATER BUREAU
LEAD AND COPPER RULE

April 21, 2016
Meeting with OHA and EPA
Part 1

PORTLAND WATER BUREAU
FROM FOREST TO FAUCET

Presentation Outline

Morning Presentation:

- Reasons for Revisiting Portland's LCR Program
- System Overview
- Portland's LCR History
- Lead Hazard Reduction Program
- Questions and Discussion

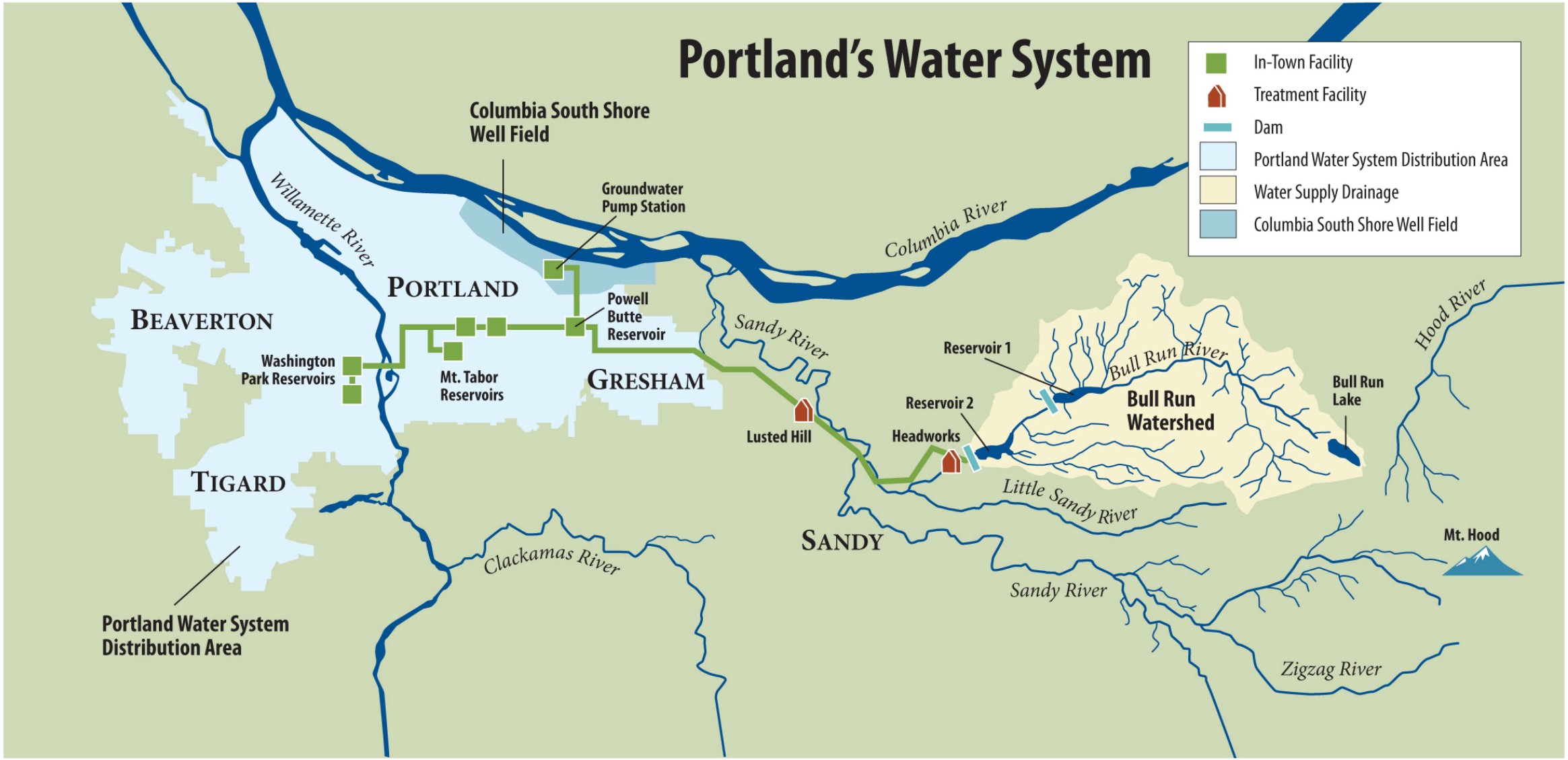
Afternoon Presentation:

- Corrosion Study
- Next Steps

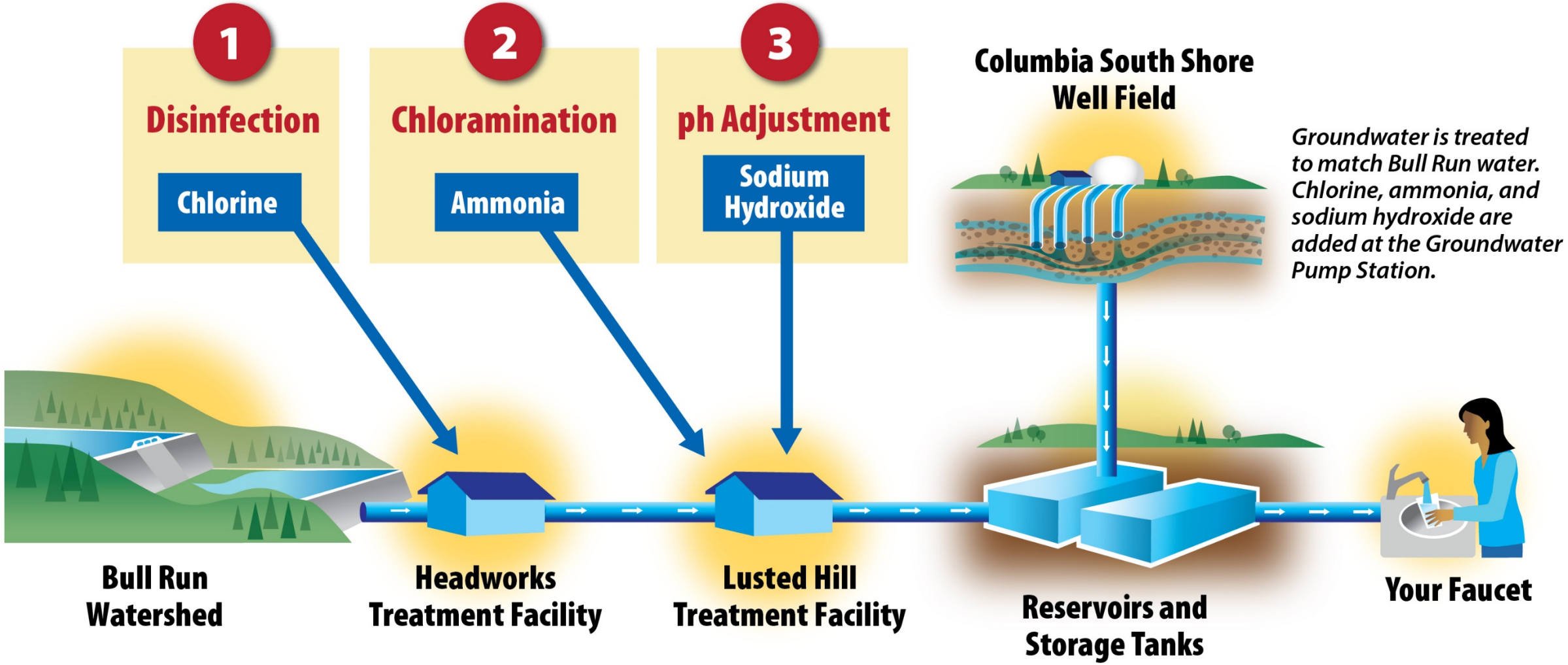
Reasons for discussing Portland's approach to the LCR

- Open reservoirs coming offline
  - Corrosion treatment enhancements were delayed after receiving treatment variance until Open Reservoir removal is completed.
- LCR Exceedances
  - Fall 2013 PWB (and consecutive systems) exceeded LCR Action Level
  - Since 2014, lead levels have held at 14 ppb.
- Corrosion Study
  - PWB embarked on a distribution system corrosion study in 2014
- Health effects of Lead
  - Lower level of concern (10→5 ug/dL)
  - Better understanding of low level exposures

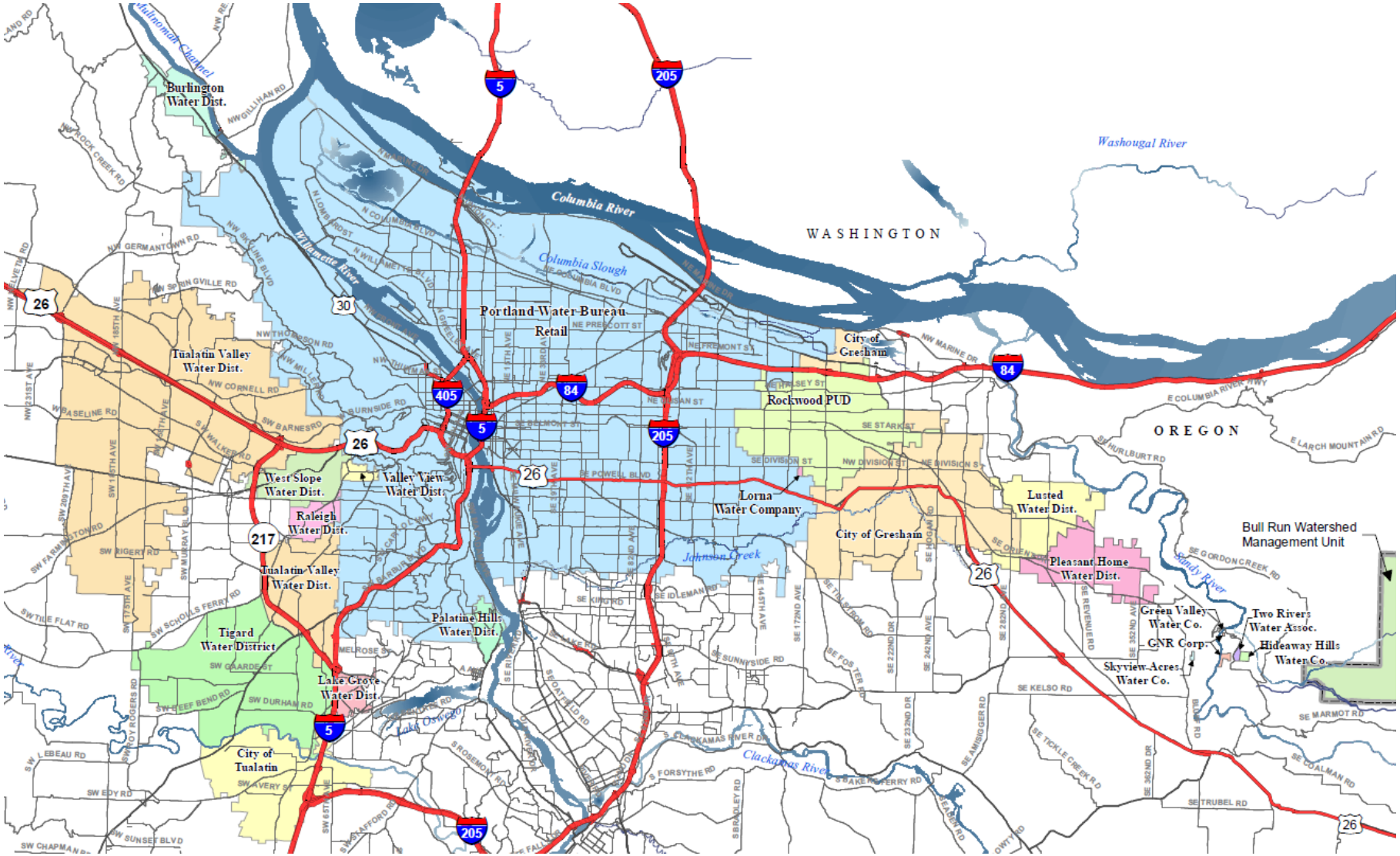
Service Area and Water Sources



Supply System Overview



Service Population & System



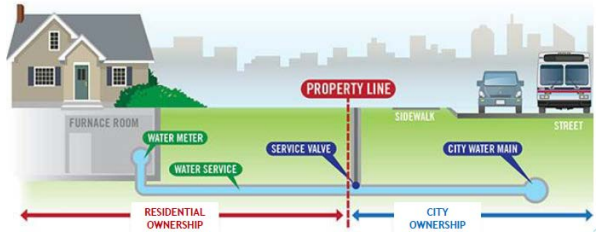
Population

- 958,765 total service
- 588,365 retail
- 370,400 wholesale

20 wholesale customers

Sources of Lead in Portland

- Portland never used lead service lines



- Removed all known lead pigtails

- Copper pipes and lead solder - most common in homes plumbed or built from 1970 - 85

- In Portland lead paint is the greatest source of exposure to lead

Removal of Lead in the Water System

Lead-based Solder

- Worked with the state of Oregon to ban the use of lead-based solder in water systems in 1985.

Lead Pigtails

- Completed the removal of all known lead pigtails (>10,000) in the distribution system, 1998. ($10M)

Lead-component Meters

- 364 large meters serving schools, hospitals, childcare facilities, community centers, public housing complexes and large apartment building were replaced from 2001-2008.

Portland's Lead and Copper Rule Timeline

1992: LCR goes into effect

1992: Initial home tap sampling

- Lead = 48 ppb, Copper = 1.5 ppm

1994: Corrosion Control Study

- Optimized Treatment: pH = 9.0-9.5, Alkalinity = 20 mg/L
- 70-85% reduction in lead levels expected

1994: Portland City Council directs the PWB to investigate alternatives to optimal treatment

1997: Portland funds a study to model lead exposure through drinking water

Conclusions of Lead Exposure through Drinking Water Study

- Drinking water is not the major route of lead exposure in the Portland area.
- Water treatment alone would not sufficiently reduce exposure in homes with significant sources of lead in water.
- Lead-based paint is the most significant source of lead in the Portland area and presents the highest risk.
- Efforts to prevent exposure from lead-based paint could provide significant health benefit to the community.

Portland's Lead and Copper Rule Timeline

1997: PWB develops a comprehensive approach to corrosion control: Lead Hazard Reduction Program

- Water Treatment and Monitoring
- Lead in Water Education and Testing
- Public Education and Community Outreach
- Home Lead Hazard Control Program

1997: The State approves the LHRP as optimized treatment

1997: PWB raises pH from 6.5-7 to 7.5 & implements the state-approved joint monitoring plan

2002: PWB raises pH to 7.8

2002: EPA Technical Advisory Committee (TAC)

- Dr. Michelle Frey, Gregory J. Kirmeyer, Anne Sandvig, Michael Schock, Dr. Vernon Snoeyink, Dr. Rhodes Trussell

TAC Recommendations

- Confirms pH 9.0, alk 20 as OCCT as a long-term recommendation
- Short-term: Increase pH to 7.8 – 8.0
- Change JMP from consumption based to Tier 1 home based
- Increase monitoring of pH in distribution system
- Investigate nitrification in the distribution system
- Recommended further study of the effect of the open reservoirs, phosphate related issues, analogous systems

Portland's Lead and Copper Rule Timeline

2005: PWB raises pH to 8.0

2006 & 2013: LCR Tier 1 Home exceedance

2013: Targeted UDF Program

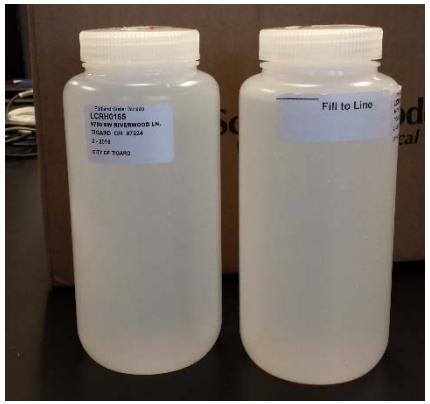
2014: PWB starts Water Quality Corrosion Study

2015: Mt. Tabor disconnected from system

April 2016: PWB meets with OHA and EPA to discuss next steps

Components of the Lead Hazard Reduction Program (LHRP)

Water Treatment & Monitoring



pH raised to 8.0

Lead in Water Education and Testing

Free water testing to all customers in the Bull Run service area

Public Education and Community Outreach

Raising awareness of all potential sources of lead, focus on highest risks to children

Home Lead Hazard Control Program

In-home risk assessments, lead hazard reduction measures

Portland's LHRP: Treatment and Monitoring

Treatment: Sodium Hydroxide pH adjustment to 8.0

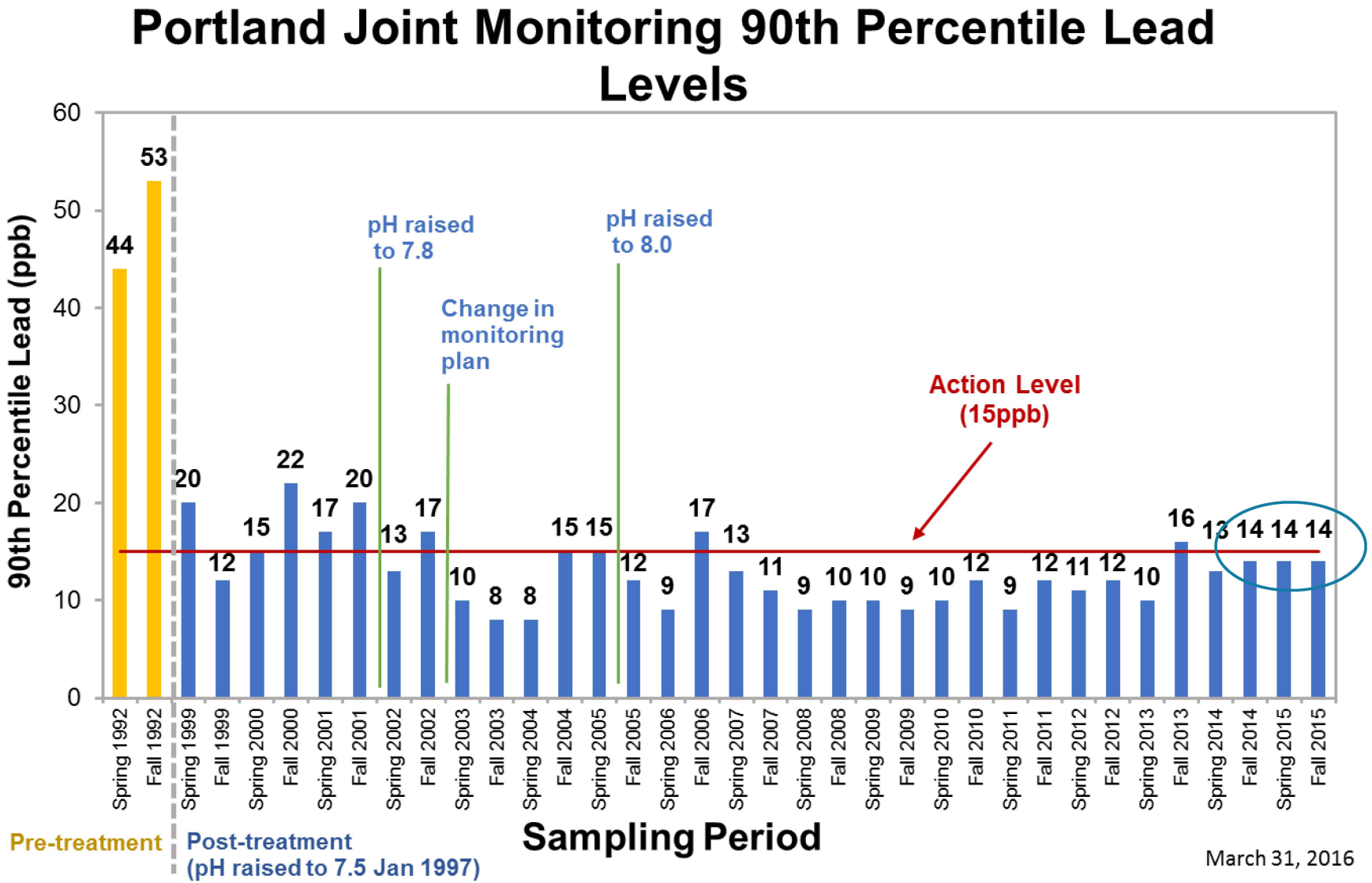
Monitoring at Taps – Joint Monitoring Plan with 11 wholesalers

- Every 6 months – minimum 100 "Tier 1" Homes (worst case)

Water Quality Parameter Monitoring

- Daily pH at entry point
- Quarterly pH and alkalinity at 25 sites in Bull Run distribution system
- Collect pH at all TCR sample locations

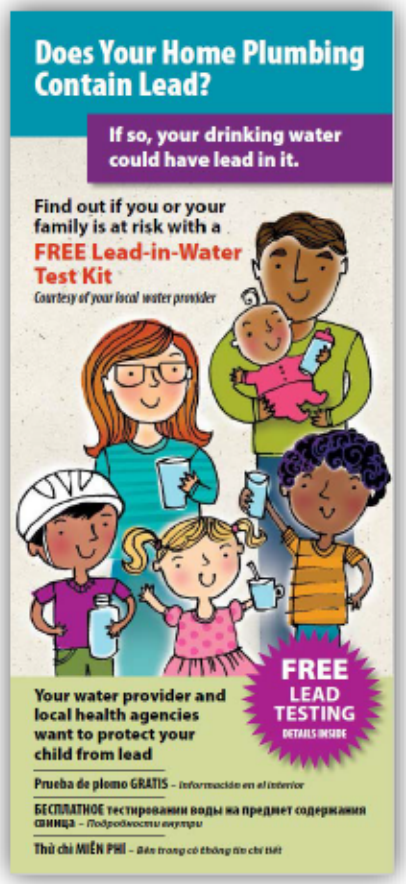
Portland's Compliance with the LCR



March 31, 2016

Portland's LHRP: Lead in Water Education & Testing

Lead brochure



LWET mailer

CCR

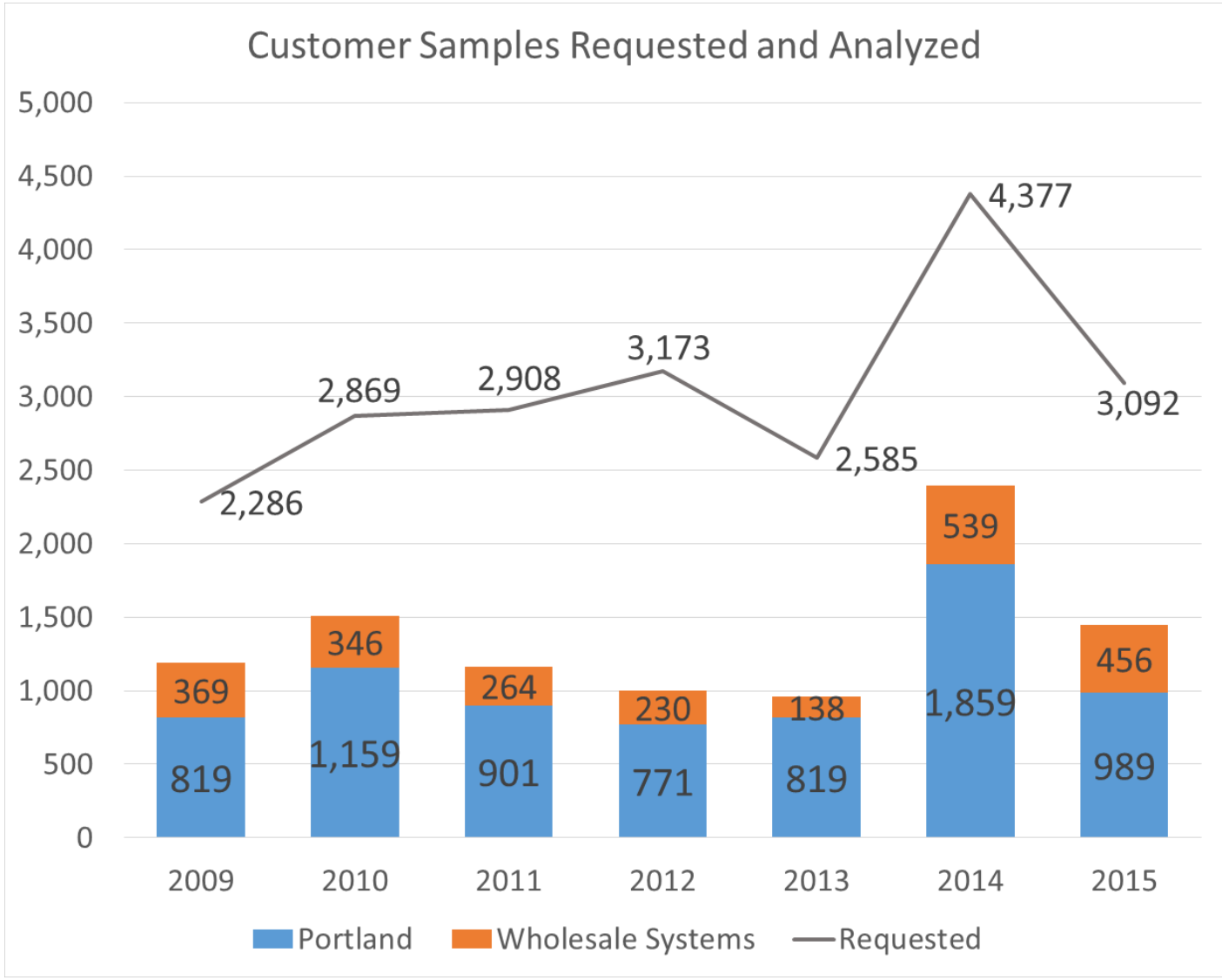
Website

Portland's LHRP: Lead in Water Education & Testing

Customer Sampling

2015 90th Percentile

Portland: 4.4 ppb
Wholesalers: 9.8 ppb



Portland's LHRP: Lead in Water Education & Testing

Customer Sampling

Follow up with customers who have results above 15 ppb:

- Direct contact: phone call
- Easy steps to reduce exposure
- Offer running and faucet and plumbing standing samples

2010-2015 customers who collected a single set of running and standing samples and had a result above the action level in the standing sample (n=67).	
Percent of homes that saw a reduction in the running sample.	100%
Percent of homes that saw an 90% or better reduction in the running sample.	85%
Percent of homes that saw an 80% or better reduction in the running sample.	96%
Percent of homes that went from above the action level to below the action level.	97%
Average percent reduction.	93%

Portland's LHRP: Public Education and Community Outreach

Examples of programs funded by the LHRP:

LeadLine - centralized resource

Blood Testing

Paint Stabilization in Schools

Lead Poisoning Prevention Workshops

Soil testing for lead contamination

Trainings

Home Investigations

Equipment Lending

Outreach at community events

Playground equipment replacement

LHRP Community Grant Stats

Since 2004:

19,800 tenants have received lead information through Community Alliance of Tenants' Renters' Rights Hotline

6,816 people have attended a Community Energy Project lead workshop

14,090 landlords have been reached by Fair Housing Council of Oregon

996 soil samples have been tested for lead through Growing Gardens

7,600 new and expecting mothers have received lead information from the International Center for Traditional Childbirth

40,500 people have called or emailed the LeadLine

12,625 blood lead level tests

98 pieces of playground equipment with lead paint were replaced by Portland Parks and Rec

186 paint stabilization projects have been completed by Portland Public Schools

Portland Housing Bureau Home Lead Hazard Control Grant Program

Since 2001, LHRP funds have been used as local match to receive 5 HUD grants

Year Awarded	Amount	Units Completed	Number of Kids
2001	$3,000,000	318	636
2004	$3,000,000	281	625
2006	$3,000,000	335	700
2009	$4,000,000	529	1,000
2013*	$3,000,000	118	118
TOTAL	$16,000,000	1,543	3,061

*As of 3/24/2016

LHRP Evaluation

Program Design and Evaluation Services (PDES) group will be conducting an evaluation of the LHRP during FY 2016-17.

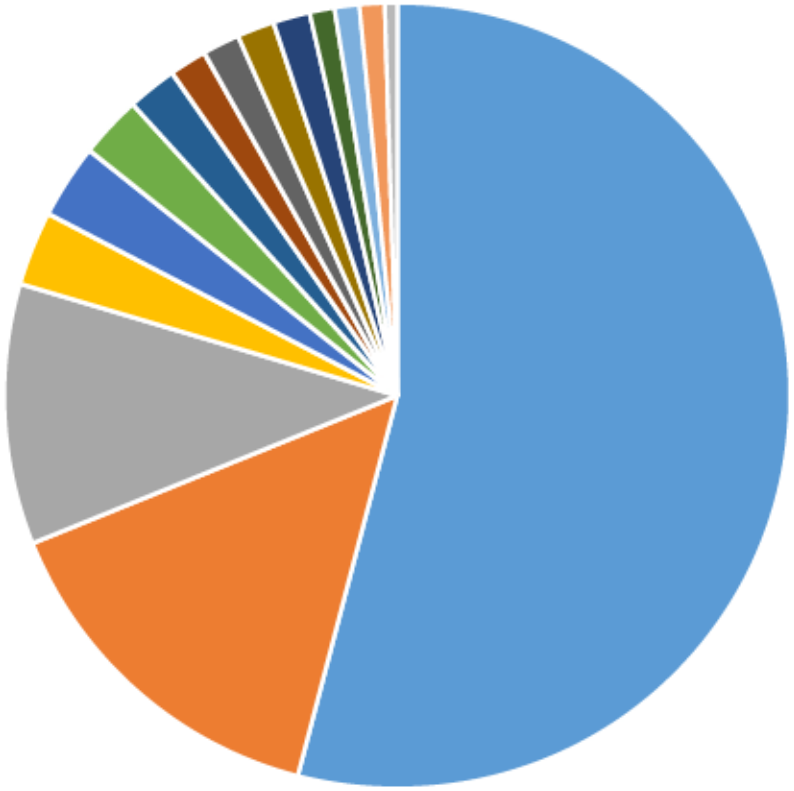
PDES is a partnership between OHA and MCHD

Questions posed by the evaluation:

- Are the LHRP partner organizations raising awareness and knowledge about lead hazard risks in the community?
- Do partner organizations improve knowledge about and use of resources for reducing lead exposure?
- Are the LHRP partner organizations targeting and reaching the most at-risk populations in the Portland community for lead exposure?

PDES will provide a final report to the Water Bureau in Fall 2017.

Multnomah County Health Department
EBLL Investigations (Jan. 2013 – March 2016)



- Paint/Dust
- Country of Origin
- Not Identified by Investigation
- Antiques/Toys/Jewelry
- No Investigation-Refusal/No Response
- Occupational (Parent Take-Home)
- Hobby
- No Record of Investigation
- Shot/Sinkers/Bullets
- Soil
- Travel to Foreign Country
- Ceramics/Pottery/Cooking Vessels
- No Investigation-LHD Decision
- Traditional Medicine/Cosmetics
- No Investigation-Moved Out of Jurisdiction

Probable Source	Number
Paint/Dust	106
Country of Origin	29
Not Identified by Investigation	21
Antiques/Toys/Jewelry	6
No Investigation-Refusal/No Response	6
Occupational (Parent Take-Home)	5
Hobby	4
No Record of Investigation	3
Shot/Sinkers/Bullets	3
Soil	3
Travel to Foreign Country	3
Ceramics/Pottery/Cooking Vessels	2
No Investigation-LHD Decision	2
Traditional Medicine/Cosmetics	2
No Investigation-Moved Out of Jurisdiction	1

Reporting

Data/Report	Reported to	Frequency
Tier 1 Home Monitoring Compliance Reports	OHA	Every 6 months
LHRP Update	EPA and OHA	Twice a year
Customer Results	Customer	As results are received from lab
Customer Results	OHA	Annually
Compliance Results	Posted to website	Updated as needed

LCR Long-Term Revisions Applied to Portland

Recommendations from LCRWG/NDWAC:

1- Replace Lead Service Lines

2- Stronger Public Education

3- Improve Corrosion Control Treatment

4- Modify Monitoring Requirements

5- Health-based Home Action Level

6- Establish Separate Requirement for Copper

EPA recommendations

Website Disclosure

- Lead sampling protocols
- Lead sampling results
- Lead service line inventory information

Tier 1 Home Sampling

- Pre-stagnation flushing
- Appropriate sample bottles
- Aerator removal

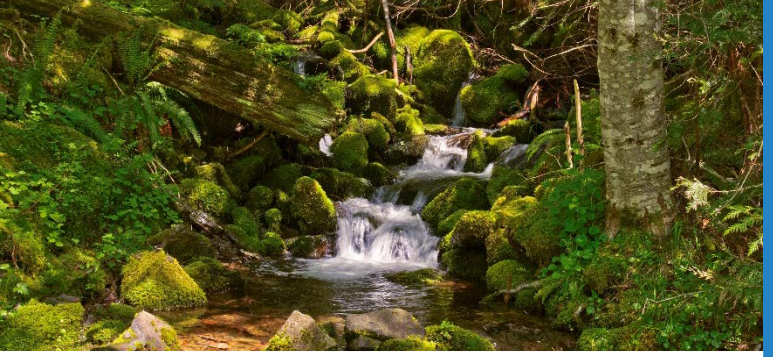
Customer Notification

- Immediate notification of excessive levels

Near-term Actions

- Water Quality Corrosion Control Study
- Taking open reservoirs offline
- Continued nitrification control measures
- Continued targeted UDF
- Work with schools and daycares

Questions?



PORTLAND'S WATER QUALITY CORROSION STUDY

April 21, 2016
Meeting with OHA and EPA
Part 2

PORTLAND WATER BUREAU
FROM FOREST TO FAUCET

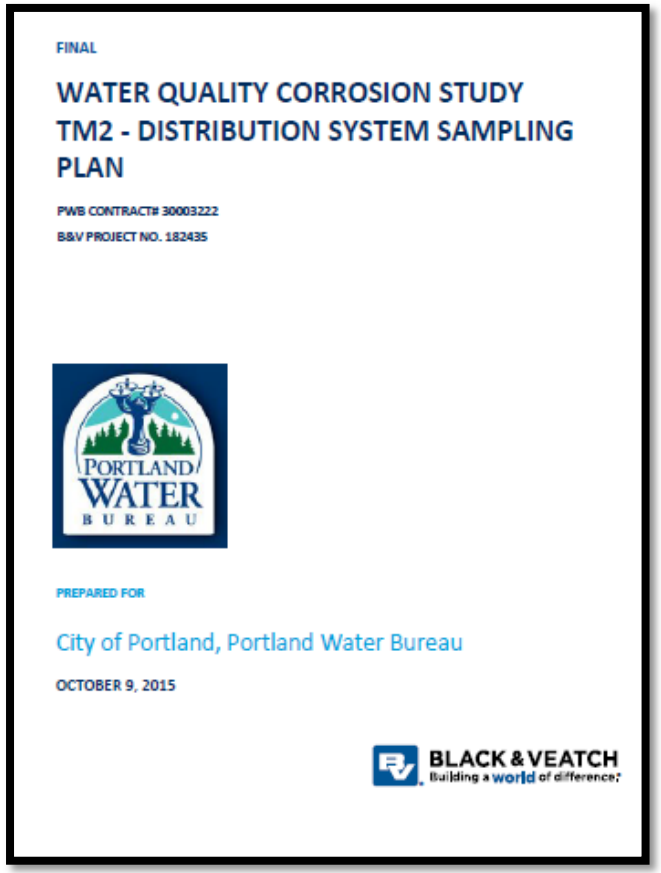
PRESENTATION OUTLINE

Corrosion Study

- Background
- Project Objectives
- Study Plan

Corrosion Control Decision

- Decision
- Treatment Considerations
- Schedule


FINAL

WATER QUALITY CORROSION STUDY
TM2 - DISTRIBUTION SYSTEM SAMPLING PLAN

PWB CONTRACT# 30003222
B&V PROJECT NO. 182435

PORTLAND WATER BUREAU

PREPARED FOR

City of Portland, Portland Water Bureau

OCTOBER 9, 2015

BLACK & VEATCH
Building a world of difference.

PORTLAND WATER BUREAU
FROM FOREST TO FAUCET

WATER QUALITY CORROSION STUDY OBJECTIVES

$240,000 project with B&V

Project objectives include:

- Better understand the causes of lead release in PWB's system
- Identify data gaps and conduct additional sampling required to better understand the role of water quality on lead release
  - *Is uniform corrosion contributing to lead observed in LCR samples?*
  - *Is scale release (caused by hydraulic or physical disturbances) or dissolution (caused by chemical changes) contributing to lead observed in LCR samples?*
  - *What premise plumbing and fixture materials are contributing to lead release for PWB customers?*
  - *Is nitrification or other microbiological activity contributing significantly to lead release?*
  - *What impact does the use of groundwater have on lead release?*
  - *Are operational changes affecting lead release in the distribution system? If so, how?*

WATER QUALITY CORROSION STUDY OBJECTIVES (CONT.)

Convene a panel of utility, consultant, and academic experts to be a technical advisory committee for this study

- List of TAC panel members:

  Dan Giammar (Washington University),
  Rick Sakaji (EBMUD),
  Salmone Freud (NYCDEP),
  Melinda Friedman (Confluence Engineering),
  Mark Knudson (TVWD)

This is not a treatment study

- Any significant changes to treatment would require pilot testing

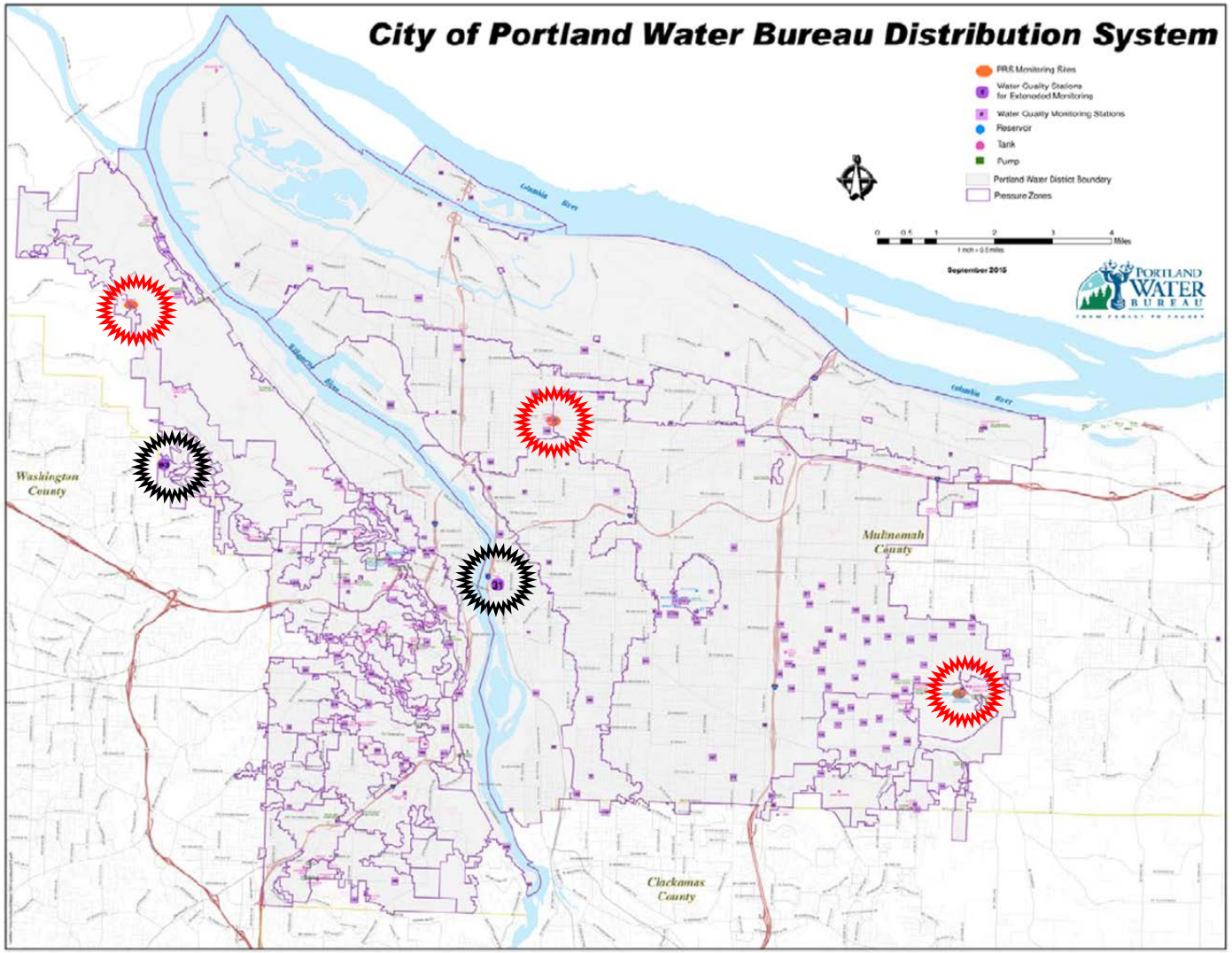
CORROSION SAMPLING PLAN

Weekly sampling over the course of a year in the distribution system

- 3 Process Research Solution (PRS) Monitoring Stations were installed
- 2 distribution system sites

Follow-up sampling at select LCR and customer homes

- Goal is to sample ~ 50 customer homes as well as several of PWB's Tier 1 homes with elevated lead levels



= PRS Stations

= Distribution system sites

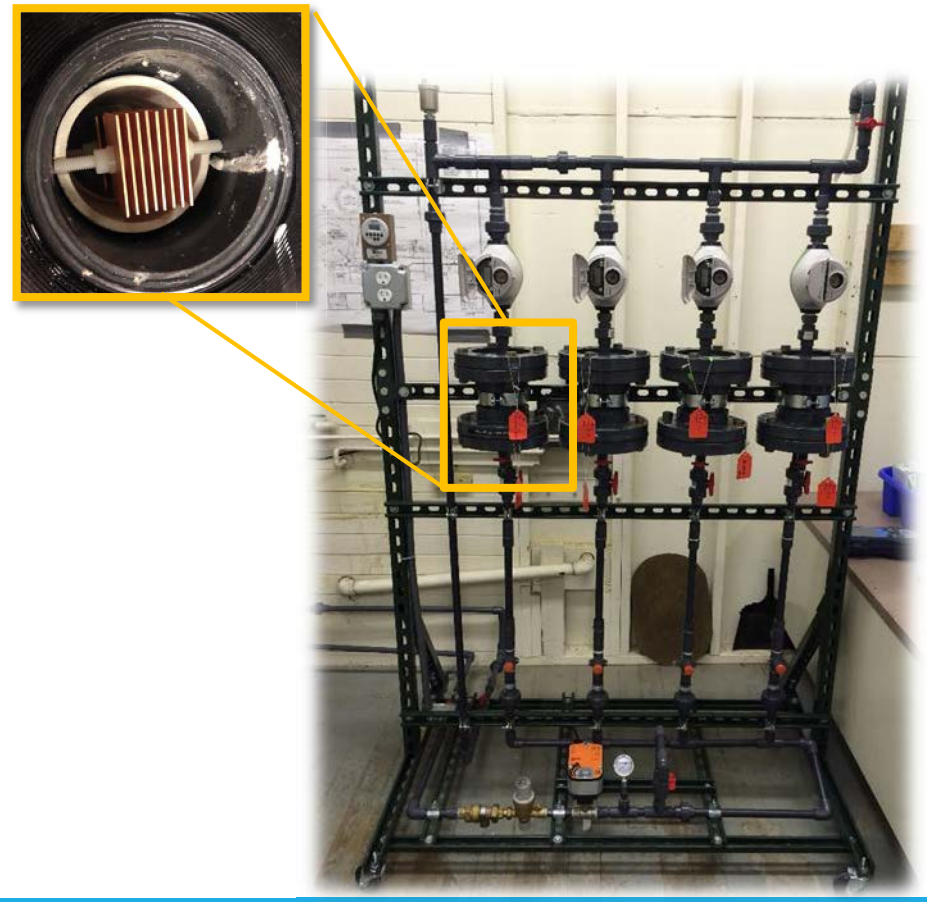
PRS STATIONS

These stations allow for controlled stagnation cycles to replicate worst case water quality as seen in customer homes

- Previous PRS monitoring station results have tracked well with LCR first draw samples in other systems

Each station includes four stagnation chambers, each containing different metals types

- Copper with Lead Solder
  - Represents material commonly found in Portland Tier 1 homes
- Galvanized Iron
  - Galvanized iron plates represent indoor piping and plumbing fixtures commonly found in Portland homes
- Brass
  - Similar to galvanized iron, brass plates represent indoor piping and plumbing fixtures commonly found in Portland homes
- Lead
  - Even though PWB does not have lead service lines, lead is used in order to magnify the response of lead to the water characteristics



PARAMETERS MONITORED AS PART OF THE WATER QUALITY CORROSION STUDY

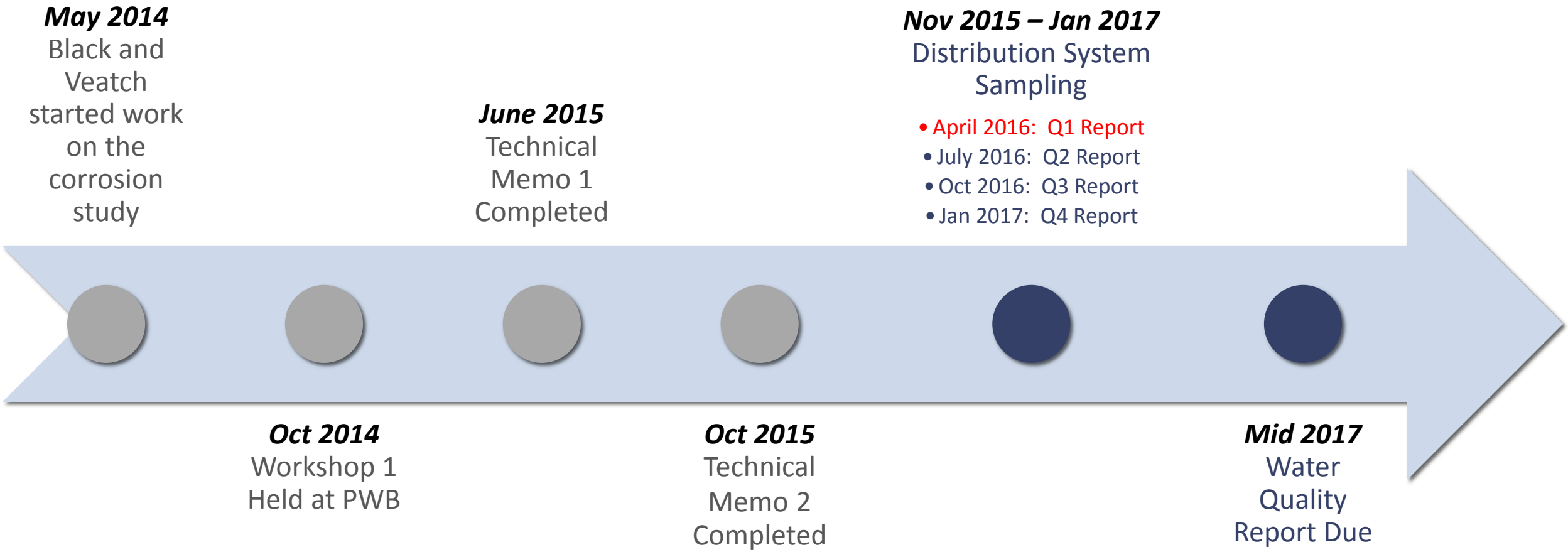
Field

- pH
- Temperature
- ORP
- Chlorine residual
- Monochloramine
- Free ammonia
- Turbidity
- Conductivity
- ATP

Lab

- Total and dissolved metals
  - lead, copper, aluminum, arsenic, cadmium, calcium, chromium, cobalt, iron, magnesium, manganese, nickel, zinc
- Total organic carbon
- Dissolved organic carbon
- Total phosphorus
- Alkalinity
- Hardness
- Chloride
- Sulfate
- Nitrate
- Nitrite
- TDS

WATER QUALITY CORROSION STUDY PROJECT TIMELINE



CORROSION CONTROL DECISION KEY DATES

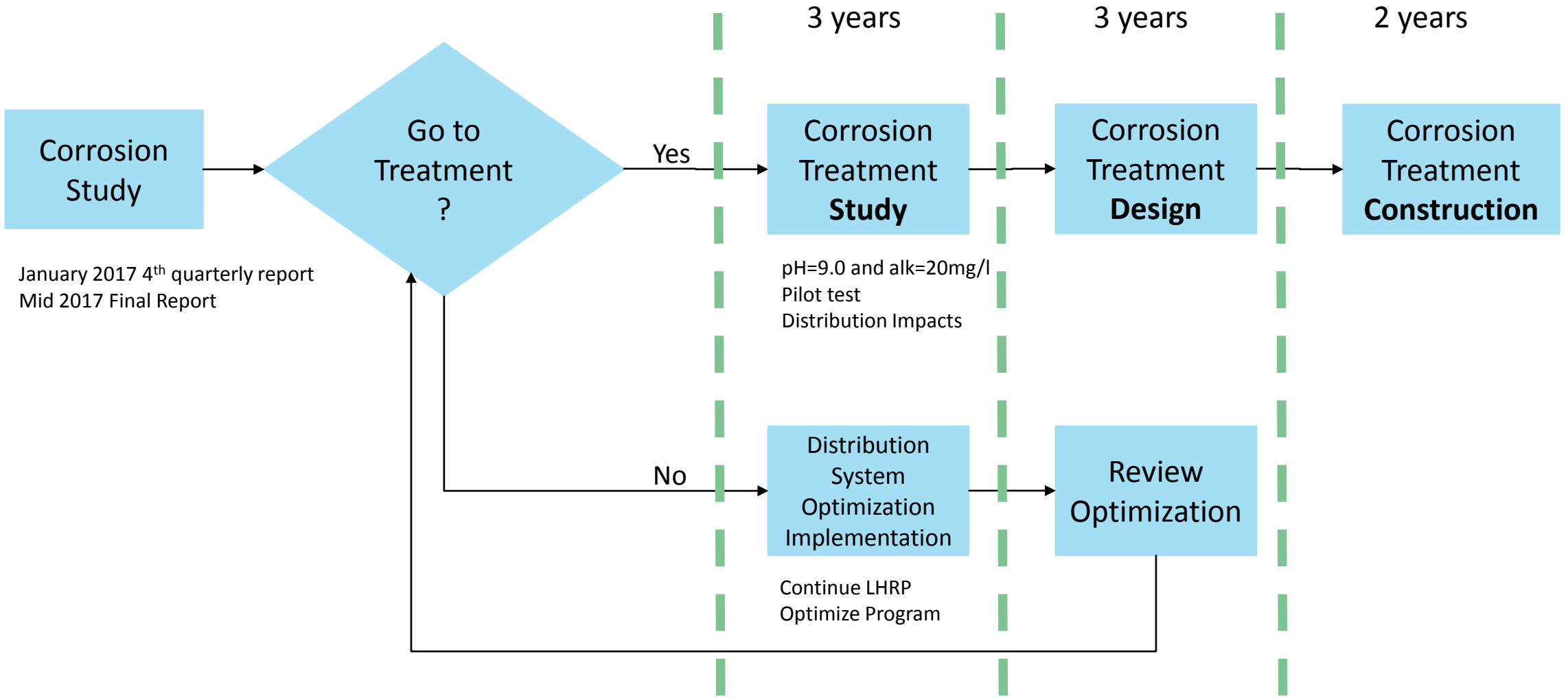
Summer 2016: Washington Park disconnected from system

January 2017: 4th quarterly sampling report for corrosion study

Mid 2017: Results from corrosion study

January 1, 2020: Washington Park reservoir online

CORROSION CONTROL DECISION DECISION TREE



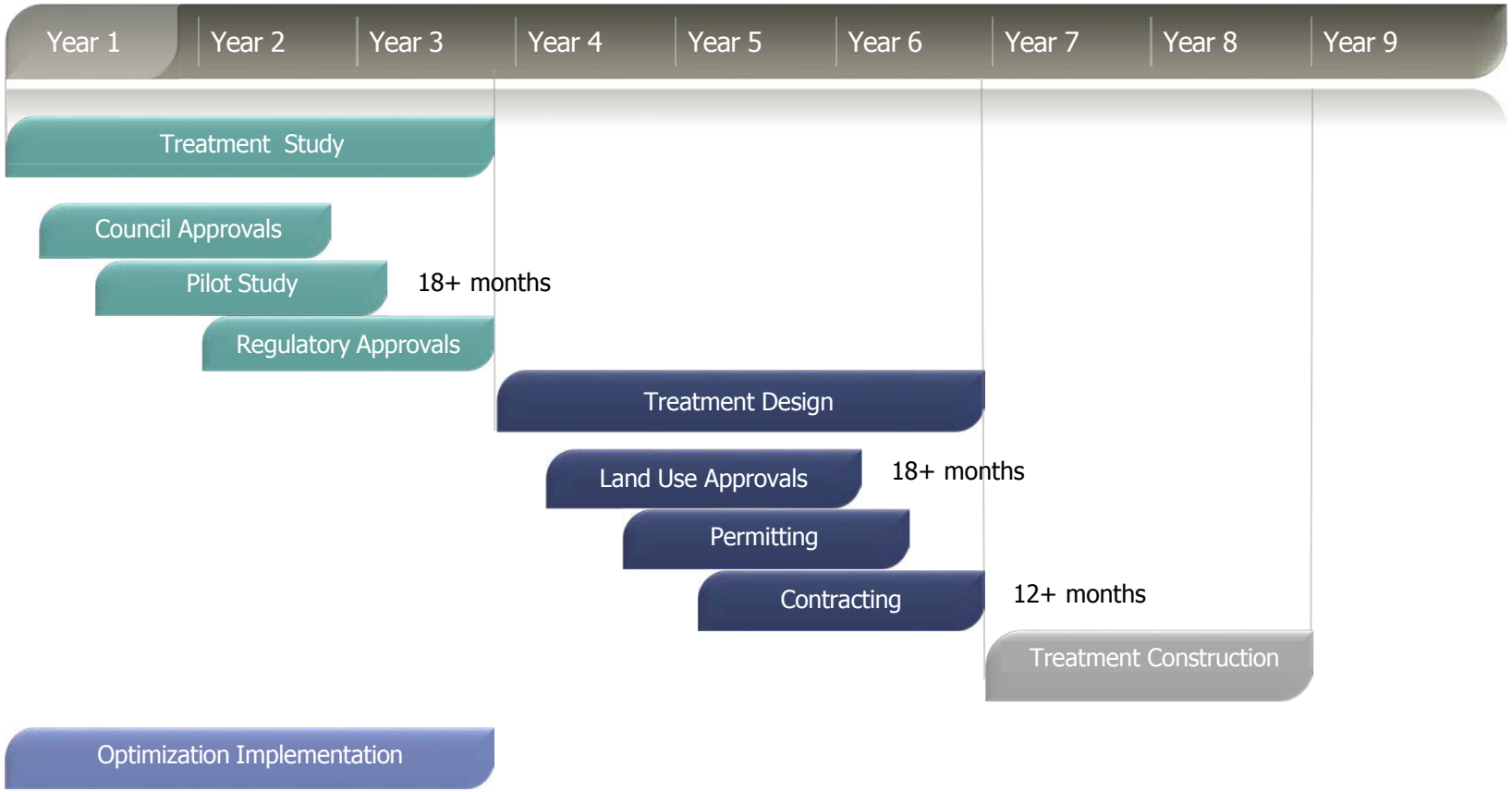
CORROSION CONTROL DECISION TREATMENT CONSIDERATIONS

- Meet OCCT requirement of LCR
- Reduce corrosiveness of our water
  - Reduces lead and copper
  - Potentially extend useful life of our pipes
- Water should become more stable
  - System pH would be more consistent
  - Potential for greater formation of monochloramines above pH 8
- WQ Impacts – want to avoid unintended consequences
  - Potential red water
  - DBPs – THMs might increase, but HAAs might decrease
  - Aesthetics
  - Unknown

CORROSION CONTROL DECISION TREATMENT CONSIDERATIONS

- Adding chemicals to Portland's water (Fluoride experience)
- Possible reduction in public health benefit if reduction of other sources of lead exposure is no longer funded
- Discharge issues
- Schedule
  - Next Slide
- Cost
  - Capital: approximately $15 Million
  - Operational: will be higher (chemicals, staffing, flushing)

CORROSION CONTROL DECISION SCHEDULE CONSIDERATIONS



Discussion

The New York Times Magazine | https://nyti.ms/2be8YEe

Flint's Water Crisis and the 'Troublemaker' Scientist

Marc Edwards took up the cause of water activists in Michigan a year ago — and earned their trust. Now he's fighting to keep it.

By DONOVAN HOHN AUG. 16, 2016

Near the railroad tracks on the outskirts of Flint, Mich., there is an old pump house, the walls of which have long served as a kind of communal billboard. The Block, people call it. People paint messages there — birthday wishes, memorials for the dead. In January, after Gov. Rick Snyder declared a state of emergency in response to Flint's water crisis, a new message appeared, addressed implicitly to Snyder but also to the world: YOU WANT OUR TRUST??? WE WANT VA TECH!!! In the history of political graffiti, "We want Va. Tech" may sound like one of the least stirring demands ever spray-painted on a wall, but in the context of Flint, it was charged with the emotion and meaning of a rallying cry.

By "Va. Tech," the message's author meant a Virginia Tech professor of civil and environmental engineering, Marc Edwards. Edwards has spent most of his career studying the aging waterworks of America, publishing the sort of papers that specialists admire and the rest of us ignore, on subjects like "ozone-induced particle destabilization" or the "role of temperature and pH in $Cu(OH)_2$ solubility." Explaining his research to laypeople, he sometimes describes it as "the C.S.I. of plumbing." Edwards is a detective with a research lab and a Ph.D. In 2000, after homeowners in suburban Maryland began reporting "pinhole leaks" in their copper pipes, the water authority there brought in Edwards. In 2002, after receiving a report

that water in a Maui neighborhood had mysteriously turned blue and was giving people rashes, Edwards took on the case.

Until last year, the most famous case Edwards investigated was the lead contamination of the water supply in the nation's capital — still the worst such event in modern American history, in magnitude and duration. In Washington, lead levels shot up in 2001, and in some neighborhoods they remained dangerously elevated until 2010. Edwards maintains, and spent years working to prove, that scientific misconduct at the Environmental Protection Agency and the Centers for Disease Control and Prevention exacerbated the D.C. crisis. A congressional investigation culminated in a 2010 report, titled "A Public Health Tragedy: How Flawed C.D.C. Data and Faulty Assumptions Endangered Children's Health in the Nation's Capital." It confirmed many of his allegations, but the experience was for Edwards a decade-long ordeal that turned him into a reluctant activist — or as he prefers to say, "a troublemaker."

For television appearances, Edwards will put on a suit and tie, and the tie almost always bears a picture of some endangered animal: a giant panda, for instance, or a water buffalo. But on the morning we met, in his lab at Virginia Tech, he was dressed in a black track suit and a pair of running shoes — the uniform he prefers. At 52, he has the youthful yet slightly skeletal good looks of an avid long-distance runner, which he is. "Before Flint, I was running 50 miles a week," he told me. "Now I'm down to 27." Running keeps him sane, he says, or at least saner than he would be otherwise. More than once during his investigations into D.C. and Flint, he wondered if he might be losing his mind.

"Before D.C.," he told me, "I think I was a normal professor." In the sciences, normal professors with tenure do not maintain websites on which they publish incriminating emails obtained under the Freedom of Information Act. Or habitually refer to unethical bureaucrats as "pathological lying scumbags." Or allude frequently to Orwell's "1984," Arendt's "The Origins of Totalitarianism" and Ibsen's "An Enemy of the People," an 1882 political drama about polluted water contaminating the profitable baths in a Norwegian town. Of his fellow tenured scientists, a normal professor doesn't say things like, "We are the greatest generation of cowards in history."

The poisoning of Flint can be traced to the moment on April 25, 2014, when, with the push of a button, the city stopped buying treated water from Detroit and began drinking from its own notoriously polluted river. In the year after the switch, the city violated the Safe Drinking Water Act four times — for increases in E. coli, coliform bacteria and trihalomethanes, a class of carcinogenic "disinfection byproducts." The switch also probably contributed to an outbreak of Legionnaires' disease that has killed at least 12 people. And for reasons that are still in dispute and under investigation, workers at Flint's hastily refurbished and understaffed treatment plant failed to add corrosion inhibitors, chemicals that coat the interior of pipes, providing a prophylactic barrier. Stop adding them, and the coating wears away, the pipes corrode, lead leaches into the water.

Edwards himself didn't discover the corrosive chemistry of Flint's water. LeeAnne Walters, a mother of four, did that after her children broke out in rashes. In early 2015, Walters began investigating. A test conducted by the city at her request detected dangerously elevated lead levels in her tap water. After obtaining the list of chemical ingredients that the Flint treatment plant was using, Walters shared them with an E.P.A. drinking-water expert named Miguel Del Toral. Notably absent from the list: corrosion inhibitors. "I couldn't believe that they didn't have corrosion control," Del Toral told me. Untreated, nearly all water will corrode metal, but some water sources are more corrosive than others, and the water from the Flint River, Del Toral says, "was corrosive as hell." He had corresponded with Edwards before; now he had Walters collect water samples from her house and send them to Edwards's lab for analysis. In one sample, the lead levels were so high that the water qualified as hazardous waste.

Last summer, when Walters went public with an E.P.A. memorandum that Del Toral wrote and sent her, the Michigan Department of Environmental Quality tried to discredit it. In statements to reporters, a department spokesman, Brad Wurfel, called Del Toral "a rogue employee" and said Michigan officials had found no evidence of a citywide lead contamination. Wurfel's advice to Flint residents: "Relax." Walters, whose son had already received a diagnosis of lead poisoning, enlisted Edwards, who began conducting, with the help of Walters and other volunteers, what he claims was "the most thorough independent evaluation of water in U.S. history."

Last September, at a news conference on the lawn of City Hall, encircled by activists, Walters by his side, Edwards announced what he had found: that lead levels in the tap water of "about 5,000 Flint homes" exceeded the safety standard — 10 parts per billion — of the World Health Organization. In October, the city switched back to Detroit water. In December, Flint's newly elected mayor, Karen Weaver, presented Edwards with a commemorative plaque. "We had cried out for a year and a half, and it wasn't until you came that you gave our voice some validation," she told him. "It wasn't until you came, and we got those Virginia Tech results, that we knew: People couldn't say we were crazy. They couldn't say we didn't know what we were talking about. They couldn't say it was our imagination."

Edwards's decision to champion the cause of activists is not one scientists typically make; they avoid political controversies for a reason. In 2011 the American Association for the Advancement of Science, the largest scientific society in the world, commissioned a paper on the "standards, benefits and risks" of advocacy. "When scientists become advocates, they become 'partisans' and are no longer neutral conveyors of scientific information," the paper stated. "While the line between neutral and partisan, between dispassionate and passionate, is not easily drawn, it nonetheless exists." Scientists who transgress that line tend to have their credibility impugned. Just ask the climatologists. Or think of Rachel Carson, who was a scientist with the United States Fish and Wildlife Service before she became an author. Upon the publication of "Silent Spring" in 1962, critics accused her of hysteria and Communism.

Consider the case of Clair Cameron Patterson, the geochemist who first determined the age of the planet from lead isotopic data. While working with that data, Patterson discovered, in the early 1960s, that scientists had grossly underestimated the amount of lead we were adding to the environment. There was lead in our gasoline, in our paint, in canned tuna, in our plumbing. The lead levels in the bodies of postwar Americans were 700 to 1,200 times as high as those of their preindustrial ancestors, Patterson estimated. For more than 20 years, the lead industry resisted his campaign to ban the metal from consumer products. The United States didn't remove the last of the lead from gasoline until 1996. Though our lead levels are still around 10 to 100 times as high as those of our preindustrial ancestors, they have, on average, been coming down ever since. But in 1965, when Patterson

first began sounding the alarm about lead, prominent toxicologists dismissed him as a "zealot" who had abandoned science for "rabble rousing."

Edwards considers Patterson a role model. He would prefer to remain dispassionate, he says, but his experiences in D.C. and Flint taught him that neutrality carries its own risks. If, as surveys suggest, Americans are less willing to defer to the authority of scientific experts than they once were, scientists themselves are partly to blame, Edwards believes. In the academy, competition over a dwindling pool of funding and the pressure to publish have created "perverse incentives," he said in a recent interview with The Chronicle of Higher Education. As a result, "the idea of science as a public good is being lost," and along with it, the "symbiotic relationship" between the scientific community and the public. For him, his intervention in Flint was a kind of demonstration project, a case study of how to conduct science ethically, in the public sphere and for the public good.

Michigan officials initially tried to discredit him, too, trotting out the rabble-rousing charge. Although the state "appreciates academic participation in this discussion," Wurfel, the Michigan Department of Environmental Quality spokesman, wrote in an email to a local reporter last September, "offering broad, dire public-health advice based on some quick testing could be seen as fanning political flames irresponsibly."

A scientist abiding the paper commissioned by the American Association for the Advancement of Science would have responded to Wurfel dispassionately, perhaps by conveying his data in a peer-reviewed journal. Instead, Edwards fought back like some 21st-century pamphleteer. On a website one of his graduate students built, flint waterstudy.org, he posted, along with incriminating documents and helpful tips for Flint residents, acerbic commentaries condemning Wurfel and other officials he considered culpable. "You wish they'd listen to reason, scientific facts, the truth," he told me. "But if they're corrupt, the only weapon you've got is ridicule."

In Flint, Edwards's pugilistic brand of advocacy seemed to work. Last winter, Wurfel and other officials resigned. In February, Congress invited Edwards to testify at hearings devoted to the Flint crisis, and in a rare display of bipartisanship, Democrats and Republicans alike solicited his opinions not only on matters of

science but also on matters of policy and morality and the law, treating him as a sort of oracle or ombudsman. It was hard to recall a scientist who had received a warmer reception on Capitol Hill. Gov. Rick Snyder had by then acceded to the demand spray-painted on the Block, appointing Edwards to the task force overseeing the state's response to the emergency in Flint. The E.P.A. awarded Virginia Tech an $80,000 grant to retest the city's water. Edwards had done as much as anyone to expose the betrayal of public trust in Flint. Who better than him to restore it?

With his son and daughter, both teenagers, and his wife, Jui-Ling, Edwards lives at the border of a national forest, atop Brush Mountain, one serration in the Appalachian chain. They heat their three-story house entirely with firewood that Edwards scavenges from the forest, and they draw their water from a well. Throughout the house, Edwards keeps gym equipment strategically placed — dumbbells in his living room, a treadmill and barbells in the basement.

He grew up in Ripley, N.Y., a rural town on the shore of Lake Erie. As a teenager, he worked menial jobs, picking grapes in the local vineyards and cleaning rooms at a motel, saving for college. He attended SUNY-Buffalo, majoring in biophysics because it was reputed to be the hardest major, combining the curriculums of biology, physics, chemistry and math. In his senior year, he applied successfully to the graduate program in civil engineering at the University of Washington, in Seattle. In his application's personal statement, he wrote that the restoration of Lake Erie, which he witnessed in the 1970s after the passage of the Clean Water Act, had given him his life's purpose: to improve "the future of water supplies."

The director of his dissertation at U.W. was an environmental engineer named Mark Benjamin. The two grew close, and have remained close, despite differences of temperament and politics. In the acknowledgments section of his dissertation, Edwards says of Benjamin, "I will do well to follow his sterling example in future professional activities, while at the same time attempting to shake the aftereffects of his Stanford socialistic drivel."

"As you probably know, since you've spent a lot of time with him, Marc has strong political views," Benjamin told me. It was true. Edwards had made his political views clear. In Virginia, when I visited him in February, we had watched the

returns of the South Carolina presidential primaries together in his living room, Edwards in gym shorts lifting 27-pound weights. He is a Republican, a fiscal conservative with a libertarian bent, as well as an environmental-justice warrior. "The crack about 'Stanford socialistic drivel' had become a running joke by then," Benjamin says. "But absolutely there was more than a grain of serious resentment at people feeling entitled by having gone to the best schools, as the world sees those rankings. Given his SUNY-Buffalo background, I'm sure he felt disrespected."

Edwards and Benjamin believe that, adhered to rigorously, the scientific method provides some protection from bias, political or otherwise, and by all accounts Edwards is a brilliant scientist. "Really, he's almost unique in the field right now, how much he's admired," Benjamin says. Other scientists I spoke to said the same, affirming the wisdom of the judges who in 2007 awarded Edwards a MacArthur Fellowship, the so-called Genius Grant. (In its citation, the foundation praised him for "playing a vital role in ensuring the safety of drinking water.")

Outside the realm of science, Edwards has strong differences of opinion with many of his admirers. In the written statement he submitted with his congressional testimony in February, he included a somewhat cryptic sentence. "While misconduct has always been a problem, at some level, since the earliest days of the scientific revolution," he wrote, "the rise of institutional scientific misconduct is a relatively new phenomenon."

When I asked him what he meant, he referred me to a 2014 book for which he wrote the foreword, "Science for Sale," by David L. Lewis, an E.P.A. whistle-blower. Lewis defines "institutional scientific misconduct" as "the fraudulent manipulation of science by government agencies, corporations and academic institutions to support government policies and industry practices." In his foreword, Edwards commends Lewis but quibbles with his definition. It's the misconduct of public institutions, not private ones, that worries Edwards most. "In my opinion," he writes, "the abuses and dangers of institutional scientific misconduct," where no profit motive appears, "far exceed those arising from misconduct in industrial science."

Edwards's cynicism about the public sector was deeply shaped by the "D.C. saga," Benjamin told me. In Washington, when Edwards started leveling allegations

against the E.P.A. and the C.D.C., he was treated by some as a pariah in his field, the scientist who cried "Lead!" in a crowded metropolis — or "the engineering equivalent," Benjamin says, "of an ambulance chaser."

Bruce Lanphear, a public-health physician who has studied environmental lead poisoning since the 1990s, shares Edwards's concern about the failures of regulatory agencies but attributes them mainly to the institution that invited Edwards to testify: Congress. He pointed out that in the last two decades Congress has cut the E.P.A.'s budget by 30 percent, even as the agency's regulatory mandates have increased.

"We're still using children as biological indicators for substandard housing," Lanphear says. "Everything is focused on short-term solutions, crisis thinking, the bottom line." The crisis in Flint has led to congressional hearings and criminal charges against nine Michigan officials but not yet to the kind of action Lanphear believes the nation needs to take. "Within the next 30 years, we're going to need to have replaced our entire water infrastructure," Lanphear says. "So what's the plan?"

This winter and spring, whenever Edwards went to Michigan, television cameras tended to follow. One morning, a team sent by RT, the Russian news network, trailed him to an elementary school — not in Flint but just outside it, in the comparatively affluent, majority-white suburb Grand Blanc. Joining Edwards on his classroom visit was Mona Hanna-Attisha, a pediatrician at Hurley Medical Center in Flint. Like many people in Michigan, she first heard of Edwards last summer. At the time, she was working on a study of her own, an analysis of pediatric blood data that would confirm what the Virginia Tech water study had implied — that blood-lead levels in Flint had shot up after the city seceded from Detroit's water system. Edwards had identified the cause, Hanna-Attisha the effect. She wasn't sure why state agencies had missed the blood-lead increase she had found. Trying to explain their failure, their collective blindness, she mentioned an aphorism she learned in medical school: "The eyes don't see what the mind doesn't know."

In a second-floor classroom, the pair sat in tiny red chairs, Edwards in an ill--fitting suit, Hanna-Attisha in an ankle-length parka, drinking cocoa from mugs and taking questions from small interrogators — the fourth-grade version of a congressional hearing. Edwards testified that something "governments don't do very

well is fix the problems they create."

"Do you blame the government for what happened?" a boy in the front row asked.

"Yes, I do," Edwards said. "Did you pick up on that?"

Another child wanted to know what happens to officials who break the law.

Hanna-Attisha joked that they get a "timeout."

Edwards liked this. "A really bad timeout!" he said. All the grown-ups laughed.

"And everyone gets fired!" the boy in front said.

"We can also have stronger laws and stronger rules," Hanna-Attisha said once the laughter died down, "to prevent this from happening in other cities."

Grand Blanc and Flint have a tangled history. A half-century ago, during the days of white flight, General Motors executives pushed to combine suburbs and city into a single metropolis — New Flint — with shared government services and a shared tax base. In 1958, opponents in the suburbs blocked the plan. People in parts of Flint now have a life expectancy 15 years lower than those in some neighboring suburbs, and even before the water crisis, children in Flint had higher blood-lead levels than their suburban counterparts. "Our Flint kids have every obstacle to success," Hanna-Attisha told me back at her office. "We have a 42 percent poverty rate here; it's about 16 percent in the state. We have one of the highest crime rates. We don't have full-service grocery stores."

Flint's plight, in other words, predated the water crisis and will outlast it. At the time of Edwards's classroom visit, four months after Flint rejoined Detroit's water system, Edwards's research team and the citizen scientists who volunteered to assist it were preparing to resample the same 271 taps that Virginia Tech sampled last summer. The results would reveal how far lead levels had fallen. Knocking on doors, they encountered an unanticipated obstacle: Many of the occupants of those 271 homes had moved away, locking their doors behind them. Civil engineers refer to the time that water spends in pipes as "water age." Flint's loss of population meant that

fewer people were opening their taps, which meant that Flint's water was getting older. The older the water, the longer it would take for corrosion inhibitors to work their way through all the pipes.

Of the 271 homes that Virginia Tech tested last summer, the lead levels in Elnora Carthan's house — 1,050 parts per billion, 70 times as high as the E.P.A. limit — were the highest. When Edwards visited Carthan's tiny yellow bungalow in the spring, scraps of copper piping lay coiled in the grass, the remnants of the service line that a construction crew sent by the city had just ripped out. The crew was still there, putting a new copper service line in, threading it under the asphalt to the water main across the street.

"It's a big C.S.I.-of-plumbing case," Edwards said, "because why does she have so much lead but no lead pipe?" He crouched on the lawn, peered into a length of pipe and blew into one end of it. Having found no clues, he tagged a few scraps to take back to his lab for further study.

In Carthan's basement, he inspected the plumbing with a flashlight. Traditionally, civil engineers have concerned themselves with public works, leaving household plumbing to plumbers. But in the 1990s, Edwards realized that the distinction between private property and public works had everything to do with legal liabilities and nothing to do with chemistry. Legally, a homeowner is responsible for what happens after water crosses the property line, which is one reason water companies are keen to attribute lead poisoning to household sources. But what happens to water at the municipal treatment plant, or on its subterranean journey, can have unintended side effects within the home. Depending on its chemistry, water can eat pinholes into copper pipes. It can turn a basement water heater into an incubator of legionella or other bacteria. And if its chemistry is corrosive, it can leach lead from the solder or from brass faucets. Old plumbing fixtures made of brass were often as much as 20 percent lead by weight, and until 2014 even brass faucets advertised as lead-free could contain up to 8 percent lead by weight in the United States. Solder, brass fixtures or maybe a chunk of lead obstructing a pipe — those, Edwards hypothesized, were the likely sources of the lead in Carthan's water. To test his hypothesis, he hired a local plumber for the day to replumb Carthan's house with PVC. From her old plumbing, he collected samples and added them to the heap of

evidence destined for his lab.

Out in her driveway, Carthan stood by, watching the scientists at work. Born in Arkansas, she moved to Flint in 1976 and had been there ever since, even though her children and grandchildren had all moved away. She herself had never drunk the poisoned water or served it to guests. "When they first switched," she said, "it had an odd smell. A really odd smell. You knew something was wrong. You turn the shower on, and you could smell it. You take a shower, five or 10 minutes later, you begin to itch. You knew there was something wrong. That's why people were complaining. But nobody was listening" — until Virginia Tech arrived. Carthan signed up to participate in last summer's water study as soon as she heard about it.

Edwards credited much of the success of his intervention in Flint to an anthropologist named Yanna Lambrinidou. Lambrinidou had helped organize a coalition of activists during D.C.'s lead crisis. It was their work, and Lambrinidou's in particular, that brought his D.C. research to the attention of Congress, Edwards told me. Without her efforts, the congressional investigation that vindicated him might never have happened.

Collaborating on the D.C. crisis, Edwards tutored Lambrinidou in the chemistry of lead corrosion. In turn, she taught him about the value of "vernacular" knowledge and the ethical hazards of scientific hubris. For several years, Edwards and Lambrinidou together taught a course at Virginia Tech called Engineering Ethics and the Public, in which students studied cases of scientific misconduct and practiced ethnographic methods — what Lambrinidou calls "learning to listen." In Flint, Edwards told me, he tried to apply everything he had learned from her.

Lambrinidou was at first reluctant to speak to me. Eventually, she explained why. Although she considered "Marc's contribution in Flint and D.C. absolutely essential," on his website and in the news media, Edwards had contributed to a simplistic "hero narrative" about Flint. This was a complaint I heard from other environmental-justice advocates — that Edwards had cast himself, or been cast by the news media, as Flint's white knight. A number of people I spoke to, Lambrinidou among them, referred to a comment that Irma Muñoz, the president of an advocacy group called Mujeres de la Tierra, had made at a recent conference on citizen science:

"We don't want our day saved," Muñoz said. "We want to save our own day."

Paul Schwartz, a water activist who worked with Edwards and Lambrinidou in D.C., told me there were times when Edwards "would be helpful and supportive, and there were times when he shoved us aside and inserted himself right into the middle of the story."

In an email to me, Lambrinidou wrote: "We are all capable of outstanding courage (even if at times we have been 'cowards') and of outstanding wrongdoing (even if at times we have been 'heroes'). This is what it means to be human, no? This is what it means to be a parent, a teacher, a doctor, a president. We all know that at times we've shined beyond even our own greatest expectations, and at times we've failed spectacularly to the point of self-shock. I think that Marc, not unlike many individuals and institutions embracing 'hero' narratives, struggles sometimes to hear this."

She described an alternative situation that might have played out in Flint, one she had seen play out in other collaborations between citizens and scientists. What if Edwards had stayed in Virginia, or at least away from the cameras? What if he had supported the activists in Flint with technical expertise but let them announce the findings of the study they conducted with his help? I wasn't sure. If LeeAnne Walters had presented the evidence on the lawn of City Hall last September, would people outside Flint have taken the evidence as seriously?

This spring, a new outsider began making trouble in Flint, the actor Mark Ruffalo, who founded an environmental group called Water Defense. Ruffalo had appointed a man named Scott Smith to serve as Water Defense's chief water scientist. When Smith went to Flint, he took what he called Water Defense Waterbugs, colorful sponges of "open-cell elastomeric foam technology." They looked like Koosh balls made from shredded swimming-pool noodles. Smith tossed them into the Flint River. He tossed them into bathtubs and shower stalls. In a video that Water Defense posted online, Smith claimed that the research carried out by others was fundamentally flawed, because it relied entirely on "grab samples" that collect "a split second" of water, and people don't "bathe for a split second." (In fact, Edwards says, Virginia Tech used an array of proven sampling methods.)

In April, at a meeting of the Flint City Council inside City Hall, Smith issued a warning that bore an uncanny resemblance to those Edwards issued last September. "It is irresponsible and incomprehensible for anyone to declare or suggest that the water in Flint is safe to bathe or shower in," Smith said. No one had tested the showers and bathtubs of Flint for "the full spectrum of chemicals, including but not limited to chemicals that volatilize or aerosolize in the air and pose a direct inhalation risk into the lungs." It was a convincing performance, not only because Smith sounded scientific but also because his assessment helped explain symptoms that residents of Flint continued to report even after they stopped drinking the poisoned water — rashes, hair loss, difficulty breathing, a burning in the lungs. In February alone, there were so many complaints from Flint residents that state and federal public-health officials opened a new investigation. (Asked to comment for this article, the C.D.C. said that "results from the investigation have not yet been released.")

"This is exactly the danger of having untrustworthy government science," Edwards wrote me in an email in May. "A Hollywood fraud rolls into town, and they cannot even call him out." Concerned that Water Defense would scare even Flint residents who reported no adverse symptoms, he decided to go after Ruffalo and Smith the way he went after government officials last fall. "A-List Actor but F-List Scientist: Mark Ruffalo Brings Fear and Misinformation to Flint" read the headline of a blog post he published on flintwaterstudy.org.

"Not everyone who challenges the claims of the E.P.A., C.D.C. and State of Michigan are automatically correct," he wrote. Smith had no degrees in the sciences, Edwards noted, and appeared to be a businessman of dubious accomplishment who was now trying to market his sponges. Edwards made the case that Water Defense's meddling would do harm. A recent increase in gastrointestinal infections in Flint, Edwards speculated, could have been caused by the poor hygiene that Smith's "fear-mongering" had encouraged. The disinfection byproducts, or DBPs, that Water Defense had detected in showers — produced by reactions between chlorine and organic matter — had been reviewed by a scientist Edwards recruited, Dr. David Reckhow of the University of Massachusetts, Amherst, "one of the foremost authorities on DBPs in the world." Reckhow's assessment: "There is nothing at all unusual or abnormal in the Flint DBP data."

Water Defense, though, made its own appeal to authority. Smith was not a credentialed scientist, it was true, but all his samples were being tested by an independent lab and reviewed by Judith Zelikoff, a toxicologist in the environmental-medicine department at New York University. (Water Defense is "producing data in an ethical and transparent manner," Zelikoff told me, "and I will continue to support them.") Once again, Flint residents were left to wonder whom to believe.

This time, Edwards's pugilistic brand of advocacy proved less effective than it had last fall. Among the activists who fought to expose Flint's water crisis, a schism emerged. There were those, led by LeeAnne Walters, who kept faith in Virginia Tech, and those, led by another Flint mother, Melissa Mays, who placed their trust in Water Defense. Mays helped conduct the fieldwork for the Virginia Tech water study and, like LeeAnne Walters, she appeared alongside Edwards at his news conference last September. Now, after his denunciation of Water Defense, she renounced him. "You aren't listening anymore," she wrote in an email that Edwards shared with me. "We'll go back to doing the work on our own with those willing to work WITH us in the community as we discover more and vindicate what the residents here already know by THE PAIN WE ARE IN, that it is not safe to bathe."

On a hot May afternoon, Mays and other Flint residents drove to Ann Arbor to protest outside the condominium on Main Street where Gov. Rick Snyder lives when he isn't in Lansing. They wore bathrobes and carried signs calling for Snyder's impeachment. "Tricky Ricky, you can't hide! We can see your dirty side!" the protesters chanted. I spotted a woman in a pink bathrobe and a FLINT LIVES MATTER T-shirt whom Edwards had introduced me to in the winter. Her name was Nayyirah Shariff, and she was a community organizer with the Flint Democracy Defense League. When we first met, Shariff expressed gratitude and admiration for what Virginia Tech had done, but her opinion of Edwards had since changed. "Now it feels like, intentionally or unintentionally, he's filling the role of the State of Michigan and how they felt about our experiences back in the summer of 2015."

When I caught up with Melissa Mays, she said, "What broke my heart the most is that when we brought Marc Edwards in last August, the state did the same thing to him, called him a fear-monger. That's the same thing that Marc just did to Water Defense." Edwards's remarks about hygiene, moreover, were offensive. People in

Flint hadn't stopped bathing despite their adverse reactions. "You're saying that we're dumb and dirty," Mays said. "That's what's wrong with us."

At the end of May, Edwards returned to Michigan to hold yet another news conference, at which he and other scientists would try to allay the fears and doubts that Water Defense had fueled. For this occasion, Edwards toned down his rhetoric, presenting the latest data neutrally. Lead levels were still too high, but they were coming down. The disinfection byproducts were comparable to the national average. Sounding weary, he continued: "I understand that the trust will never be there for some people. If the residents in Flint, given their journey, decide they never want to drink tap water again, never want to take a bath or shower again, I'm not going to try to talk them out of it, because they went through hell for 18 months."

After the news conference ended, Edwards visited the home of Mari Copeny, the 9-year-old known as Little Miss Flint, whose letter to President Obama prompted him to visit. From LeeAnne Walters, Edwards had learned that Water Defense had collected samples in Mari's home. She was at school, but her mother, Lulu Brezzell, let Edwards in. Even after the city returned to Detroit's system, the water gave her family bad rashes, Brezzell said. She showed him pictures — angry red splotches on hands and arms and legs. Washing the dishes made the skin on her knuckles blister and split. She and her children were still doing their best to practice good hygiene, but they had learned to take "speed showers" — no more than two minutes. Water Defense had found high levels of chloroform in her water. Another scientist, with Hydroviv, a company that sells water filters, told her that her chloroform levels were "comparable to other municipal water sources." Like many people in Flint, she didn't know what or whom to believe, but she was inclined to trust her symptoms and her senses. Her water smelled "like a swimming pool," and it had acquired a mysterious blue tint.

"So I do a lot of work with blue water all over the country," Edwards said. About 80 percent of blue-water cases are "natural," a trick of the light, he explained. In the remaining 20 percent, the tint comes from dissolved copper, and unlike lead, a little copper is harmless. To figure out whether Brezzell's blue water was natural or chemical, all you had to do was place a bottle of it and a bottle of store-bought water against a white background.

Upstairs in her little bathroom, he filled the tub. As the water rose, it took on a tint. "Can you see it?" Brezzell asked. "Nice and blue?"

"Oh, yeah, that's blue," Edwards said.

She was relieved to hear him say this. "People were saying: 'You're crazy. The water's not blue.' I'm like, 'Yes, it is!' "

"So now the question, though: Is it bluer than normal water?" Edwards said. He performed his test, filling a bottle from Brezzell's tub and comparing it with a bottle of store-bought water.

"They're a different color!" Brezzell said hopefully.

Edwards held the bottles up to a fluorescent light above the sink.

"That is blue water," Edwards said. "But it's light blue." He took the two bottles outside. In natural light, they were harder to distinguish. Compared with other blue water he had studied, on a blueness scale of 1 to 10, hers was low, around a 1.5, he estimated. He meant this to sound reassuring: The 1.5 was close to normal, most likely indicative of a little copper, but nothing to worry about.

"It's still darker, though," Brezzell said, and you could tell from the insistence in her voice that she was neither comforted nor convinced.

Edwards was not surprised by her reaction, he later told me. She had horrible rashes and so did her children. She was in pain. "And when you're in pain, you want an answer, even if it's wrong," and he had no firm conclusions to offer, only data and hypotheses. All he knew for certain was what the lab tests eventually told him: that contrary to what Water Defense had told her, the chloroform levels were typical for American cities. The same was true of the disinfection byproducts and copper. Her chlorine levels, though well below the E.P.A. limit, were a bit high. Perhaps this explained the rashes. Perhaps she and her children were sensitive to chlorine. Perhaps a filter for her shower head would help.

Early this month, I spoke to Edwards one last time. A year ago, he was the troublemaking outsider whom the authorities were accusing of "fanning the political

flames irresponsibly." Now he was the authority making that case about others, and if many of the activists now considered him an untrustworthy agent of the state, there was nothing he could do about it. In both roles, he said, he had been the advocate for "sound science."

"This is what a 'dark age' looks like," he wrote me in an email the morning after our conversation. "When science is no longer a source of enlightenment, people still need to believe in something." The people of Flint had been betrayed, and the betrayal had pushed some of them "into the anti-science camp." He continued: "We lost our authority and the public trust with good reason. After Flint kids were protected, I took off my activist suit and put on my lab coat. Some people assumed my motives could be changed just as easily. Not so, but arguing about it is not productive. Our energies have to be focused on not betraying the public in the first place."

Correction: August 28, 2016

Picture credits on Aug. 21 with an article about the water crisis in Flint, Mich., omitted the photographer's middle initial. He is Jeremy M. Lange.

Correction: September 11, 2016

An article on Aug. 21 about the water-contamination crisis in Flint, Mich., described incorrectly a statement the American Association for the Advancement of Science (A.A.A.S.) made on advocacy in science. It was in a paper commissioned for an A.A.A.S. workshop; it was not an official report. And it was commissioned in 2011, not 2016.

Correction: September 4, 2016

An article on Aug. 21 about Flint's water-contamination crisis referred incorrectly to Scott Smith's relationship with Water Defense when he was named the group's chief water scientist. He was appointed to the post and receives no compensation beyond expenses; he was not hired.

Donovan Hohn is the author of "Moby-Duck: The True Story of 28,800 Bath Toys Lost at Sea." He last wrote for the magazine about whether it is possible for engineers to reverse environmental damage.

A version of this article appears in print on August 21, 2016, on Page MM40 of the Sunday Magazine with

the headline: The__Zealot.

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Lead and Copper Rule Long-Term Revisions

Overview

Lead exposure occurs through many pathways, including soil, dust, food, and drinking water. Through a series of policies – including the phase-outs of lead in gasoline and paint – the U.S. has made major progress in reducing lead exposure and childhood blood lead levels over the past several decades. Although the LCR has resulted in substantial reductions in lead in drinking water, there is a compelling need to strengthen its public health protections and clarify its implementation requirements.

Revisions Being Considered

The Lead and Copper Rule Revisions White Paper provides examples of regulatory options to improve the existing rule. The paper highlights key challenges, opportunities, and analytical issues presented by these options. Options include lead service line replacement, improving optimal corrosion control treatment requirements, consideration of a health-based benchmark, the potential role of point-of-use filters, clarifications or strengthening of tap sampling requirements, increased transparency, and public education requirements

- Read more about the current Lead and Copper Rule.

Lead Modeling Peer Review

As a part of EPA's ongoing effort to understand and assess lead exposure to children, EPA is initiating a peer review of draft scientific modeling approaches to inform EPA's evaluation of potential health-based benchmarks for lead in drinking water. Read more.

Stakeholder Consultations

To help shape an updated Lead and Copper Rule, EPA has engaged with multiple stakeholders representing a wide range of expertise.

National Drinking Water Advisory Council (NDWAC) Lead and Copper Rule Working Group

The NDWAC Lead and Copper Rule Working Group was convened beginning in March 2014 to provide advice to EPA in addressing the five issues listed below:

- Sample site selection criteria;
- Lead sampling protocols;
- Public education for copper;
- Measures to ensure optimal corrosion control treatment; and
- Lead service line replacement.

- NDWAC Recommendations to the Administrator for the Long Term Revisions to the Lead and Copper Rule (LCR) and Past Meeting Summaries

Science Advisory Board Evaluation of the Effectiveness of Partial Lead Service Line Replacements

EPA's Office of Water requested the Science Advisory Board (SAB) evaluate the current scientific data to determine the effectiveness of partial lead service line replacements (PLSLR) in reducing drinking water lead levels. The SAB convened the Drinking Water Committee Augmented for the Review of the Effectiveness of Partial Lead Service Line Replacements to study the issues and report their findings and conclusions. The charge to the SAB was centered around five issues including:

- Associations between PLSLR and blood lead levels in children;
- Water sampling data at the tap before and after PLSLR;
- Comparisons between partial and full lead service line replacements;
- PLSLR techniques; and
- The impact of galvanic corrosion.

- Read the SAB's September 2011 report and recommendations

Stakeholder Meeting Concerning Potential Long-Term Revisions to the Lead and Copper Rule

EPA held a public meeting on November 4, 2010 to discuss potential Long-Term Revisions to the LCR. The meeting was held to obtain stakeholder feedback about key issues and options to address the issues.

- **Federal Register Notice:** Notice of a Public Meeting: Stakeholder Meeting Concerning EPA's Long-Term Revisions to the Regulation of Lead and Copper in Drinking Water
- Review the presentations from the Lead and Copper Rule Stakeholder Meeting - November 4, 2010

Tribal Consultations

Revisions to the LCR may impact tribes. EPA consulted via teleconference with Indian Tribes on the proposed LCR revisions in 2011. Additional details and background information regarding this consultation

can be found in the Tribal Notification Letter.

- Read the Tribal Notification Letter

Environmental Justice

Because LCR revisions may have environmental justice impacts, in 2011 EPA held a public meeting to discuss environmental justice considerations.

- **Federal Register Notice:** Notice of a Public Meeting: Environmental Justice Considerations for Drinking Water Regulatory Efforts - March 3, 2011

Contact Us to ask a question, provide feedback, or report a problem.

LEAD AND COPPER RULE REVISIONS WHITE PAPER

October 2016

U. S. Environmental Protection Agency

Office of Water

Washington, DC 20460

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I. Executive Summary

Exposure to lead is known to present serious health risks to the brain and nervous system of children. The recent crisis in Flint, Michigan, has brought increased attention to the challenge of lead in drinking water systems across the country. It is important to recognize that major reductions in been achieved in childhood exposure to lead in the United States. Data show that from 1976 – 1980 the median blood lead level of a child (1-5 years old) was 15 micrograms per deciliter. That median level has been reduced dramatically since then, to 1 microgram per deciliter, based on the most recent data. Further, over the last twenty-five years, the percentage of children aged 1–5 years with blood lead levels less than or equal to 5 micrograms per deciliter declined more than ten-fold, and blood lead levels fell dramatically for all racial and ethnic groups. These improvements were made by removing lead from toys and lead solder in cans, taking lead out of gasoline, reducing exposure to lead in paint and dust in homes and during renovations, greatly reducing the allowable content of lead in plumbing materials in homes and other buildings, and further reducing lead in drinking water through the federal Lead and Copper Rule (LCR). Although we have taken significant steps to protect our children from the detrimental effects of lead poisoning, there is more to do.

Lead and copper enter drinking water mainly from corrosion of lead and copper containing plumbing materials. Lead was widely used in plumbing materials until Congress banned its use in 1986, and there are an estimated 6.5 to 10 million homes served by lead service lines (LSLs) in thousands of communities nationwide, in addition to millions of older buildings with lead solder across the U.S. Lead exposure, whether through drinking water, soil, dust or air, can result in serious adverse health effects, particularly for young children. Infants and children exposed to lead may experience delays in physical and mental development and may show deficits in attention span and learning disabilities. In adults, lead exposure can cause kidney problems and high blood pressure. Copper exposure can cause stomach and intestinal distress, liver and kidney damage, and complications of Wilson's disease in genetically predisposed people.

In 1991, EPA promulgated the LCR – a treatment technique regulation under the Safe Drinking Water Act (SDWA) – to protect public health by minimizing lead and copper levels in drinking water, primarily by reducing water corrosivity through corrosion control treatment. This rule applies to 68,000 public water systems nationwide. EPA has continued to work to make the LCR more effective through interim revisions promulgated in 2000 and 2007.

Implementation of the LCR over the past twenty-five years has resulted in major improvements in public health; the number of the nation's large drinking water systems with a 90th percentile sample value exceeding the LCR action level of 15 parts per billion has decreased by over 90 percent since the initial implementation of the LCR. However, the regulation and its implementation are in urgent need of an overhaul. Lead crises in Washington, DC, and in Flint, Michigan, and the subsequent national attention focused on lead in drinking water in other communities, have underscored significant challenges in the implementation of the current rule, including a rule structure that for many systems only compels protective actions after public health threats have been identified. Key challenges include the rule's complexity, the degree of discretion it affords with regard to optimization of corrosion control treatment and compliance sampling practices that in some cases, may not adequately protect from lead exposure, and limited specific focus on key areas of concern such as schools. There is a compelling need to modernize and strengthen implementation of the rule – to strengthen its public health protections and to clarify its implementation requirements to make it more effective and more readily enforceable.

EPA has conducted extensive engagement with stakeholder groups and the public to inform revisions to the LCR. In December of 2015, EPA received comprehensive recommendations from the National Drinking Water Advisory Council (NDWAC) and other concerned stakeholders on potential steps to strengthen the LCR. EPA is carefully evaluating the recommendations from these groups. In addition, EPA is giving extensive consideration to the national experience in implementing the rule as well as the experience in Flint, MI, as we develop proposed revisions to the rule.

Key Principles for LCR Revisions

EPA's goal for the LCR revisions is to improve public health protection while ensuring effective implementation by the 68,000 drinking water systems that are covered by the rule. This includes strengthening corrosion control treatment in drinking water systems to further reduce exposure to lead and copper and identifying additional actions that will equitably reduce the public's exposure to lead and copper when corrosion control treatment alone is not effective. In developing proposed revisions to the LCR, EPA will be guided by several key principles, including:

- Focus on Minimizing Exposure to Lead in Drinking Water: Improve public health protection by reducing exposure to lead in drinking water to the maximum amount possible through proactive measures to remove sources of lead and educating consumers about the health effects of lead and actions to reduce exposure.
- Clear and Enforceable Requirements: Improve implementation by designing a more prescriptive regulation with fewer discretionary decision points that rely on the judgment of individuals in states and drinking water utilities that may lack expertise in the complexities of corrosion control treatment and distribution system management.
- Transparency: Stronger programs to educate consumers about health risks and actions to reduce exposure to lead in drinking water, better access for consumers to information related to the location of LSLs, and more rapid test results of all tap samples and water quality parameter monitoring.
- Environmental Justice and Children's Health: Because of disparities in the quality of housing, community economic status, and access to medical care, lead in drinking water (and other media) disproportionately affects lower-income people. In addition, lead has disproportionate health effects on infants and children. In revising the LCR, EPA seeks to address environmental justice concerns and to prioritize protection of infants and children who are most vulnerable to the harmful effects of lead exposure.
- Integrating Drinking Water with Cross-Media Lead Reduction Efforts: Leveraging efforts of state and local public health authorities to provide integrated approaches to comprehensively reduce exposure to lead from drinking water, paint, dust, soil and other potential sources of exposure.

EPA is carefully considering NDWAC advice and other stakeholder input and is undertaking key analytical work to develop proposed revisions to the LCR. We are considering an approach that will incorporate both technology- based and health-based elements – to ensure effective reductions of lead in drinking water at the water system level, while at the same time providing consumers with the information, tools and protections needed to address remaining risks. We anticipate that these elements will be supported by clear and robust revised sampling requirements, strengthened reporting, transparency provisions that ensure consumers have rapid access to relevant information and public education materials. Key potential elements under consideration are discussed in Section 3; these elements are highly interdependent, and potential revisions to the rule must be considered in an integrated perspective.

II. Background

Health Effects of Lead

Over the past decade, epidemiologic studies have consistently demonstrated that there is no safe level of lead. In particular, studies conducted in diverse populations of children consistently demonstrate the harmful effects of lead exposure on cognitive function, as measured by IQ decrements, decreased academic performance and poorer performance on tests of executive function. Lead exposure is also associated with decreased attention, and increased impulsivity and hyperactivity in children. In adults, long-term lead exposure results in increased blood pressure and hypertension. In addition to its effect on blood pressure, lead exposure can also lead to coronary heart disease and death from cardiovascular causes and is associated with cognitive function decrements, symptoms of depression and anxiety, and immune effects in adults.

Health Effects of Copper

Copper has been demonstrated to cause gastrointestinal distress following short term exposure and can cause liver and kidney damage during longer term exposures. Copper exposures are of particular concern for people with Wilson's disease.

Lead in Plumbing Materials

The extent to which leaded materials occur in drinking water distribution systems and plumbing materials in homes and buildings (premise plumbing) varies across the U.S. Much of the variation is due to the quality and age of the housing stock; older homes are more likely to have pipes and plumbing materials containing lead. Where they are present, the most significant source of lead in drinking water are leaded pipes that extend from the water main underneath the street to the residence (lead service lines, or LSLs) however, faucets and fixtures with leaded brass and pipes with lead solder can also contribute to the presence of lead in drinking water. Water chemistry also plays a role in lead levels, because some water sources are more corrosive to leaded plumbing materials if not treated for corrosion control.

In 1986, Congress amended the Safe Drinking Water Act, prohibiting the use of pipes, solder or flux that are not "lead free" in public water systems or plumbing in facilities providing water for human consumption. At the time, "lead free" was defined as solder and flux with no more than 0.2% lead and pipes with no more than 8%. Prior to this, leaded materials were commonly used in plumbing materials and for service lines connecting residences and buildings to water mains. In 1996, Congress further amended SDWA to expand the prohibition to encompass plumbing fittings and fixtures and to prohibit the introduction into commerce of pipes, fitting, and fixtures, solder or flux that is not lead free. The Reduction of Lead in Drinking Water Act of 2011 created exemptions to the prohibitions and revised the maximum allowable lead content from not more than 8% to not more than a weighted average of 0.25% lead on the wetted surface; further reducing the amount of lead in contact with drinking water when that law became effective in January 2014. While these prohibitions have reduced the amount of lead allowed in covered plumbing materials after they went into effect, there are many buildings that still have LSLs and/or plumbing materials made with a higher percentage of lead than currently allowed for new installations or repairs of existing plumbing.

Summary of the Current Lead and Copper Rule

Under SDWA, EPA establishes national primary drinking water regulations (NPDWRs) which either establish a maximum contaminant level (MCL) or a treatment technique "to prevent known or anticipated adverse effects on the health of persons to the extent feasible." The Lead and Copper Rule (LCR) is a treatment technique rule, first promulgated in 1991 and revised in 2000 and 2007, which requires water systems to conduct tap sampling for lead and copper to determine the actions water systems must take to reduce exposure to lead and copper. Recognizing that there is no safe level of lead in drinking water, the LCR set a health-based maximum contaminant level goal of zero. Under the LCR, water systems must work with their customers to collect samples from locations with LSLs and/or leaded plumbing materials. The LCR established action levels of 0.015 mg/L (15 ppb) for lead and 1.3 mg/L (ppm) for copper, based on the 90th percentile sample level.

The action level for copper is set at the health-based maximum contaminant level goal for copper. The action level for lead is based upon EPA's evaluation of available data on corrosion control's ability to reduce lead levels at the tap. Corrosion control treatment (CCT) typically involves the addition of chemicals such as orthophosphate, or chemical adjustment of drinking water pH, to reduce the corrosivity of drinking water and thus the level of leaching of lead and copper from plumbing materials. Whereas an MCL is an enforceable level that drinking water cannot exceed without violation, an action level is a screening tool for determining when certain treatment technique actions are needed. If the lead or copper action level is exceeded in more than ten percent of tap water samples collected during any monitoring period (i.e., if the 90th percentile level is greater than the action level), a water system must take certain actions.

The type of action that is triggered depends upon the size of the system and the actions it has taken previously. All water systems serving more than 50,000 people were required to install corrosion control treatment soon after the LCR went into effect. Systems serving less than 50,000 people are not required to install corrosion treatment if the system meets the lead and copper action levels during each of two consecutive six-month monitoring periods. Systems serving less than 50,000 people that exceed the action level and have not yet installed CCT must begin working with their state to monitor water quality parameters and install and maintain CCT. Any system that exceeds the lead action level must conduct public education. Any system with LSLs that exceeds the lead action level after installing CCT must begin LSL replacement (LSLR). Although LSLR programs are conducted by public water systems, in many cases, the portion of the LSL that extends from the water main to the residential property line is owned by the water system, while the portion of the line that extends from the property line to the home is solely owned by the homeowner. Under the current rule, water systems conducting LSLR must offer building owners the opportunity to replace their portion of the line at the time the system is replacing the portion of the service line owned by the system, but the system is not obligated to pay for replacing the portion of the line it does not own.

Key Challenges with the Current Lead and Copper Rule

The LCR is one of the most complicated drinking water regulations for states and drinking water utilities to implement due to the need to control corrosivity of treated drinking water as it travels through often antiquated distribution and plumbing systems on the way to the consumer's tap. The LCR is the only NPDWR that requires sampling in homes, often by the consumers themselves. The rule includes complex sampling and treatment technique requirements intended to protect against exposure to lead and copper in drinking water. States and public water systems must have expertise and resources to identify the sampling locations and to collect and analyze samples correctly. Even greater expertise is needed for

systems and states to identify on a system-specific basis the optimal CCT and water quality parameter monitoring to assure effective operation. The current structure of the rule compels additional protective actions on the part of a water system only after a potential problem has been identified, which may create a disincentive for utilities to identify potential problems with lead and copper in the drinking water system. It is also worth noting that road construction activities or maintenance of gas or buried power lines can cause disturbance of LSLs, in some cases introducing high levels of lead into drinking water through the release of lead particulates into the drinking water distribution system.

When corrosion control alone is not sufficient, LSLR, public education, and further actions on the part of consumers to reduce their exposure to lead are necessary. Consumers' ability to understand and afford these actions can pose challenges. In most communities, LSLs are partially owned by the utility and partially owned by the homeowner; the cost of full LSLRs has been estimated to be $2,500-$5,500 per line, but some industry estimates for an average replacement are as high as $8,700 per line.

Summary of National Drinking Water Advisory Council Recommendations

The National Drinking Water Advisory Council (NDWAC) is a Federal Advisory Committee that supports EPA in performing its duties and responsibilities related to the national drinking water program. The council was created through a provision in the SDWA of 1974. The NDWAC LCR Working Group was formed to provide advice to EPA in considering potential revisions to the LCR. In December 2015, the NDWAC provided specific recommendations to the Administrator for LCR revisions including:

- Require proactive LSLR programs, which set replacement goals, effectively engage customers in implementing those goals, and provide improved access to information about LSLs, in place of current requirements in which LSLs must be replaced only after a lead action level exceedance (ALE);
- Establish more robust public education requirements for lead and LSLs, by updating the Consumer Confidence Report (CCR), adding targeted outreach to consumers with LSLs and other vulnerable populations (pregnant women and families with infants and young children), and increasing the information available to the public;
- Strengthen CCT, retaining the current rule requirements to re-assess CCT if changes to source water or treatment are planned, adding a requirement to review updates to EPA guidance to determine if new scientific information warrants changes;
- Modify monitoring requirements to provide for consumer requested tap samples for lead and to utilize results of tap samples for lead to inform consumer action to reduce the risks in their homes, to inform the appropriate public health agency when results are above a designated household action level, and to assess the effectiveness of CCT and/or other reasons for elevated lead results;
- Tailor water quality parameters (WQPs) to the specific CCT plan for each system, and increase the frequency of WQP monitoring for process control;
- Establish a health-based, household action level that triggers a report to the consumer and to the applicable health agency for follow up;
- Separate the requirements for copper from those for lead and focus new requirements where water is corrosive to copper; and
- Establish appropriate compliance and enforcement mechanisms.

Summary of Other Stakeholder Input

EPA has also received recommendations for revisions to the LCR from other stakeholders including a NDWAC Working Group member who dissented on a number of the NDWAC recommendations, the

Flint Water Interagency Coordinating Committee, and local citizens impacted by the experience in Flint. These recommendations emphasize the importance of enforceable goals for LSLR, recognize the significant lead exposure risks that can accompany partial service line replacements (PLSLRs) and provide clearer and more prescriptive requirements for sampling and corrosion control protocols that reduce the opportunities for systems to generate biased sampling results or improperly implement corrosion control procedures. EPA has received input from other stakeholders similarly concerned with eliminating PLSLRs and strengthening the sampling and corrosion control provisions of the LCR. In addition, the Board of the American Water Works Association (AWWA), which represents drinking water utilities, voted unanimously in March of 2016 to support the NDWAC recommendations, including those that would ultimately lead to complete replacement of LSLs.

III. Key Issues and Potential Elements under Consideration

EPA expects that proposed revisions to the LCR will include both technology-driven and health-based elements that focus on proactive, preventative actions to avoid high lead levels and health risks. In addition, we expect to propose robust and ongoing communication and information sharing with consumers that will foster actions by consumers to reduce risks. The potential elements under consideration are interconnected components that together will address the challenges with the current rule and improve public health protection in the revised rule.

In developing revisions to the LCR, EPA must adhere to the SDWA's statutory requirements and achieve the greatest public health protection feasible. The SDWA requires that any treatment technique rule must prevent known or anticipated adverse effects on the health of persons to the extent feasible and revisions to any NPDWR must maintain or strengthen public health protection. In addition, EPA must prepare a Health Risk Reduction Cost Analysis to evaluate if the benefits justify the costs of the rule. EPA is committed to using the best available science. As knowledge about lead contamination in drinking water evolves, we will continue to engage with stakeholders and consider their viewpoints and relevant science in developing revisions to the LCR.

Lead Service Line Replacement

As noted above, LSLs, which connect a residence or building to the water main, can be a significant source of lead in drinking water. The total number of LSLs currently in use in the US is unknown; estimates range from 6.5 million to greater than 10 million homes that have service lines that are at least partially made of lead. The current LCR requires LSLR only after a lead ALE, and allows partial LSLR when an owner of a home or building is unable or unwilling to pay for replacement of the portion of the service line not owned by the water system.

In 2010, EPA asked its Science Advisory Board to evaluate the data regarding the effectiveness of the partial LSLR, in comparison to full line replacement. The EPA Science Advisory Board concluded in its 2011 report to EPA that:

> PLSLRs have not been shown to reliably reduce drinking water lead levels in the short term, ranging from days to months, and potentially even longer. Additionally, PLSLR is frequently associated with short-term elevated drinking water lead levels for some period of time after replacement, suggesting the potential for harm, rather than benefit during that time period. Available data suggest that the elevated tap water lead levels

tend to then gradually stabilize over time following PLSLR, sometimes at levels below and sometimes at levels similar to those observed prior to PLSLR. [1]

Much of the discussion regarding potential LCR revisions has focused on mandatory, proactive LSLR, as a potential opportunity to eliminate one of the primary sources of lead in drinking water, thus reducing reliance on corrosion control to reduce lead in drinking water at the tap.

The NDWAC has recommended that the Agency require proactive full LSLR programs with the following elements:

- Requiring all PWSs to establish a LSLR program that effectively informs and engages customers to encourage them to share appropriately in fully removing LSLs, unless the system can demonstrate that LSLs are not present in their system;
- Targeted outreach to customers with LSLs, with information about the risks of lead exposure, an offer to test a tap sample, and information about and encouragement to participate in the LSLR program;
- Dates by which systems should have met interim goals and completed replacement of all LSLs and partial LSLs, without penalty to the water system for those homeowners who refuse to participate in the replacement program as long as the water system has made a meaningful effort to work with such a homeowner;
- Creating incentives for understanding where LSLs and PLSLs exist, while making action on full replacement, rather than on investigation of the location of LSLs and PLSLs the priority;
- Maintaining ongoing-outreach to homeowners where LSLs or PLSLs still exist;
- Implementation of standard operating procedures (SOPs), either from EPA guidance or tailored to the system, that helps define operations that disturb LSLs and practices to minimize disturbance and consumer exposure to lead; and
- Stronger programs to educate consumers, and to provide test results of tap samples at the request of consumers.

It is important to recognize that LSLR presents substantial economic, legal, technical and environmental justice challenges. First, it is costly. Estimated costs for LSLRs range from $2500 to more than $8000 per line, suggesting an estimated cost of eliminating all 6.5 to 10 million LSLs nationwide ranging from 16 to 80 billion dollars. Potential costs may be disproportionately borne by specific low-income localities, such as Detroit, which has an estimated 100,000 LSLs and where 40 percent of the population is below the poverty line. Second, LSLs are often partially or totally owned by private homeowners. Under the current LCR, public water systems are responsible for replacement of LSL or the portion of the LSL it owns. This is typically the portion of the line from the water main to the property line. There are important legal questions about EPA's authority to mandate replacement of privately owned portions of lines and about water systems' authority under state or local law to require and/or pay for such replacement. To the extent water systems rely on homeowners to pay for replacement of privately owned portions of lines, there are concerns about consumer's ability to pay and the possibility that lower-income homeowners will be unable to replace lines, resulting in disparate levels of protection. However, a number of cities and towns across the nation have successfully implemented full LSLR and have developed innovative approaches to addressing these challenges, including Lansing, Michigan; Madison, Wisconsin; and more recently Boston, Massachusetts – and EPA is looking at this experience in the context of developing proposed revisions to the LCR.

[1] Science Advisory Board, U.S. Environmental Protection Agency, "Evaluation of the Effectiveness of Partial Lead Service Line Replacements," transmitted to Lisa Jackson, EPA Administrator, September 28, 2011.

EPA is considering proposing full LSLR programs. In assessing options for an LCR revision proposal, EPA is evaluating a number of important issues, including:

- The appropriate pace of LSLR and the mechanism for implementing and enforcing any LSLR program requirements. Consideration of number of LSLs that can feasibly be replaced on an annual basis will need to be considered as well as water system size.
- Costs and benefits of LSLR for reducing lead exposures. National costs could range from 16 to 80 billion dollars. Benefits will be estimated based upon avoided effects of lead exposure such as IQ loss in developing children. EPA will evaluate how much additional lead exposure reduction can be achieved in removing LSLs from water systems with optimized corrosion control. EPA will also evaluate other measures that can reduce lead exposure to assure that resources are focused on reducing the most significant sources of lead.
- How to provide for full LSLR where the utility does not own the full line, including an evaluation of whether a potential change to the definition of "control" under the SDWA would facilitate full LSLR.[2]
- Requiring drinking water utilities to update their distribution system materials inventory to identify the number and location of LSLs in their system.
- How to address potential equity concerns with LSLR requirements and consumers ability to pay for replacement of their portion of the LSL. Identifying and evaluating incentive and creative funding mechanisms are critical as is encouraging use of Drinking Water State Revolving Fund to the extent possible.
- How to address LSLR in rental properties, particularly where low income residents do not control the property or have the ability to contribute to the cost of LSLR.
- Whether to prohibit or otherwise limit partial LSLR, and how to address concerns related to potential disturbance of LSLs during emergency repairs to water mains that are connected to LSLs.
- How to address the short term increases in lead levels that can follow LSLRs (i.e., requiring water systems to provide filters when lines, or enhanced household flushing recommendations).

Improved Optimal Corrosion Control Treatment Requirements

Optimal Corrosion Control Treatment (OCCT) is the primary treatment technique on which the LCR focuses, and as noted above, it has been successful on a national basis in reducing lead and copper levels at the tap. Even if the revised LCR includes requirements for full LSLR, full replacement of LSLs would likely take decades to complete, and LSLR will not address potential risks from lead and copper materials present in premise plumbing in tens of millions of homes across the U.S. As a result, CCT requirements will continue to be a key element of a revised LCR.

Since the initial implementation of the LCR, systems have faced ongoing challenges of continuing to maintain optimal corrosion control while making necessary adjustments to treatment processes or system operations unrelated to corrosion control to comply with other NPDWRs. Determining whether treatment is optimized can be challenging for individual systems, given the wide variability in

[2] The Safe Drinking Water Act defines the term public water system as "…a system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least fifteen service connections or regularly serves at least twenty-five individuals. Such term includes (i) any collection, treatment, storage, and distribution facilities ***under the control of*** the operator of such system and used primarily in connection with such system, and any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system."

distribution system composition, source water characteristics and approaches to complying with other NPDWRs, such as the surface water treatment rules. While the impact of changes in some water quality parameters on lead and copper levels are well understood, such as fluctuations in pH or alkalinity, others are more complex, such as the quantity and type of disinfectant used or the chemical composition of the protective scales within the LSLs. Small and medium systems (those serving <50,000 persons) are not required to commence development of a CCT plan under the existing LCR unless they have a lead ALE.

The NDWAC recommends that:

- EPA release a revised CCT guidance manual as soon as possible and update this manual every six years, so that PWSs and primacy agencies can take advantage of improvements in the science;
- EPA provide increased expert assistance on CCT to PWSs and primacy agencies;
- The LCR continue to require re-evaluation of CCT when a PWS makes a change in treatment or source water;
- The LCR continue to require water quality parameter monitoring to ensure that the OCCT is achieving the treatment objectives and that EPA consider requiring such monitoring on a more frequent basis with additional guidance on process control methods; and
- Large systems review their existing CCT plan in light of current science in a newly revised guidance manual with their primacy agency to determine whether the WQPs reflect the best available current science.

Recognizing the continuing central importance of CCT in reducing lead exposures, EPA is considering a range of options for strengthening CCT requirements in the proposed rule that could help to provide clearer requirements, reduce uncertainty, and ensure broader and more consistent proactive application of CCT to avoid high lead levels. Options under consideration include:

- Requiring large water systems (serving > 50,000 persons) to evaluate and re-optimize CCT when EPA publishes updated CCT guidance. This option would provide a mechanism to ensure water systems are considering the best available science to inform treatment decisions.
- Given that CCT is also effective at reducing lead leaching in premise plumbing (not just LSLs), requiring all systems in the U.S. to implement CCT, regardless of system size, tap sampling results, or the presence of LSLs; or alternatively, broadening the categories of systems for which CCT is required; requiring all systems to assume that their distribution system includes the presence of LSLs unless or until they provide the primacy agency with a robust distribution system materials evaluation that demonstrates that this is not the case.
- Requiring water systems that are already applying CCT that exceed the lead action level to evaluate and re-optimize CCT.

Incorporating a Health-Based Benchmark to Strengthen Protection

Although the current LCR is focused on protecting public health by reducing lead and copper exposures, it does so through “technology-based” requirements. The 1991 LCR established an action level for lead of 15 ppb (for the 90th percentile sample) based on an assessment that it was generally representative of effective CCT. Although public discussion often mistakes the action level as having significance in terms of health impacts, EPA has consistently emphasized that the health-based maximum contaminant level goal (MCLG) for lead in the current LCR is zero and that there is no safe level of lead exposure. While the future LCR will maintain treatment technique requirements (e.g., CCT, public education and LSLR) to reduce lead exposures, a health-based benchmark for lead in drinking water could help to guide appropriate actions to communicate and mitigate risk, particularly at the household level.

As part of its 2015 recommendations, the NDWAC suggested that EPA establish a "household action level" based on the amount of lead in drinking water that would raise an average, healthy infant's blood lead level to greater than five micrograms per deciliter based on consumption of infant formula made with water. According to the NDWAC recommendations, water systems would be required to notify the consumer and the local public health agency if this level were exceeded – with the expectation that individuals and local officials will use this information to take prompt actions at the household level to mitigate lead risks.

While EPA has not yet determined the specific role of a health based benchmark for lead in drinking water in the new rule, the Agency sees value in providing states, drinking water systems and the public with a greater understanding of the potential health implications for vulnerable populations of specific levels of lead in drinking water. EPA is currently developing up-to-date scientific modeling of the relationship between lead levels in drinking water and blood lead levels – particularly for sensitive lifestages such as formula-fed infants and children under age 6. EPA expects to conduct an expert peer review panel to identify approaches to derive a health based value for lead in drinking water. Following this public peer review process, EPA expects to evaluate and determine what specific role or roles a health-based value may play in the revised LCR. EPA anticipates that the proposal will consider the "household action level" approach recommended by the NDWAC, but a health-based value could also help to inform other potential elements of a revised LCR – including public education requirements, prioritization of households for LSLR or other risk mitigation actions at the household level, and potential requirements related to schools or other priority locations.

Considering the Potential Role of Point of Use Filters

One of the insights that has emerged from work in response to the crisis in Flint, Michigan, is the efficacy of point-of-use household filters in reducing lead levels at the tap. There are a broad array of point-of-use filters that are certified by independent third party labs for lead reduction. Recently, EPA collected samples from these filters installed on taps in Flint, Michigan, and verified that these filters are effective in reducing lead levels. Filters require periodic replacement of cartridges to remain effective. The SDWA requires point of use devices specified as a feasible technology to achieve compliance with an MCL or treatment technique requirements to be owned, controlled, and maintained by the water utility. While filters are not an appropriate substitute for CCT, LSLR, or other actions to properly manage and reduce lead levels at the system level, EPA is considering role for filters in addressing risks from lead and copper at the household level. Potential roles include requiring point of use filters where there has been a disturbance of a LSL or where tap sampling indicates an exceedance of a health-based benchmark or action level.

Clarify and Strengthen Sampling Requirements

The goal of the LCR sampling requirements – including site selection criteria and tap sampling procedures — is to cost effectively assess the effectiveness of a water system's CCT and to trigger additional actions to reduce exposure when necessary. The target locations in the LCR are focused on the homes that are likely to have the highest risk for lead exposure. The lead sampling protocol requires a one liter first draw sample collected after water has remained stagnant for at least 6 hours. Implementation of the sample site selection criteria and the sampling protocol are challenging and provide opportunity for error, particularly given that samples are collected by the residents themselves. In addition, numerous stakeholders have criticized the current rule as providing too much discretion in sampling approaches and providing opportunities for systems to implement their sampling procedures

to avoid exceeding the action level, even in circumstances where corrosion control has not been optimized.

On February 29, 2016, EPA issued a memorandum encouraging states and drinking water utilities to implement protective LCR sampling procedures, based on lessons learned in Flint, Michigan, and other communities. These sampling procedures include eliminating the practice of flushing the tap prior to the mandatory 6-8 hour stagnation period (pre-stagnation flushing), ensuring that faucet aerators are not removed prior to conducting tap sampling under the LCR, and encouraging the use of wide mouth bottles for collection of tap samples to avoid the loss of any of the first draw sample. EPA expects to incorporate each of these recommended sampling procedures as proposed requirements in the proposal for the revised LCR.

In addition, EPA has increased oversight of state programs to ensure effective implementation of the LCR. As part of these efforts, EPA sent letters on February 29, 2016, to state commissioners to ensure consistency with EPA regulations and guidance. The letter requested that primacy agencies work collaboratively with EPA to ensure national consistency and improve transparency and public information regarding the implementation of the rule.

The majority of the states confirmed that they have been consistent with EPA guidance and the LCR. Some primacy agencies specifically stated in their response that they would be undertaking steps to ensure that their protocols and procedures follow the LCR and applicable guidance. Regarding the use of EPA guidance on LCR sampling protocols and optimization corrosion control procedures, the majority of the primacy agencies confirmed that they use relevant guidance and protocols for sampling and corrosion control. Some primacy agencies had previously encouraged pre-flushing but stated they would update their protocols to ensure consistency with the recently published EPA sampling memo.

The NDWAC recommends that a voluntary customer-initiated sampling program based on a more robust and targeted public education be substituted for the current LCR tap sampling requirements.
The results of the voluntary tap sampling program would be used for three separate purposes:

- Informing and empowering individual households to take action to reduce risk;
- Reporting to health officials when monitoring results exceed a “household action level”; and
- Providing an ongoing source of information to the utility to assess effectiveness of CCT.

In the proposed LCR revisions, EPA intends to propose clear and robust sampling requirements to serve the goals of: (1) providing appropriately robust information on how the overall system is performing in reducing lead levels; and (2) providing information on household levels that can be compared to health-based levels, to help guide mitigation actions at individual homes.

EPA is continuing to evaluate specific procedures for tap sampling, including:

- The continued use of “first draw” tap samples, sequential sampling to characterize lead levels in drinking water that has been in contact with premise plumbing and the LSL, random daytime samples, whether the rule should include a variety of tap sampling protocols to meet different needs for customers and the system, and whether the rule should provide for systems to sample customer’s taps on request.
- Mandatory sampling for schools that are not public water systems in the revised LCR, given the presence of vulnerable populations in the school environment and the ongoing challenges that schools continue to encounter with elevated lead levels in drinking water.

- ORD partnering with technology developers in industry and academia to identify available technologies that can be used to support real-time monitoring of water quality parameters for measuring the effectiveness of corrosion control in the distribution system.

Increased Transparency and Information Sharing

Transparency and public sharing of data and information is a cornerstone of EPA's efforts to strengthen the effectiveness of its rules. The drinking water crisis in Flint, Michigan, and subsequent focus on lead issues in other communities has underscored the need for transparency with the public in implementing actions to reduce lead in drinking water. EPA took important steps to advance these efforts on February 29, 2016, when the Agency sent letters to every governor and drinking water primacy agency responsible for implementing the LCR, urging a series of actions to address risks from lead in drinking water. The Agency called on primacy agencies to work with public water systems to increase transparency in implementation of the LCR by posting on their public websites:

- the materials inventory that systems were required to complete under the LCR, including the locations of LSLs, together with any more updated inventory or map of LSLs and lead plumbing in the system; and
- LCR compliance sampling results collected by the system, as well as justifications for invalidation of LCR samples.

The Agency also asked that states enhance efforts to ensure that residents promptly receive lead sampling results from their homes, together with clear information on lead risks and how to abate them, and that the general public receives prompt information on high lead levels in drinking water systems.

Many of the responses from state commissioners identified practices and policies that enhance the implementation of the LCR and increase public transparency. States identified opportunities to promote transparency at the state level by posting individual lead compliance samples, and not just the 90th percentile values on their public websites utilizing the Drinking Water Watch or similar tools. To complement this effort, some public water systems are providing online searchable databases that provide information on known locations of LSLs, or providing videos that show homeowners how to determine whether their home is served by a LSL.

To shorten reporting and notice timeframes, some states have adopted more stringent timelines for water systems to provide consumer notices to all who receive water from sites that were sampled and resulted in a lead ALE. While the LCR allows up to 30 days, some states are requiring notice to consumers as quickly as 48 hours after sampling. In addition, some states require laboratories that analyze lead compliance samples to contact the state within 24 hours of confirming that a sample analysis has exceeded the 15 parts per billion action level for lead. Consistent with the EPA's 2013 E-Reporting Policy[3] the agency intends to use, to the maximum extent practicable, common agency tools, information systems, and data sets for E-Reporting for the revised LCR. E-Reporting can facilitate faster access to data and other information critical to consumers to understand lead and copper levels in their drinking water and within the water system and to make informed decisions regarding actions they may take to reduce exposure from lead in drinking water.

The NDWAC recommends that EPA strengthen requirements for public access to information about LSLs, tap monitoring results and other relevant information. Enhanced requirements for sharing compliance

[3] https://www.epa.gov/compliance/policy-statement-e-reporting-epa-regulations

data and other information with the public can play a critical role in strengthening the protections provided by the LCR. By providing individuals and communities with prompt and accurate information, the LCR can help to leverage broader public involvement and engagement in ensuring accountability, consistency in meeting regulatory requirements, and prompt action to mitigate high lead levels or other risks, both at the system and household level.

Accordingly, the agency expects to propose stronger public transparency elements for the revised LCR. Measures under consideration include:

- Requiring drinking water utilities to post all LCR sampling results and sample invalidation justifications on their publicly accessible website in a form that protects the privacy of customers;
- Mandating shorter time frames for providing lead sampling results to consumers;
- Mandating shorter time frames for providing the public with public health education when high lead levels are detected in their drinking water system;
- Enhanced requirements for sharing the results of the materials evaluation conducted by drinking water system, including publicly identifying the location of LSLs within the community in a way that protects privacy of homeowners;
- Enhanced requirements for states to publicly identify each system within their state that is currently or has recently experienced an ALE, along with the specific steps the system is required to fulfill and their progress in implementing these requirements
- Requiring systems to provide information on the number of lead tap samples collected, number of samples that exceed the lead action level, information about voluntary sample results and any recent changes to CCT or water quality parameters that might affect lead levels in their water; and
- Requiring more timely electronic reporting of sampling results to primacy agencies and EPA.

Public Education Requirements

A critical element of the LCR is public health education to ensure that the public has easy access to clear information on lead and copper risks in drinking water and how to mitigate them. The current LCR requires public health education in response to a lead ALEs. One concern with this approach is that systems can have up to 10 percent of homes with highly elevated levels of lead in drinking water without causing an ALE and triggering the public health education requirements of the rule.

The NDWAC recommends that:

- EPA establish an easily accessible, national clearinghouse of information about lead in drinking water to serve the needs of the public and of public water systems;
- Require information be sent to all new customers on the potential risks of lead in drinking water;
- Revise the current CCR language to address LSLs and update the health statements;
- Add requirements for targeted outreach to customers with LSLs; and
- Expand the current requirements for outreach to caregivers/health care providers of vulnerable populations.

EPA is considering modifications to the rule to strengthen the public education requirements by requiring ongoing, proactive and targeted public education to effectively communicate drinking water lead risks, promote tap sampling, and provide actions consumers can take to reduce lead exposures regardless of ALEs by the system.

The Agency is also considering requiring water utilities to provide information on lead risks to all new customers at the time of service connection, expanding the current LCR requirements for public outreach to caregivers and healthcare providers for vulnerable populations, and revising the current requirement for CCRs so that these reports address the status of LSLs in each city.

Customers with LSLs are at heightened risk for lead exposures in drinking water. EPA is considering a number of potential public education requirements in the proposed LCR revisions to help mitigate these risks, including:

- Requiring water systems to provide targeted outreach to customers with LSLs and to provide these customers with invitations to have their water tested and to participate in a LSLR program, regardless of ALEs in the system;
- Requiring water system to provide public access for LSL inventories, which would include the locations of those service lines;
- Requiring that customers be notified of emergency or planned maintenance that may disrupt LSLs, therefore increasing lead levels, and be provided with information on actions that can be used to mitigate exposure; and
- Requiring a standard operating procedure be prepared and provided to other utilities who may disturb LSLs for maintenance or capital improvements.

Potential Revised Copper Requirements

Published corrosion literature since 1991 on copper has shown that copper and lead leaching patterns differ. The current LCR sample site selection criteria targets highest-risk lead sites, and tap samples for both lead and copper are collected at these locations. Some stakeholders have expressed concerns that elevated levels of copper may be missed using this approach.
The NDWAC Recommends:

- Instead of basing action on the results of routine, in-home copper sampling, actions should be based on the aggressiveness of the water to copper. Systems can determine if their water is aggressive to copper by doing WQP monitoring in the distribution system. All PWSs should be assumed to have water that is aggressive to copper unless they demonstrate that it is not.
- EPA should develop criteria to define water that is not aggressive to copper for the purpose of establishing whether a system falls into that category (or “bin”) for the purposes of the LCR. EPA should consider the accuracy and potential variability of pH and alkalinity monitoring as well as corrosivity to copper in establishing pH and alkalinity ranges. The criteria also should include consideration of passivation time.
- PWSs can choose one of several approaches to demonstrate that their water is not aggressive to copper.
- PWSs with water classified as non-aggressive to copper must continue to demonstrate that the water is non-aggressive. PWS’s can choose to:
    - Maintain those WQPs that demonstrate it maintains non-aggressive water, or
    - Conduct copper sampling at vulnerable homes (houses < 2 years old with new copper plumbing) to demonstrate that water chemistry is non-aggressive cooper levels fall under the AL/MCL).

EPA is considering modifications to the LCR requirements to provide greater attention to the potential risks associated with elevated levels of copper in drinking water. Options that are being considered include modifications to the sample site selection criteria to include sites that are at greatest risk of producing elevated levels of copper, and developing water quality parameters designed to identify

systems that have water aggressive to copper. Systems with aggressive water could be required to install CCT and/or conduct public education for copper, while systems with nonaggressive water could be required to periodically demonstrate that leaching of copper is not a concern for the water system.

Relationship with Broader Lead Issues

While the LCR revisions are focused on lead in drinking water, EPA recognizes that the ultimate goal is comprehensive reduction in exposures to lead from all contaminated media, some of which may present greater risks than drinking water in individual communities or homes.

Lead can be ingested from various sources, including lead paint and house dust contaminated by lead paint, as well as soil, drinking water, and food. The effects of lead exposure are generally measured by blood lead levels. As a result of the multitude of possible exposure pathways, the contribution from specific pathways (e.g., consumer products, diet, soil, ambient air) to blood lead concentrations can vary widely for each individual.

Young children, infants, and fetuses are particularly vulnerable to lead because their behavior patterns typically lead to higher exposures, they absorb a greater proportion of the lead they ingest than adults, physical and behavioral effects of lead occur at lower exposure levels in children than in adults, and the central nervous system of children undergoes rapid development and impacts during this period can have lifelong effects.

EPA estimates that drinking water can make up 20 percent or more of a total exposure to lead. In some circumstances, infants who consume mostly mixed formula can receive 40 percent to 60 percent of their exposure to lead from drinking water. Current water sampling protocols were designed to assess the adequacy of CCT, not the level of human exposure to lead. Important fluctuations in water lead levels can be missed because of limitations inherent in sampling protocols that EPA uses, making it difficult to assess household exposure through drinking water.[4]

Pathways of exposure to lead related to ambient air include both inhalation of lead and ingestion of lead in dust or soil that originated in the ambient air. For example, dietary lead exposure may be air-related if ambient air lead deposits on plant materials or in water that becomes available for human consumption. (They may also be water-related if cooking is undertaken in tap water with high lead levels.)

Dust and soil particles containing lead are typically in the size range that is ingested rather than inhaled. However, soil can act as a reservoir for deposited lead emissions, and exposure to soil contaminated with deposited lead can occur through re-suspended particulate matter as well as hand-to-mouth contact, which is the main pathway of childhood exposure to lead.

To address these concerns, EPA is committed to continuing to work with federal, state and local partners to reduce lead risks in all contaminated media**.**

[4] Brown, Mary Jean and Margolis, Stephen, Division of Emergency and Environmental Health Services, National Center for Environmental Health, Centers for Disease Control, "Lead in Drinking Water and Human Blood Lead Levels in the United States," *Morbidity and Mortality Weekly Report*, August 10, 2012.

IV. Conclusion

It is critical that EPA thoughtfully revise the LCR to strengthen the rule to reduce exposure to lead in drinking water, especially for infants and children and communities bearing a disproportionate risk. It is also important that LCR revisions improve implementation and enforceability of the rule requirements. This paper provides examples of regulatory provisions EPA is considering and evaluating in order to improve public health protection. While EPA has received extensive recommendations from NDWAC and other stakeholders, the Agency is committed to continue to engage with stakeholders and consider all viewpoints in revising the LCR. EPA is committed to using the best available science and to conducting robust analyses of regulatory options that have been informed by stakeholder input. The Agency welcomes input and feedback on the ideas presented in this paper to support development of a Notice of Proposed Rulemaking of LCR Revisions for publication in the Federal Register and public review and comment in 2017.

Oregon Public Health
Drinking Water Data Online

Oregon Health Authority

Introduction :: Data Search Options :: WS Name Look Up :: WS ID Look Up :: DWS Home :: Quick Data Links

PWS ID: 00657 ---- PORTLAND WATER BUREAU

Lead and Copper Compliance Actions

- No lead and copper schedules found.

Action Levels: Lead = 0.015 mg/L; Copper = 1.3 mg/L

All detailed results

Lead and Copper 90th Percentile Summary Results and Consumer Notices*

Sample Dates	Date Received	Sample Count	Duration	Lead (mg/L)	Copper (mg/L)	Consumer Notice Date*
Oct 15, 2016 - Oct 26, 2016	Nov 18, 2016	112	6M	**0.0174**	0.3140	12/08/2016
Mar 15, 2016 - Apr 27, 2016	Jun 10, 2016	114	6M	0.0131	0.2876	
Oct 26, 2015 - Nov 12, 2015	Jan 08, 2016	114	6M	0.0141	0.3362	
Apr 28, 2015 - May 12, 2015	Jul 10, 2015	112	6M	0.0141	0.3260	
Sep 30, 2014 - Oct 15, 2014	Dec 10, 2014	114	6M	0.0142	0.3350	
May 15, 2014 - May 27, 2014	Jul 10, 2014	110	6M	0.0129	0.2930	
Nov 09, 2013 - Nov 18, 2013	Jan 10, 2014	108	6M	**0.0159**	0.5000	
May 08, 2013 - May 21, 2013	Jul 10, 2013	111	6M	0.0100	0.2700	
Oct 10, 2012 - Oct 23, 2012	Jan 09, 2013	112	6M	0.0120	0.3400	
May 09, 2012 - May 23, 2012	Jul 10, 2012	112	6M	0.0110	0.2700	
Oct 11, 2011 - Oct 24, 2011	Dec 08, 2011	111	6M	0.0120	0.2900	
Apr 27, 2011 - May 17, 2011	Jul 07, 2011	114	6M	0.0090	0.2700	
Oct 14, 2010 - Oct 22, 2010	Jan 07, 2011	112	6M	0.0120	0.3400	
Apr 02, 2010 - May 10, 2010	Jul 08, 2010	110	6M	0.0100	0.3300	
Oct 14, 2009 - Oct 26, 2009	Jan 08, 2010	115	6M	0.0090	0.3700	
May 08, 2009 - May 21, 2009	Jul 09, 2009	113	6M	0.0100	0.2700	
Jul 01, 2008 - Dec 31, 2008	Jan 09, 2009	116	6M	0.0100	0.3300	
May 12, 2008 - May 28, 2008	Jul 09, 2008	105	6M	0.0090	0.2800	
Nov 17, 2007 - Dec 07, 2007	Jan 10, 2008	111	6M	0.0110	0.2800	
May 17, 2007 - Jun 01, 2007	Jul 10, 2007	116	6M	0.0130	0.2800	
Oct 19, 2006 - Dec 05, 2006	Jan 10, 2007	116	6M	**0.0170**	0.5000	
May 22, 2006 - May 26, 2006	Jul 10, 2006	117	6M	0.0090	0.3100	
Oct 17, 2005 - Oct 31, 2005	Dec 09, 2005	115	6M	0.0120	0.3500	
May 18, 2005 - Jun 01, 2005	Jul 08, 2005	119	6M	0.0150	0.3900	
Oct 19, 2004 - Nov 22, 2004	Dec 30, 2004	111	6M	0.0150	0.0420	
May 02, 2004 - Jun 25, 2004	Jul 09, 2004	123	6M	0.0080	0.3600	
Oct 21, 2003 - Nov 04, 2003	Dec 10, 2003	110	6M	0.0080	0.3300	
May 10, 2003 - Jun 30, 2003	Jul 11, 2003	113	6M	0.0104	0.3450	
Oct 23, 2002 - Nov 03, 2002	Jan 10, 2003	147	6M	**0.0170**	0.5000	
May 06, 2002 - May 21, 2002	Jul 10, 2002	133	6M	0.0130	0.4200	
Nov 09, 2001 - Nov 22, 2001	Jan 08, 2002	134	6M	**0.0200**	0.8100	
May 10, 2001 - May 22, 2001	Jul 09, 2001	144	6M	**0.0170**	0.6200	
Sep 14, 2000 - Sep 22, 2000	Jan 10, 2001	124	6M	**0.0220**	0.7100	
Apr 07, 2000 - May 22, 2000	Jul 10, 2000	125	6M	0.0150	0.6600	
Oct 19, 1999 - Nov 01, 1999	Jan 18, 2000	126	6M	0.0120	0.6000	
May 12, 1999 - Jun 06, 1999	Jul 08, 1999	126	6M	**0.0210**	0.6400	
Nov 05, 1998 - Nov 17, 1998	Jan 13, 1999	127	6M	**0.0190**	0.6600	
May 07, 1998 - May 29, 1998	Jul 09, 1998	129	6M	0.0150	0.6700	
Nov 09, 1997 - Nov 21, 1997	Jan 09, 1998	129	6M	0.0130	0.6800	
May 24, 1997 - Jun 05, 1997	Jul 16, 1997	130	6M	0.0120	0.6500	
Jul 01, 1992 - Dec 01, 1992	Jan 11, 1993	125	6M	**0.0530**	1.3000	
Jan 01, 1992 - Jun 13, 1992	Jul 13, 1992	126	6M	**0.0440**	**1.8000**	

*Consumer notice date is the date water customers were notified of their tap results. Consumer notice records are not available prior to 2016.

Lead Hazard
Reduction Program Report

December 12, 1996

by:
Economic and Engineering Services, Inc.
and
The City of Portland
Bureau of Water Works

Contents

Executive Summary

Overview

This report provides a description of the proposed Lead Hazard Reduction Program that has been developed as an alternative to Lead and Copper Rule (LCR) requirements for corrosion control treatment and public education. The goal of this alternative approach is to achieve better public health protection from lead exposure, at an equivalent lower cost than would have been achieved with LCR requirements.

Background

In 1991, the EPA promulgated the Lead and Copper Rule. LCR requirements include corrosion control treatment to minimize lead and copper at the customer's tap. Such treatment would involve increasing the pH of Bull Run water from current levels of about 6.8 to 9.0-9.5, and increasing alkalinity from current levels of 6-12 mg/L to at least 25 mg/L as $CaCO_3$ (Montgomery Watson and EES, 1994).

In June 1994, the Portland City Council directed the Water Bureau to conduct a study to investigate alternatives for LCR compliance. Several pivotal conclusions of this study are:

Drinking water is not a major route of lead exposure in the Portland area. The median lead level in samples of running water from customers' taps is less than 1 ug/L (non-detectable).

Although water treatment would provide some reduction of lead and copper exposure through drinking water in the community, water treatment alone would not sufficiently reduce exposure in some homes with a very significant source of lead in water; and

The most significant source of lead exposure in the Portland metropolitan area is lead-based paint, and efforts focused on preventing exposures from this source could provide a significant health benefit to the community.

The proposed Lead Hazard Reduction Program presented in this report was developed in partnership with the Oregon Health Division; Multnomah, Washington and Clackamas County Health Departments, and the Water Managers Advisory Board.

Program Design Concepts

The goal of the Lead Hazard Reduction Program is to achieve better public health protection from lead exposure, at an equivalent or lower cost, than would have been achieved with the corrosion control treatment and public education requirements of the Lead and Copper Rule.

Interventions to reduce lead exposures should be targeted at those exposure pathways that have the greatest impact on the health of the child by reducing his or her body-lead burden (EPA, 1995). EPA has estimated that for a typical 2 year old child living in an urban environment, or in a non-urban house with interior lead-based paint, household dust and soil accounts for over 90% of the child's daily intake of lead (EPA, 1995). In the Portland area, 60% of recent cases of elevated blood lead levels are believed to be related to exposure to lead-based paint.

As part of the LHRP, corrosion control treatment would be provided, but at a reduced level than that defined as optimal by the Lead and Copper Rule. The savings in capital and operating costs would be used to fund interventions that reduce lead exposures that would be expected to provide the greatest benefits to children at most risk.

The Lead Hazard Reduction Program should:

1. Be implemented throughout entire Bull Run service area

2. Focus efforts on those lead source and exposure pathways that would be expected to have the greatest impact on reducing a child's body lead burden

3. Focus efforts on those persons living within the Bull Run service area who are at most risk to significant lead exposure

4. Focus efforts on primary prevention

5. Focus on implementing feasible and cost-effective methods for reducing lead hazards

6. Supplement or complement efforts performed by other organizations with similar objectives, including state and county health agencies, and community-based groups

7. Develop and support community participation in lead hazard reduction efforts

8. Be evaluated on a regular basis for effectiveness in achieving objectives, and modified as necessary or desired to enhance effectiveness

9. Be developed in partnership with and supported by Oregon Health Division's Drinking Water program, State and County Health Departments, Portland's wholesale water customers, and interested organizations and individuals within the community, and other stakeholders

10. Be conducted to serve as a demonstration project for community lead hazard reduction efforts

nationwide.

Program Description

There are four main components to the Lead Hazard Reduction Program:

1. Water Treatment for Corrosion Control

Corrosion control treatment would consist of raising pH to about 7.3 in the distribution system, or slightly higher if necessary to meet copper action levels. It is estimated that this level of treatment would reduce lead levels in standing water by 40%, and copper levels by 55%. With this treatment, as also for the higher "optimal" level of treatment, the lead action level would likely not be met in Bull Run water systems.

This moderate increase in pH should provide substantial benefits related to decreased copper levels, including less copper discharged into the environment from wastewater treatment plants, and many fewer problems with blue staining of sinks and bathtubs. This treatment will also provide significant reductions in lead levels in standing water for those customers with a source(s) of lead in their water plumbing system.

2. Free Lead-in-Water Testing Program

The purpose of this component is to identify customers within the Bull Run service area that may be at significant risk from elevated lead levels in drinking water and assist them in reducing the risk of lead exposure from this source.

Two major activities are associated with this component. The first is modification and expansion of the Portland Water Bureau's free lead in water testing program. The program would be expanded to include customers within the entire Bull Run service area, but would probably be limited to customers living in homes with plumbing systems that are likely to be associated with significant risk for elevated lead in water levels.

The second activity would be providing assistance to customers with elevated lead levels. This assistance would, at least initially in the program, take the form of an offer of a home plumbing system inspection to determine the specific source of lead and to recommend practical and effective ways of reducing exposure.

3. Home Lead Hazard Reduction

The purpose of this component is to reduce actual or potential risks of significant lead exposure from lead-based paint and other sources in at-risk homes in highest risk neighborhoods. This component is a cornerstone activity in the LHRP and could become one of the most substantial lead hazard reduction projects undertaken in the country.

Data from the Oregon Childhood Lead Poisoning Prevention Project (OCLPPP) for

Multnomah County shows an strong positive relationship between increasing occurrence of elevated blood lead levels and increasing age of home. Prevalence of older homes and other risk factors would be used to identify highest risk neighborhoods within the service area. Within each high-risk neighborhood, a base of support would be developed for the LHRP. The neighborhood support groups assistance and advice would be sought throughout program implementation. Within each neighborhood, a survey will be conducted to identify significant non-residential lead exposure sources for children in the neighborhood.

Home lead risk evaluations would be offered to all eligible homes in the neighborhood. Several people from the neighborhood ("neighborhood peers") would be hired and trained to offer and conduct these evaluations.

These home lead risk evaluations will consist primarily of 1) completing a checklist of questions about the home that are relevant to estimating the level of lead risk exposure in the home, 2) collecting a sample of household dust and/or soil for laboratory analysis, and 3) in-home education of potential lead exposure risks. Blood lead level testing for children age 6 or younger will be offered through the OCLPPP program. A packet of information would be left at each eligible residence, whether or not a risk evaluation was accepted by the residents.

Recommendations for hazard reduction would be offered to tenants or property owners in which an actual or potential lead hazard was identified. A range of potential in-home interventions would be recommended based on the nature and extent of hazards identified, taking into account any relevant circumstances associated with the particular residence.

Recommendations would be consistent with HUD/EPA recommended treatments for lead-based maintenance and hazard control in rental housing, such as correcting conditions in which painted surfaces could produce lead dust, specialized cleaning, and covering bare residential soil and performing essential maintenance (HUD, 1995).

LHRP staff will encourage the resident or rental property owner to control the hazard as recommended by developing a workplan with the resident, and offering assistance in the form of training and/or basic supplies (such as protective plastic sheeting, tape, respirator, access to HEPA vacuum cleaner). Additional resources in the form of financial assistance to low income families may be provided if the ongoing implementation evaluation indicates that lack of financial assistance poses an obstacle to reducing lead hazards and no other avenues for assistance are available.

The "Community Mobilization Framework" (CMF) approach, used by the CDC in demonstration projects to prevent HIV infection in women and children (Person and Cotten, 1996), may be useful to consider for this project. The CMF includes becoming familiar with the organizations and individuals within the community to identify potential partners; asking them for support, ranging from simple endorsement to active participation in coalitions; and recruiting community residents ("peer networkers") to promote program messages and conduct intervention activities. This approach offers the potential advantages of 1) extending limited resources of single agencies; 2) maximizing exposure to program through

collaboration; 3) building on unique strengths and access channels of organizations and individuals in the community; and 4) allowing agencies, such as state and county health departments to develop credible relationships with non-traditional community partners.

This component would be evaluated on an on-going basis to assess the program's effectiveness and would be modified as necessary for improvement.

4. Lead Exposure Prevention Education

The purpose of this component is to provide primary prevention of lead exposure through public education. The goal is to increase the awareness of the entire community about lead health risks and make special efforts to effectively provide relevant information to those at greatest risk of lead exposure. A well designed and implemented public education program has the potential to be the most effective means of preventing lead exposure.

The proposed education program would be more effective than the required LCR program in preventing significant lead exposures in the community for a number of reasons. Messages delivered in this program address multiple potential sources of lead exposure, not just water. Message would be delivered to a large set of target audiences, the most important of which may be those providing general care and health care to young children. Also, a Lead Hazard Reduction Information Center would be developed and operated as part of this program.

Administration

The proposed administrative structure of the Lead Hazard Reduction Program is shown in Exhibit ES-1.

A steering committee will be developed to ensure that the objectives of the Lead Hazard Reduction Program are met. The steering committee should include representatives from the Portland Water Bureau, Water Managers Advisory Board, Oregon Health Division Occupational, Environmental and Injury Epidemiology (OEI-EPI) Section, Multnomah County Health Department, Washington County Health Department, Clackamas County Health Department, OHD/Multnomah County Program Design and Evaluation Services (PDES) Staff, and representatives from community based organizations. A program manager will be designated by the Water Bureau to ensure that regulatory requirements are met throughout the LHRP.

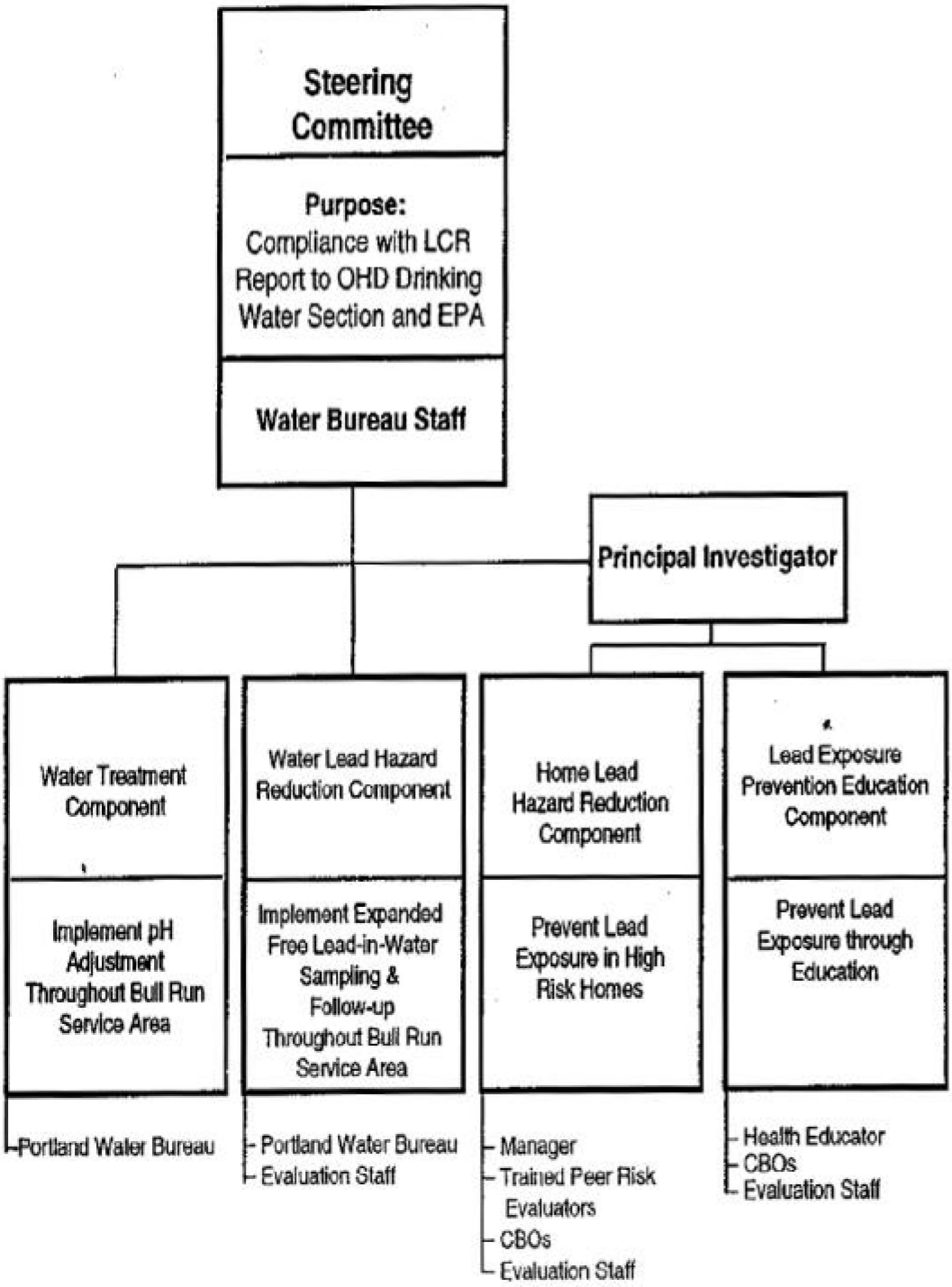
The Water Treatment Component and the Lead-in-Water Testing Component would be conducted by the Water Bureau. The PDES staff will evaluate the effectiveness of the lead-in-water testing component.

A Principal Investigator will be responsible for the Home Lead Hazard Reduction Component and the Lead Exposure Prevention Education component. The Home Lead Hazard Reduction Component will be carried out by a Manager and a group of trained neighborhood peers who will conduct much of the field work. The Lead Exposure Prevention Education component will be carried out by a health educator and community based organizations (CBOs). The activities for both these

components will be evaluated by the PDES staff.

Contractual arrangements in the form of interagency agreements will be used to establish the working relationships and will include detailed workplans and budgets.

Exhibit ES-1
Responsibilities by Component



Budget

A five year budget for this program has been developed and is summarized in Table ES-1.

Table ES-1
Preliminary Cost Estimates for Lead Hazard Reduction Program

Component	1996	1997	1998	1999	2000	2001
Water Treatment	$1,210,000	392,000	407,680	423,987	440,947	458,585
Water Lead Hazard Reduction		75,000	104,000	108,160	112,486	116,986
Home Lead Hazard Reduction		314,000	434,000	451,360	469,414	488,191
Prevention Education		218,000	167,700	174,408	181,384	188,640
Oversight		55,000	40,000	41,600	43,264	59,995
TOTAL LHRP	1,210,000	1,054,000	1,153,380	1,199,515	1,247,496	1,312,396
LCR Approach	3,210,000	1,310,520	1,362,941	1,417,458	1,474,157	1,533,123
LHRP Savings	2,000,000	256,520	209,561	217,943	226,661	220,727

The LCR required approach is estimated to cost an additional $2.00 million in capital costs and an additional $200,000 or more per year to operate as compared to the Lead Hazard Reduction Program.

Section 1
Introduction

1.1 The Lead and Copper Rule

In 1991, EPA promulgated the Lead and Copper Rule (LCR) to reduce lead and copper at customers' taps. This set of regulations (Federal Register, 1991) establishes a treatment technique that includes a regulatory schedule and requirements for corrosion control treatment, public education, and monitoring for various water quality parameters.

Large systems such as Portland's are required to determine the optimal type of corrosion control treatment for their system and provide this treatment by January 1997. The LCR defines this as treatment that minimizes lead and copper levels in drinking water without causing violations of other drinking water standards.

The LCR also requires implementation of a specified public education program as long as lead action levels are exceeded. The lead action level is exceeded if the concentration of lead in more than 10 percent of standing tap water samples collected from a group of homes that are believed to be at highest risk of having elevated lead in water is greater than 0.015 mg/L. During initial monitoring conducted in 1992, lead and copper action levels were exceeded in the City of Portland and other water systems using Bull Run water.

An Alternative Lead and Copper Rule Compliance Approach

In June 1994, the City of Portland's Bureau of Water Works (Water Bureau) completed its corrosion control study as required by the LCR. This study (Montgomery Watson and EES, 1994) indicates that minimizing lead and copper in Bull Run water would involve increasing pH in the distribution system from current levels of about 6.8 to pH 9.0-9.5, and also increasing alkalinity from current levels of 6-12 mg/L to at least 25 mg/L as CaCO3.

Also in June 1994, the Portland City Council, in accordance with recommendations from the citizens' Water Quality Advisory Committee, and the Water Managers Advisory Board (managers of water systems purchasing Bull Run water), directed the Water Bureau to pursue a strategy for LCR compliance that included:

- design of a corrosion control treatment facility
- a study to investigate alternatives for compliance; and
- a decision regarding the construction of corrosion control treatment facilities based on the results of the study.

In August 1995, the Water Bureau completed the study to investigate alternatives for LCR compliance (EES, 1995). The study included development of a model to estimate the effects of various interventions on lead exposure through drinking water, as indicated by predicted changes in blood lead levels. The interventions considered included several different levels of corrosion control treatment (ranging from treatment to minimize lead and copper levels to no treatment),

removal of sources of lead in water (such as solder and faucets), and combinations thereof. Several pivotal conclusions of this study are:

Drinking water is not a major route of lead exposure in the Portland area. The median lead level in samples of running water from customers' taps is less than 1 ug/L (non-detectable).

Although water treatment would provide some reduction of lead and copper exposure through drinking water in the community, water treatment alone would not sufficiently reduce exposure in some homes with a very significant source of lead in water; and

The most significant source of lead exposure in the Portland metropolitan area is lead-based paint, and efforts focused on preventing exposures from this source could provide a significant health benefit to the community.

1.3 Lead Hazard Reduction Program Development

The Water Bureau assembled the following group of stakeholders and consultant team to help develop the Lead Hazard Reduction Program (LHRP):

Table 1-1
Lead Hazard Reduction Program Development Committee

Portland Bureau of Water Works	Babette Faris Rosemary Menard Mort Anoushiravani Darren Kipper
Water Managers Advisory Board	Dean Fritzke (Tualatin Valley Water District) Dave Gilbey (Powell Valley Road Water District) Keely Thompson (City of Gresham)
Oregon Health Division - Drinking Water Section	Dave Leland Chris Hughes
Oregon Health Division - OEI - EPI Section	Narda Tolentino Rick Leiker
Oregon Childhood Lead Poisoning Prevention Program (OCLPPP)	Chris Johnson
Multnomah County Health Department	Hilda Adams
Washington County Health Department	Clay Parton
Multnomah County Health Department	Dr. Harold Osterrud
Oregon Health Division/Multnomah County Evaluation Section	Dr. Mike Stark
Urban League of Portland	Don Francis
Consultant Team	Lee Odell (EES) Gregg Kirmeyer (EES) Greg Wetterau (EES) Dr. William Morton (OHSU)

The development committee held four workshops since May 1996 and numerous subcommittee meetings to develop the LHRP. The objective of the first workshop was to identify which lead exposure prevention related activities were already being conducted by other agencies in the community and to identify which activities potentially could be included in the LHRP. The objective of the second workshop was to prioritize these activities and recommend program design concepts. The objective of the third workshop was to identify the major program components and the objective of the fourth workshop was to develop these components.

Section 2
Background

2.1 Lead Health Effects

Lead is most hazardous to children under the age of 6, whose still developing nervous systems are particularly vulnerable to lead and whose normal activities expose them to lead-contaminated dust and soil. High levels in the blood of young children can produce permanent nervous system damage. Recent research indicates that relatively low blood lead levels can produce significant nervous system effects, such as reduction in intelligence and attention span, reading and learning disabilities, and behavior problems. These relatively low blood levels are typically not accompanied by identifiable symptoms.

The Centers for Disease Control (CDC) indicate that, because 10 ug/dL is the lower level of the range at which effects are now identified, primary prevention activities - efforts to prevent exposure through community-wide environmental interventions and nutritional and educational campaigns - should be directed at reducing children's blood lead levels at least to below 10 ug/dL. Some studies have suggested harmful effects at even lower levels, but information currently available is not adequate for effects below about 10 ug/dL to be evaluated definitively. As yet, no threshold has been identified for the harmful effects of lead. (CDC, 1991).

2.2 Sources of Lead Exposure (CDC, 1991; HUD, 1995, EPA, 1995)

When considering the effectiveness of an intervention strategy for reducing a child's body-lead burden, it is important to recognize the many different avenues by which a child may encounter lead. Major sources of lead in the environment include paint, industrial emissions, gasoline, and solder. Lead from these sources can accumulate in soil, dust, air, food, and water. Regulations on lead solder in cans and leaded gasoline emissions have greatly reduced the concentrations of lead in food and in air. Relatively little has been done to reduce hazards from lead-based paint in housing and from lead-contaminated soil. Lead-based paint, and lead-contaminated dust and soil have been identified as the principal sources of lead exposure for children.

Lead-based paint is the most widespread and dangerous high-dose source of lead exposure for pre-school children. Dust lead comes from chipping or peeling lead-based paint and is created by friction or impact or when disturbed during repainting or remodeling projects. The other significant pathway of lead exposure is dust from bare lead-contaminated soil. Soil contamination can be traced to past widespread use of leaded gasoline, to deteriorating exterior paint (on houses, bridges, and industrial facilities), and in some areas, to industrial sources of lead. Other, usually less common, sources of lead can include drinking water (where lead solder was used in the home), imported ceramic tableware with lead glaze, old toys or furniture painted with lead-based paint, parental clothing (where a parent's work or hobby involves high levels of lead), and home remedies used by some ethnic groups.

2.3 Blood Lead Levels in the United States

At the time the Lead and Copper Rule was developed, the best available study of blood lead levels in the United States was the National Health and Nutrition Examination Survey II (NHANES II) (Brody, et.al., 1994). The NHANES II study included measurement of blood lead levels in over 40,000 random samples collected from 1978 to 1983 from people across the country. Results indicated that the median blood lead level was 12.8 ug/dL and that nearly 80% of Americans had blood lead levels above 10 ug/dL, the current level of concern, as shown in Exhibit 2-1. The preamble to the Lead and Copper Rule states that "because many children now have blood lead levels above the level of concern, EPA's policy goal continues to be that drinking water should contribute minimal additional lead to existing body burdens of lead" (Federal Register, 1991).

In 1994, the results of the first phase of the follow-up study, NHANES III, were published (Brody, et.al., 1994). The NHANES III study included blood lead level measurements collected from 1988 to 1991. Results indicated that the median blood lead level had dropped to 2.8 ug/dL and that about 20% of Americans had blood lead levels above the level of concern, a tremendous reduction in blood lead levels from 1978-1983 levels, as shown in Exhibit 2-2. This dramatic reduction in blood lead levels is primarily attributed to the increased use of non-leaded gasoline (Pirkle, et.al., 1994).

Exhibit 2-1

US Blood Lead Levels
NHANES II Study
Measured in 1978-1983 (from Brody, et.al., 1994)

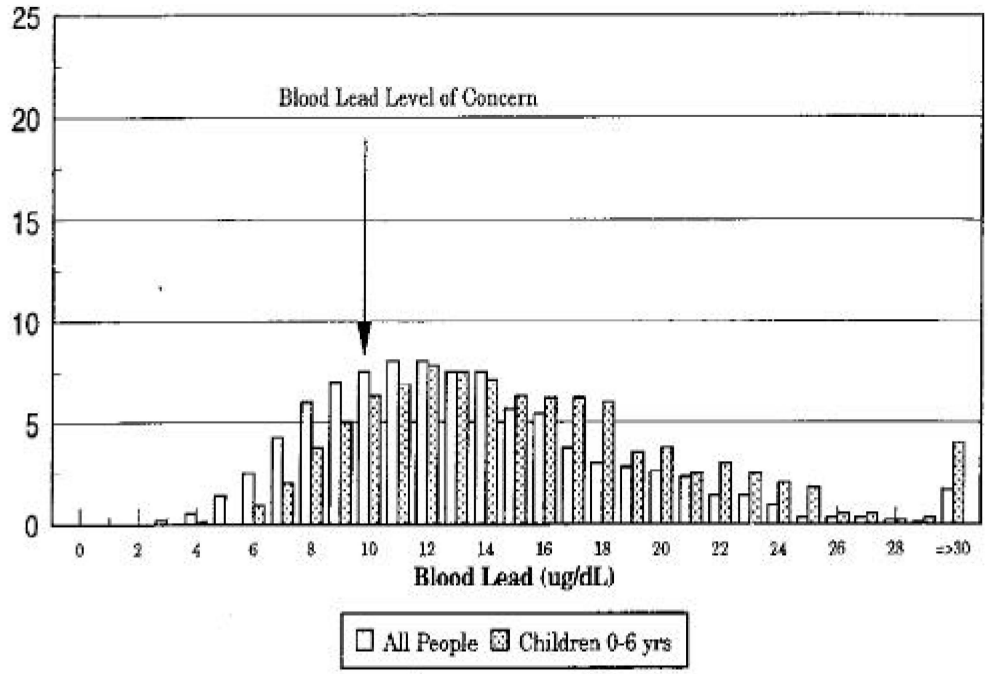
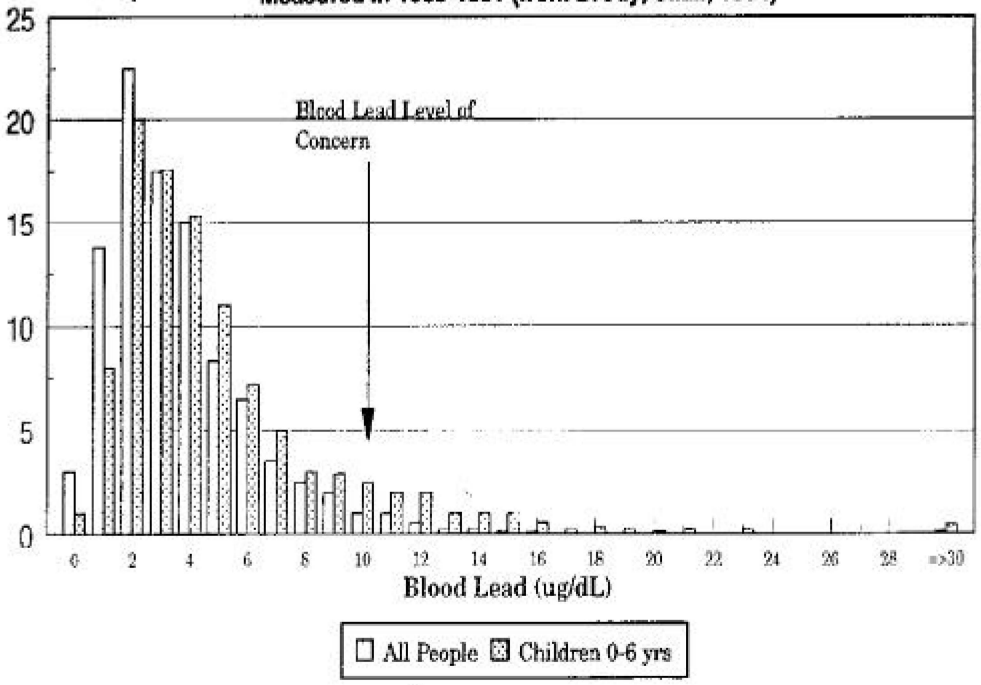


Exhibit 2-2

US Blood Lead Levels
NHANES III Study
Measured in 1988-1991 (from Brody, et.al., 1994)



2.4 Blood Lead Levels and Major Sources of Lead Exposure in the Portland Area

As part of the study to evaluate alternatives for LCR compliance (EES, 1995) blood lead level distribution data were evaluated with the help of the Oregon Health Division (OHD) Occupational, Environmental and Injury Epidemiology (OEI-EPI) section. It was concluded that the best available data to characterize the existing distribution of blood lead levels in the Portland area is:

- For infants and children less than 6 years of age: Oregon Childhood Lead Poisoning Prevention Project (OCLPPP) screening data from Multnomah County, 1992 through 1994. (OCLPPP, 1994)

- For all others: National Health and Nutrition Examination Survey (NHANES) III, Phase I National Summary Statistics, 1988 through 1991. (Brody, et.al, 1994)

The OCLPPP screening data were collected by the Multnomah County Health Department from 1992 through 1994 as part of a four-county blood lead screening project coordinated by the Oregon Health Division and funded by the CDC.

Table 2-1 is a summary of the blood lead level distributions for these two sets of data.

Table 2-1
Summary of Best Available Data to Characterize Blood Lead Levels in the Portland Area

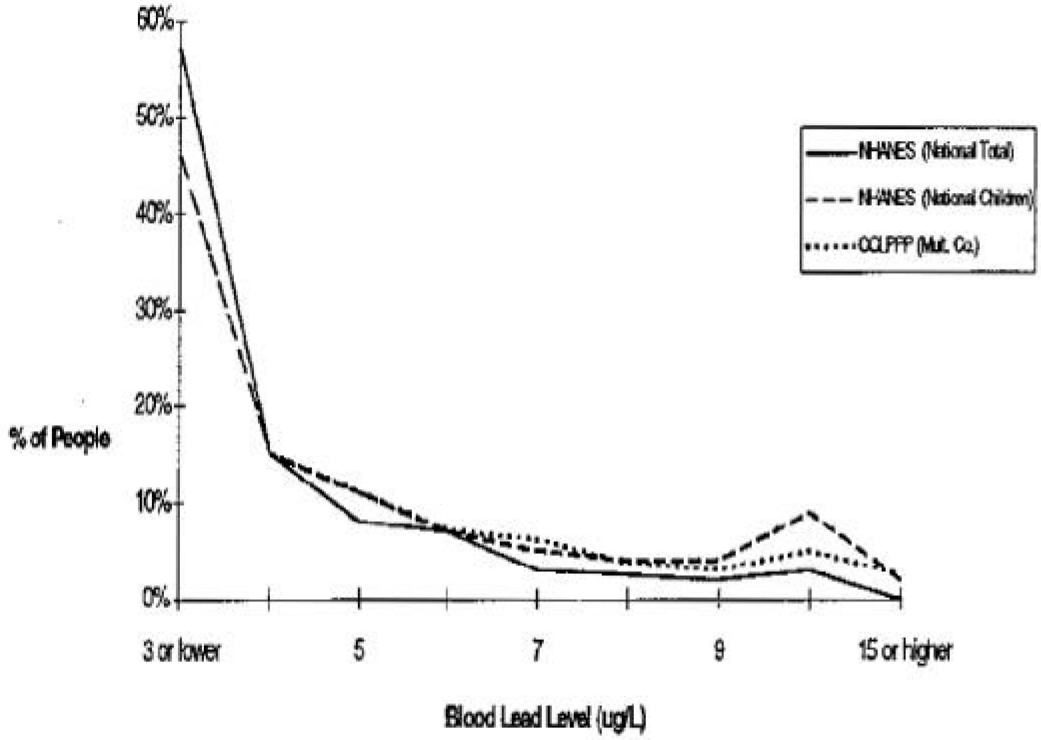
Statistic	Children: OCLPPP (1)	Adults: NHANES III (2)
50th percentile (median)	3.8 ug/dL	3 ug/dL
90th percentile	10 ug/dL	7.3 ug/dL
95th percentile	16 ug/dL	9.4 ug/dL
Number of samples	2,169	40,000

(1) Oregon Childhood Lead Poisoning Prevention Project, Multnomah County, 1992 through 1994, children 0-6 years of age. Children tested were county clinic patients or were at community screening locations.

(2) National Health and Nutrition Examination Survey, Phase III, 1989 through 1991.`

The blood lead level distributions indicated by the Multnomah County OCLPPP data and NHANES III data are very similar, as shown in Exhibit 2-3.

Exhibit 2-3
Multnomah County Screening and NHANES III
Blood Lead Level Comparison



The OCLPPP data for Multnomah County show a strong positive relationship between occurrence of elevated blood lead levels and age of home, as indicated in Table 2-2 and Exhibit 2-4. About 1 out of 6 children tested who were living in homes built before 1930 had elevated blood lead levels (≥10 ug/dL). Also, children living in homes built before 1930 were more than 2.5 times more likely to have elevated blood lead levels than children living in homes built after 1930.

The OCLPPP data also suggest that various subpopulations may be at higher than average risk: for example, children 2-3 years old, African-American children, and Hispanic children.

Table 2-2

Blood Lead Level and Home Age
OCLPPP Data (1992 - 1994)
Multnomah County
Children 0-6 years old

Blood Lead Level (ug/dL)	Number and % of children tested living in homes built before 1930	Number and % of children tested living in homes built in 1930 or after	Total number and % of children tested
< 10	790(41%)	1137(59%)	1927 (100%)
10-14	96(60%)	65(40%)	161 (100%)
15-19	45(76%)	14(24%)	59 (100%)
20 or more	28(88%)	4(12%)	32 (100%)
			2179 = Total
Chances of having an elevated blood lead level, EBLL:			
>= 10 ug/dL	1 in 6 (17.6%)	1 in 15 (6.8%)	
>= 15 ug/dL	1 in 13 (7.6%)	1 in 68 (1.5%)	
>= 20 ug/dL	1 in 34 (2.9%)	1 in 305 (0.3%)	

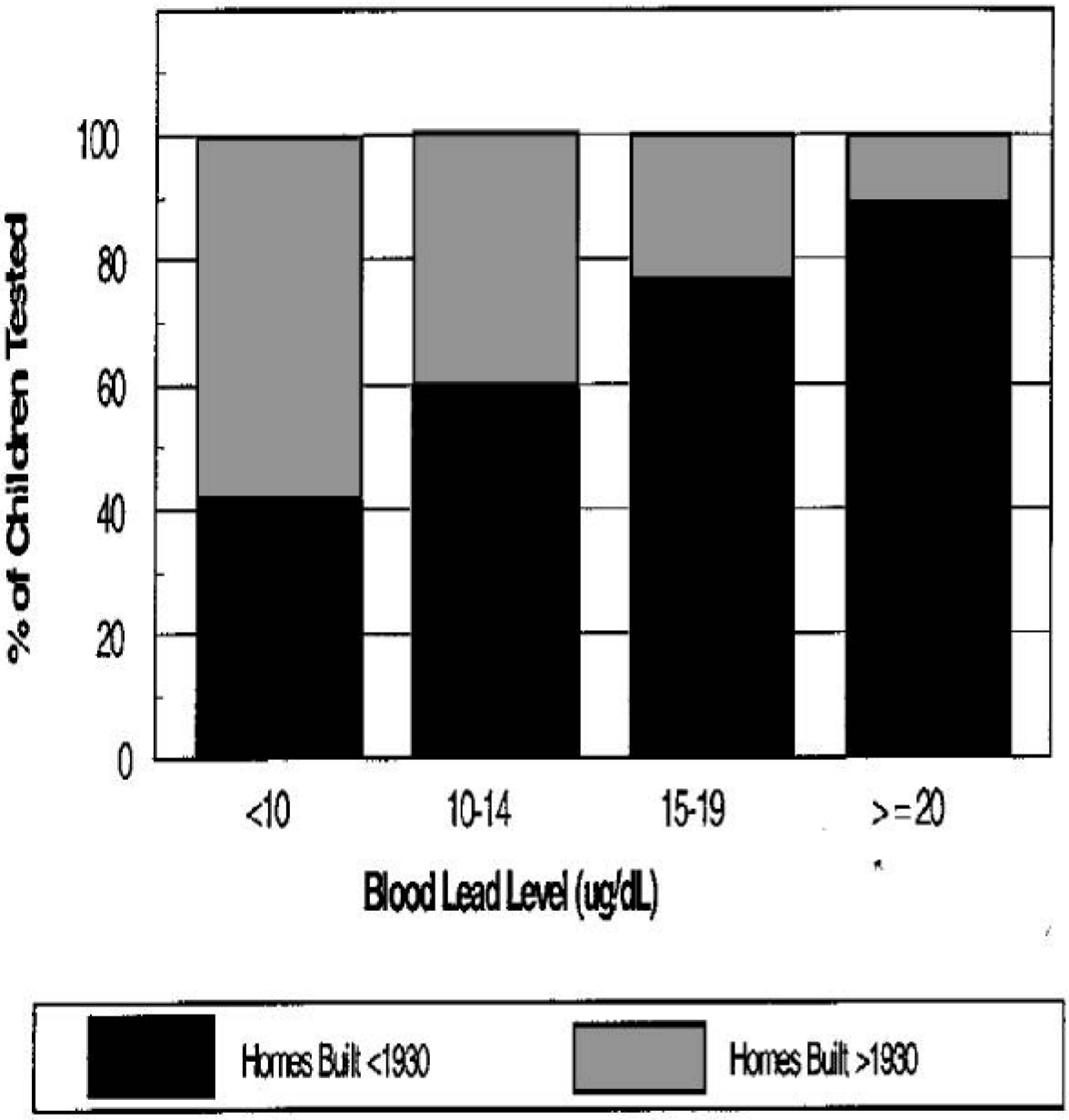
Medical laboratories in Oregon are required to report cases of elevated blood lead levels (EBLLs) of 10 or more ug/dL to the Oregon Health Division. These reports are followed-up by County public health professionals in several ways, depending on the reported blood lead level.

The results of about 110 recent investigations of EBLL cases (15 or more ug/dL) in Multnomah and Washington Counties indicate that:

- approximately 60% of the cases of are related to exposure of lead-based paint, through ingestion or inhalation of paint chips, or lead-contaminated soil or dust;
- approximately 20% are attributed to exposure to lead from a variety of sources including occupational or hobby related sources, sources from country of origin of recent immigrants; and water (1 case);
- for approximately 20% of the cases, the source(s) of lead exposure could not be determined by the investigation.

Exhibit 2-4

Relationship Between Home Age and Blood Lead Levels
OCLPPP Multnomah County Testing, 1992-1994
Children Age 0-6 Years



2.5 Lead Levels In Portland Area Drinking Water

There is no detectable amount of lead and very low levels of copper in Portland's Bull Run source water. Lead and copper enter drinking water primarily as a result of corrosion of building plumbing materials. The most common sources of these metals include lead-soldered joints in copper pipe and faucets and other fixtures made from lead-bearing brass.

The Water Bureau has two sets of data for lead and copper concentrations in water at customers' taps:

1) Lead and Copper Rule Compliance Monitoring

   The LCR requires every water system to collect water samples from homes likely to be at highest risk for elevated levels of lead and/or copper in drinking water. The LCR required the Water Bureau to collect standing water samples from at least 100 of these homes twice in 1992.

2) Customer Requests for Free Lead-in-Water Analysis

   The Water Bureau maintains a data base of results of drinking water analyses requested by customers. Most of the requests for lead analyses are in response to the Bureau's ongoing offer of free lead-in-water testing to its customers. Standing samples, which are mostly likely to contain elevated lead and copper levels, are collected. Running samples have significantly lower levels of metals than standing samples. Running samples better represent water actually consumed by most people than do standing samples. Although this set of data is not a true random sample of homes in the Portland area, it contains more than 1,000 samples from all areas of the City and all ages of homes and it is the best data set available to estimate the distribution of lead and copper in Portland's drinking water.

Table 2-3 summarizes data regarding lead in the City of Portland's drinking water.

Table 2-3
Lead Levels at Customers' Taps

Sample Type	STANDING [1]	STANDING [1]	RUNNING [2]
	Samples from "Highest Risk" Homes as defined by LCR [3]	Samples from Homes Requesting Water Analysis [4]	Samples from Homes Requesting Water Analysis [5]
50th percentile (50% of the samples are below this value)	10 ug/L	6 ug/L	< 1 ug/L
90th percentile (90% of the samples are below this value)	49 ug/L	26 ug/L	4 ug/L
99th percentile (99% of the samples are below this value)	200 ug/L	99 ug/L	
Percentage of samples that exceed the lead "action level", 15 ug/L [6]	29%	19%	2%

Number of samples	251	1063	3048

ug/L: micrograms per liter (parts per billion)

(1) Samples taken from a kitchen or bathroom sink that have stood in contact with home plumbing materials for about 8 hours.
(2) Samples taken from a kitchen or bathroom sink that have been allowed to flow for at least a minute.
(3) Samples from homes in Portland likely to be at highest risk for elevated levels of lead and/or copper in drinking water as per the LCR, i.e., homes contain copper pipe joined with lead-containing solder built 1982-1985 ("Tier 1" homes), 1992.
(4) Customer requests for free lead in water analysis, 1992-1994.
(5) Customer requests for free lead in water analysis, 1980-1994.
(6) The percentage of samples from "Tier 1" homes above the "action level" determines what actions a water system must take to comply with the LCR. Portland and other Bull Run water systems must implement public education programs.

Data presented in Table 2-4 indicate that lead levels in standing water samples are not directly related to home age. This is probably due to 1) replacement of galvanized pipe in older homes with new copper pipe joined with lead-based solder, and 2) widespread use of faucets with lead-bearing brass. These data indicate that at-risk homes cannot be identified on the basis of housing age alone.

Table 2-4
Lead Levels at Customers' Taps by Home Age

Standing Samples (1)

Year Home Built	Number of samples	Median (50th percentile) (ug/L)	90th percentile (ug/L)
Before 1930 (3)	466	6	24
1930-1939 (3)	44	5	46
1940-1949 (3)	70	6	28
1950-1959 (3)	71	4	19
1960-1969 (3)	54	8	34
1970-1979 (3)	72	10	32
1980-1984 (2)(3)	264	7	49
1985-1995 (3)	17	4	14

(1) Samples from a kitchen or bathroom sink, that have stood in contact with home plumbing materials for about 8 hours.
(2) Samples from homes likely to be at highest risk for elevated levels of lead and/or copper in drinking water as per the LCR, i.e., homes contain copper pipe joined with lead-containing solder built 1982-1985.
(3) Customer requests for free lead in water analysis, 1992-1994.

2.6 Reduction of Lead and Copper Levels in Drinking Water with Corrosion Control Treatment

A number of sources of information were evaluated to estimate the extent to which pH adjustments in the range of 7.5 - 9.5 would result in reduced lower lead and copper levels in drinking water. These include theoretical solubility calculations, bench scale electrochemical and pipe loop testing of Bull Run water, and analogous system data. Table 2-5 presents a summary of estimated extent of lead and copper reductions, expressed in terms of percent reductions from existing levels (EES, 1995). These were used to estimate changes in lead levels in standing samples at customers' taps and resulting potential changes in blood lead levels.

Table 2-5
Predicted Reductions in Lead and Copper Levels from Existing Levels for Various pH Adjustments (EES, 1995)

	pH 7-7.5	pH 8-8.5	pH 9-9.5
Lead Reduction	40%	60%	70%
Copper Reduction	55%	70%	80%

Note: predicted reductions are in standing water levels at customer taps.

Preliminary design of treatment requirements to meet each pH level were prepared. Treatment requirements are summarized in Table 2-6.

Table 2-6
Treatment Plant Requirements to Meet pH Objectives

pH Objective	Chemicals Fed	Capital Cost	Annual O&M Cost
pH 7 - 7.5	Sodium Hydroxide	$1,210,000	$392,000
pH 9 - 9.5	Sodium Hydroxide, Soda Ash, CO_2	$3,210,000	$1,188,000

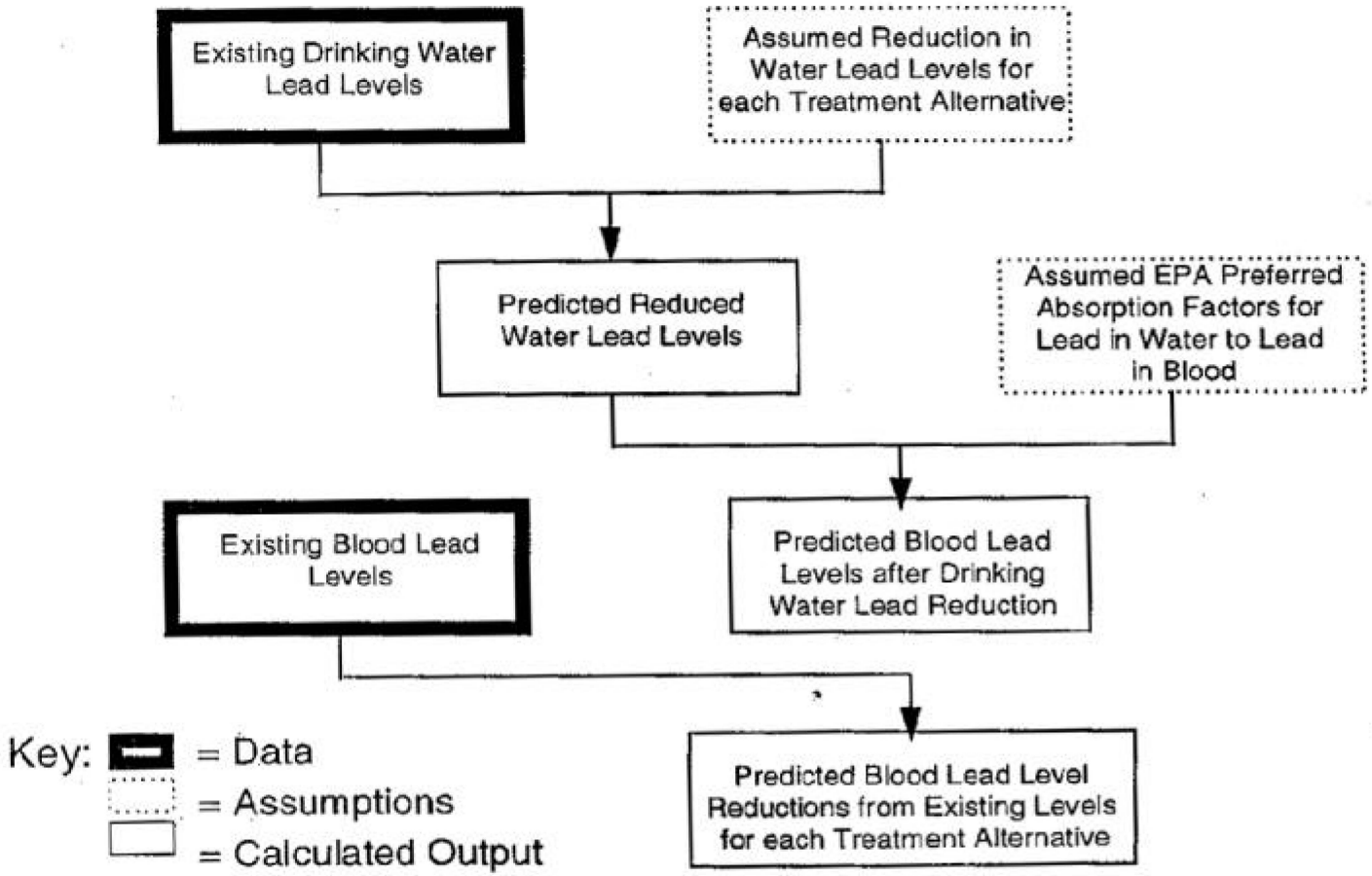
Source: Montgomery Watson (1996)

2.7 Model to Estimate the Potential Reductions in Blood Lead Levels Due to Corrosion Control Treatment

As part of the study to evaluate alternatives for LCR compliance (EES, 1995), a model was developed to estimate the potential reduction in blood lead levels that could be obtained as a result of corrosion control treatment. Exhibit 2-5 is a schematic diagram of the model approach.

Reductions in blood lead levels were estimated on a "population basis" and on an "individual basis". "Population-based" modeling was used to compare the existing distribution of blood lead levels in the community to predicted distributions after implementation of various treatment alternatives. "Individual-based" modeling was used to predict the reduction in blood lead level that an infant, child or adult would experience as a result of consuming water with a specified lead concentration.

Exhibit 2-5
Model to Estimate Potential Reductions in Blood Lead Levels Due to Corrosion Control Treatment



Some of the conclusions drawn from the modeling efforts are:

Drinking water is not a major route of lead exposure in the Portland area. The median lead level in samples of running water from customers' taps is less than 1 ug/L (non-detectable).

However, it is possible that lead in drinking water could significantly contribute to an individual's total lead exposure if that individual regularly consumes standing water drawn from a plumbing system containing significant sources of lead.

In about 50% of Portland area homes, this very unlikely but possible consumption scenario could result in a contribution of at least 1.5 ug/dL to an infant's blood lead level; in about 1% of homes, the contribution could be at least 7 ug/dL.

In homes where significantly elevated levels of lead in standing water occur, and standing water is regularly consumed, corrosion control treatment alone would not preclude the possibility of lead from water substantially contributing to an individual's total lead exposure.

For example, an infant regularly consuming only formula or juice made with standing water with 100 ug/L of lead could experience a blood lead level contribution of 7.3 ug/dL from this source. Corrosion control treatment to minimize lead levels in drinking water (pH 9.0-9.5) would be expected to reduce the water lead level by 70% to 30 ug/L and result in a still substantial blood lead level contribution of 4.5 ug/dL.

In homes where significantly elevated levels of lead in standing water occur, only lead source removal (solder or faucet), or in most cases tap flushing to remove standing water before consumption, would eliminate the possibility of substantial contributions of lead from water to an individual's total lead exposure.

The reduction in blood lead levels that would be expected as a result of corrosion control treatment to minimize levels (pH 9.0 to 9.5) compared to a lesser extent of treatment (pH 7.0 to 7.5) are estimated with these examples:

As described above, regular consumption of standing water with 100 ug/L of lead could result in a blood lead level concentration of 7.3 ug/dL for infants. Corrosion control treatments involving pH adjustments to pH 9.0-9.5 or pH 7.0-7.5 could result in reduced blood level contributions of 4.5 ug/dL or 5.7 ug/dL, respectively.

The estimated maximum number of children in Multnomah County whose blood lead levels could be reduced from above to below 10 µg/dL (the current level of concern) through corrosion control treatment ranges from about 300 children with pH adjustment to 9.0-9.5, to about 200 children with pH adjustment to 7.0-7.5 (based on the assumption that all children drink only standing, not running water).

The estimated maximum number of children in Multnomah County whose blood lead levels could be reduced by more than 2 µg/dL through corrosion control treatment ranges from about 2700 children with pH adjustment to 9.0-9.5, to about 800 children with pH

adjustment to 7.0-7.5 (again, based on the assumption that all children drink only standing, not running water).

2.8 Lead-Based Paint Hazard Reduction and Financing Task Force

In enacting Title X of the Housing and Community Development Act of 1992, Congress recognized that it did not have solutions for the problems posed by lead based paint in private housing. Congress directed the Secretary of the Department of Housing and Urban Development (HUD), in consultation with the Administrator of the Environmental Protection Agency (EPA), to create a task force to make recommendations on lead based paint hazard reduction and financing. The task force was comprised of 39 men and women representing a diversity of constituencies, opinions, professions, training, and experiences. The main focus of the task force was to provide recommendations to reduce hazards from lead based paint in pre-1978 housing and from lead contaminated soil. The task force found that changes were needed in virtually every aspect of the nation' approach to lead based paint hazards, including:

How housing is maintained and renovated;
How renovation activities are financed;
- How insurance and legal systems respond to injured children;
- How citizens are educated about lead hazards; and

How governments respond when children are discovered to have elevated blood lead levels.

The task force also found that public financing will be necessary to control lead based paint hazards in older, economically distressed housing where much of the problem is concentrated. Of the key task force recommendations was a recommendation that State Legislatures and Regulators should adopt benchmark lead based paint maintenance and hazard control standards for rental housing. The benchmark standards are designed to be reasonable, protective, specific, and enforceable. As an example, standard treatments for houses not undergoing a risk assessment, would include:

Safely repaired deteriorated paint,
Provide smooth and cleanable horizontal surfaces,
Correct conditions in which painted surfaces are rubbing, binding or being crushed that could produce lead dust,
Cover or restrict access to bare residential soil,
- Specialized cleaning, and
- Perform sufficient dust testing to ensure safety.

These treatments were designed to be cost effective and reasonable for both home owners and protection of children exposed to lead. The task force also recommended essential maintenance practices for property owners that include:

Safe work practices during work that disturbs paint,
Visual examinations for deteriorating paint,
- Repair of deteriorated paint and the cause of the deterioration,
- Generic lead based paint hazard information to tenants,

- Written notice to tenants, and
- Training of maintenance staff.

The task force further identified recommendations that may affect federal, state, and local governments (HUD, 1995).

Section 3
Lead Hazard Reduction Program Goal and Design Concepts

3.1 Program Goal

The goal of the Lead Hazard Reduction Program is to achieve better public health protection from lead exposure, at an equivalent lower cost, than would have been achieved with the corrosion control treatment and public education requirements of the Lead and Copper Rule.

Interventions to reduce lead exposures should be targeted at those exposures pathways that have the greatest impact on the health of the child by reducing his or her body-lead burden (EPA, 1995). EPA has estimated that for a typical 2 year old child living in an urban environment, or in a non-urban house with interior lead-based paint, household dust and soil accounts for 90% of the child's daily intake of lead (EPA, 1995). In the Portland area, 60% of recent cases of elevated blood lead levels were found to be related to exposure of lead-based paint.

The LCR requires large water systems to begin providing optimal corrosion control treatment by January 1, 1997. Optimal corrosion control treatment is defined as treatment that minimizes lead and copper levels in drinking water without causing violations of other drinking water standards.

The Water Bureau's LCR Corrosion Control Study (Montgomery Watson and EES, 1994) indicates that minimizing lead and copper in Portland's water would involve increasing pH to 9-9.5 (moderately alkaline pH) from current values of 6.5-7 (slightly acidic to neutral pH) and increasing alkalinity to at least 25 mg/L as $CaCO_3$ to maintain a stable pH throughout the distribution system. Such treatment may reduce lead levels in standing water by an estimated 70% and copper levels by 80%. Construction of a treatment facility with the capability of feeding multiple chemicals would be required.

The LHRP is proposed as an alternative to the optimal corrosion control treatment requirements and public education requirements of the LCR. Under this proposal, "optimal treatment" for Bull Run water systems could be defined as "corrosion control treatment to reduce lead and copper levels in drinking water along with additional interventions to reduce lead exposures that have the greatest health impact on children at most risk." As part of the LHRP, corrosion control treatment would be provided, but at a reduced level than that defined as optimal by the Lead and Copper Rule. Corrosion control treatment would consist of raising pH to about 7.3 in the distribution system, which would be expected to reduce lead levels in standing water by 40% and copper levels by 55%. This would involve construction of a treatment facility with the capability of feeding sodium hydroxide only. The savings in capital and operating costs would be used to fund interventions that reduce lead exposures that would be expected to provide the greatest benefits to children at most risk.

3.2 Centers for Disease Control Lead Guidelines

In its 1991 Strategic Plan, CDC concluded that childhood lead poisoning is a major public health problem and identified a number of steps needed to eliminate the disease. These include; (1) establishing a national surveillance system to test and identify children with elevated levels of lead in their blood, (2) establishing a nationwide program to increase lead-based paint interventions, (3) increasing lead-poisoning prevention activities, and (4) reducing exposures from other lead sources, including contaminated soil.

The CDC's lead poisoning prevention branch is currently in the process of revising its 1991 guidance on screening for the prevention of lead poisoning. The final document is expected in 1996. These new guidelines will indicate more explicitly how to determine the communities in which universal screening efforts need to be enhanced and the communities in which other tools are more appropriate for addressing childhood lead poisoning. The guidelines also revise the goals and strategies necessary to end childhood lead poisoning as a public health problem. It is expected that for communities such as Portland a more targeted blood lead screening program will be recommended.

3.3 Interventions to Reduce Lead Hazards

Information presented in this section is from a recent comprehensive review of literature regarding the effectiveness of lead hazard interventions (EPA, 1995).

A lead hazard intervention is defined as any non-medical activity that seeks to prevent a child from being exposed to the lead in the surrounding environment. Interventions include activities that attempt to remove or isolate a source of lead exposure (such as abatement of lead-based paint, dust or soil with elevated lead levels), as well as activities that attempt to reduce a child's lead exposure by modifying behavior patterns (such as through in-home education of parents).

3.3.1 Targeted Lead Exposure Pathways

Interventions are not performed merely to reduce or eliminate environmental lead levels; the aim is always to positively impact the health of children or adults. Intervention to reduce lead exposures should be targeted at those exposure pathways that have the greatest impact on the health of the child by reducing his or her body-lead burden. An intervention can reduce a child's lead exposure no more than that consistent with the source of exposure targeted. Potentially, an intervention can be successful in reducing a particular environmental lead exposure and yet produce no positive impact in a child only marginally exposed to the abated lead hazard.

The EPA (1995) has estimated typical daily lead exposures for a 2-year old child from air, food, water, dust and soil for a particular type of residence. Table 3-1 describes the lead intake profile for a child living in an urban environment. Urban children whose lead exposure resembles this profile may benefit from interventions associated with exposure through household dust and/or soil. Table 3-2 describes the lead intake profile for a child whose non-urban residence contains lead-based paint. Abatement of both lead-based paint and elevated dust lead would be most effective at reducing lead intake for a child with this intake profile.

Table 3-1
Lead Intake for a Two-Year-Old Child in an Urban Environment (EPA, 1995)

Environmental Media	Pb Concentration	Daily Amount Consumed	Daily Pb Intake	% of Total Intake
Inhale Air	0.75 ug/m^3	5 m^3	3.75 ug	3
Food, Water, Beverages	0.0033 ug/g	1500 g	5.0 ug	4
Dust-Household	1000 ug/g	0.05 g	50 ug	42
Soil	1500 ug/g	0.04 g	60 ug	50
Dust-Occupational	150 ug/g	0.01 g	1.5 ug	1
Total			120.75 ug	100

Table 3-2
Lead Intake for a Two-Year-Old Child in a Non-Urban House with Interior Lead-Based Paint (EPA, 1995)

Environmental Media	Pb Concentration	Daily Amount Consumed	Daily Pb Intake	% of Total Intake
Inhale Air	0.10 ug/m^3	5 m^3	0.5 ug	0
Food, Water, Beverages	0.0033 ug/g	1500 g	5.0 ug	4
Dust-Household	2500 ug/g	0.05 g	125 ug	92
Soil	90 ug/g	0.04 g	4.5 ug	3
Dust-Occupational	150 ug/g	0.01 g	1.5 ug	1
Total			136.5 ug	100

3.3.2 Major Findings of the Review

Although the literature is limited in extent, the major findings of this review are:

Blood lead concentrations declined after lead hazard intervention, at least for children with blood lead levels > 20 ug/dL.

Short term increases in exposed children's blood lead concentrations may result when abatements are performed improperly.

There is insufficient information available to identify a particular intervention strategy as markedly more effective than others.

Comparable reduction in blood lead concentrations are observed resulting from abatement of lead-based paint, abatement of dust and soil with elevated lead levels, and in-home educational efforts.

It is unclear whether more-costly, large scale abatement strategies are more successful than less expensive (though sometimes more labor intensive), in-place management practices.

Information is lacking on the effectiveness of lead hazard interventions:

beyond 1 year following the intervention;
among children with blood lead levels <= 20 ug/dL; and

- that attempt to prevent elevated blood lead levels before they occur.

3.3.3 Issues Related to Assessing Intervention Efficacy

The goal is to utilize a measure(s) which adequately reflects the impact of the intervention on affected children.

It is often infeasible to directly assess particular health outcomes following an intervention. Some outcomes may not manifest themselves for a long time. Some outcomes are subtle and, as such, are complicated and costly to measure directly. This assessment is made more difficult when considering interventions targeted at children with low to moderate lead exposure.

Measures of body burden such as blood lead concentration may serve as alternative biomarkers of lead exposure and intervention effectiveness, because of the established association between elevated blood lead levels and adverse health effects. When it is impractical or inappropriate to measure blood lead concentrations, levels in environmental media, such as dust lead levels, can provide valuable information. Such measures cannot demonstrate an intervention's impact on affected children in terms of actual exposure or health effects, but they can be used to evaluate the effectiveness of a particular intervention in reducing or eliminating a targeted lead hazard.

The effect of an intervention on blood lead concentration (or other measures) is the change in concentration above and beyond that due to other factors other than the strategy itself, which can be characterized by examining a comparable control population.

A important issue in planning studies to assess intervention effectiveness is the timing of the measurements following the interventions. Pre-intervention measures should be collected to provide a basis for comparison, but the timing of post-intervention measures to best assess the effectiveness of an intervention can be difficult to determine.

Information is lacking on the efficacy achieved by preventing elevated blood lead concentrations before they occur.

3.4 Design Concepts

The Program Development Committee outlined these concepts as a basis for design of the project. The Lead Hazard Reduction Program should:

1. Be implemented throughout entire Bull Run service area

This includes the City of Portland's water service area, and the service areas of its wholesale water customers that use Bull Run water as their sole source or major source of supply during

periods of normal operation. The Program should be funded by these water systems. The Portland Water Bureau should have the lead responsibility for administering and implementing the program on behalf of the Bull Run water systems.

2. Focus efforts on those lead source and exposure pathways that would be expected to have the greatest impact on reducing a child's body lead burden

Lead-based paint and lead-contaminated dusts and soils remain the primary sources and pathways of lead exposure for children. The LHRP should concentrate its efforts focus on these sources and pathways, but should also include efforts to reduce exposure through drinking water and other significant pathways.

3. Focus efforts on those persons living within the Bull Run service area who are most risk to significant lead exposure

Lead is most hazardous to children under the age of 6, whose still developing nervous systems are particularly vulnerable to lead and whose normal activities expose them to lead-contaminated dust and soil (CDC, 1991). Local lead risk assessment data indicate that children living in homes built before 1930 were 2.5 times more likely to have elevated blood lead levels than children living in homes built after 1930. Also, this data suggests that various subpopulations may be at higher than average risk: children 2-3 years old, African-American children, and Hispanic children.

Because the residences of children at most risk are not evenly distributed throughout the service area, some LHRP risk reduction efforts may not be applied uniformly throughout the service area.

4. Focus efforts on primary prevention

The CDC recommends that efforts need to be increasingly focused on preventing lead poisoning before it occurs, and notes that this will require community wide interventions as well as educational campaigns (CDC, 1991).

5. Focus on implementing feasible and cost-effective methods for reducing lead hazards

Currently information indicates that more costly, large scale abatement strategies are no more effective than less expensive, in-place management practices and in home education. Even if effective, applying abatement source isolation or removal methods to the nation's housing stock could prove to be prohibitively expensive (EPA, 1995). Many housing experts believe that on-going controls such as paint stabilization, specialized cleaning, and essential maintenance practices may be cost-effective, except where a major renovation is planned (HUD, 1995). A national task force has recently developed recommendations for cost effective measures that can prevent lead exposure and essential maintenance practices for property owners (HUD, 1995).

6. Supplement or complement efforts performed by other organizations with similar objectives, including state and county health agencies, and community-based groups

Currently state and county efforts involving lead revolve around people that have been identified as having an elevated blood lead level. An elevated blood lead level is defined as 10 ug/dL of lead in blood. The Oregon Health Division keeps records and analyzes available data on blood lead from several sources. From laboratories within the State, any elevated blood lead test is required to be reported. OHD also monitors the ongoing Oregon Childhood Lead Poisoning Prevention Program (OCLPPP) monitoring program and tracks all blood lead data below and above 10 ug/dL. Multnomah County, (e.g., Multnomah and Washington Counties) investigates all elevated blood lead levels that are reported and forwarded to them by the State Health Division. In addition, Multnomah County is also participating in the

OCLPPP program and houses staff that are leading the State-wide effort. The OCLPPP program is funded through a CDC grant in addition, other federal grant monies may apply to federally-owned housing through HUD.

7. Develop and support community participation in lead hazard reduction efforts

The implementation plan should be designed to maximize broad community participation in promoting, supporting, and delivering the LHRP in highest risk neighborhoods. The "Community Mobilization Framework" (CMF) approach, used by the CDC in demonstration projects to prevent HIV infection in women and children (Person and Cotten, 1996) may be useful to consider for this project. It includes, includes becoming familiar with the organizations and individuals within the community to identify potential partners; asking them for support, ranging from simple endorsement to active participation in coalitions; and recruiting community residents ("peer networkers") to promote program messages and conduct intervention activities.

8. Be evaluated on a regular basis for effectiveness in achieving objectives, and modified as necessary or desired to enhance effectiveness

The evaluation of the LHRP should consist of 1) formative evaluation, to assist in the design of the program's interventions; 2) implementation evaluation to determine the extent to which implementation objectives are achieved, including a description of problems encountered and solutions offered; 3) outcome evaluation to determine the degree to which the program's activities are associated with the reduction of lead hazards, and 4) cost evaluation to estimate the cost of obtaining the program's benefits. Specific measures that will be used to determine effectiveness of LHRP activities should be determined during design of program interventions.

Information is lacking on the effectiveness of lead hazard interventions 1) that attempt to prevent elevated blood lead levels before they occur; 2) among children with blood lead levels <= 20 ug/dL; and 3) beyond 1 year following the intervention (EPA, 1995). The LHRP may be able to contribute to the state of knowledge on these issues.

The LHRP's design should be flexible and dynamic and should be modified as necessary during implementation to enhance effectiveness.

9. Be developed in partnership with and supported by Oregon Health Division's Drinking Water program, State and County Health Departments, Portland's wholesale water customers, and interested organizations and individuals within the community, and other stakeholders

10. Be conducted to serve as a demonstration project for community lead hazard reduction efforts nationwide

It is estimated that LHRP development, implementation, and evaluation would require a

period of about 5 years. The Portland Water Bureau and its wholesale water customers should commit to funding the LHRP for at least this amount of time. After this period of time, the future of the LHRP should be considered in terms of its value to the community (benefits achieved and potentially achievable), and value as an alternative to LCR optimal treatment and public education requirements.

Section 4
Lead Hazard Reduction Program Components

4.1 Introduction

The proposed Lead Hazard Reduction Program has 4 main components:

Water Treatment for Corrosion Control
Lead-in-Water Testing
- Home Lead Hazard Reduction Program for Homes in Highest Risk Neighborhoods

Lead Exposure Prevention Education for Other Targeted Groups.

Each of these components are described in this section, including the purpose of the component, the activities associated with the component, and how the component will be developed, implemented and evaluated as part of the LHRP.

The LHRP presented in this section represents the best efforts and current level of knowledge of the development committee in preparing an effective program for reducing lead risks from water and other routes of exposure. The program is envisioned to be not only one that will provide a significant public health benefit, but also one that has the opportunity to fill in a number of information data gaps with respect to the effectiveness of lead risk reduction interventions. During 1997, refinement of the program design and evaluation measures will be made in association with EPA and other interested stakeholders.

4.2 Water Treatment for Corrosion Control

4.2.1 Purpose

The purpose of the water treatment component is to reduce lead and copper levels in standing water samples at the customer's tap.

The Lead and Copper Rule requires treatment to minimize lead and copper levels in drinking water. For Bull Run water, this would involve raising pH in the distribution system from current levels of about 6.8 to 9.0-9.5 and increasing alkalinity to at least 25 mg/L as $CaCO_3$. It is estimated that this level of treatment would reduce lead levels in standing water by 70%, and copper levels by 80%. For water systems using Bull Run water, the copper action level would likely be met, but the lead action level may possibly not be met, even with this optimal level of treatment.

As part of the Lead Hazard Reduction Program, corrosion control treatment would be provided, but at a reduced level than that defined as optimal by the Lead and Copper Rule. Corrosion control treatment would consist of raising pH to about 7.3 in the distribution

system, or slightly higher if necessary to meet copper action levels. It is estimated that this level of treatment would reduce lead levels in standing water by 40%, and copper levels by 55%. With this treatment, as also for the higher "optimal" level of treatment, the lead action level would likely not be met in Bull Run water systems.

This moderate increase in pH should provide substantial benefits related to decreased copper levels, including less copper discharged into the environment from wastewater treatment plants, and many fewer problems with blue staining of sinks and bathtubs. This treatment will also provide significant reductions in lead levels in standing water for those customers with a source(s) of lead in their water plumbing system.

4.2.2 Activities

Activities associated with this component include construction and operation of a caustic soda feed facility at the Portland Water Bureau's Lusted Hill site. Approximately 1-2 mg/L of caustic soda would be fed to adjust pH in the distribution system to about 7.3. This treatment target will be reevaluated if the copper action level cannot be met, if pH is unstable within the distribution system, or if other water quality problems become apparent.

4.2.3 Development

The Water Bureau is responsible for the development of this component. The corrosion control treatment facility is currently under construction at the Water Bureau's Lusted Hill site. Also, changes in treatment operations plans, operator training, and monitoring plans are underway.

4.2.4 Implementation

The Water Bureau will provide corrosion control treatment for Bull Run water that is served to the City of Portland and the metropolitan area through its wholesale water customers. The LCR requires that corrosion control treatment be provided by January 1997, and that it continue indefinitely.

4.2.5 Outcome Evaluation

The effects of corrosion control treatment will be evaluated by monitoring required by the LCR and additional monitoring planned by the Water Bureau. This includes:

1) semi-annual monitoring of Tier 1 homes and evaluation of data collected "upon request" in monitoring of customer homes to determine the effectiveness of treatment in reducing lead and copper levels in standing tap water;

2) semi-annual monitoring of Tier 1 homes to determine if lead and copper action levels are being met;

3) monitoring to determine pH stability throughout the distribution system; and

4) monitoring to assess secondary changes in water quality, such as disinfection efficacy, taste, and others.

This evaluation will be conducted by the Portland Water Bureau in cooperation with is wholesale water customers.

4.3 Lead-in-Water Testing Component

4.3.1 Purpose

The purpose of this component is to identify customers within the Bull Run service area that may be at significant risk from elevated lead levels in drinking water and assist them in reducing the risk of lead exposure from this source.

Although most people within the Bull Run service area drink water that is essentially lead-free, some homes within the service area have a significant source of lead within the plumbing system, as indicated in Table 2-3, and standing water may contain significantly elevated lead levels. Analysis of data from Portland Water Bureau customers' homes indicates that as many as 1% of homes could have lead levels in standing water of about 100 or more micrograms per liter (parts per billion). The alternatives to compliance with the LCR study (EES, 1995) indicates that corrosion control treatment alone - either the level of treatment needed to minimize lead and copper (required by the LCR) or the reduced level of treatment (proposed in the LHRP) - would not be expected to sufficiently reduce lead levels in drinking water in homes with very significant water lead sources so that no other health protective actions would be advised. One of the most effective ways of reducing lead in drinking water in these homes is to let water run from the tap for a minute or so if water has not been used for 6 to 8 hours.

It is not easy to predict which homes may have a significant source of lead in their plumbing system. Analysis of data from Portland Water Bureau customers homes indicates that homes of any age can have elevated lead-in-water levels, although homes likely to have copper pipe joined with lead-based solder (plumbing installed from the mid-60's to the mid-1980's) are at greatest risk (See Table 2-4).

The Portland Water Bureau offers free lead-in-water testing to any of its customers who express concerns about lead in their tap water, although this program is not currently widely advertised. Customers taking advantage of this offer receive a form letter indicating the laboratory results and reminding them that flushing the tap is the most effective way of reducing lead levels in drinking water.

4.3.2 Activities

Two major activities are associated with this component. The first is modification and expansion of the Portland Water Bureau's free lead in water testing program. The program would be expanded to include customers within the entire Bull Run service area, but would

probably be limited to customers living in homes with plumbing systems that are likely to be associated with significant risk for elevated lead in water levels.

The second activity would be providing assistance to customers with elevated lead levels. This assistance would, at least initially in the program, take the form of an offer of a home plumbing system assessment to determine the specific source of lead and to recommend practical and effective ways of reducing exposure.

4.3.3 Development

Development of this component's initial design would involve two main "formulative evaluation" steps: first, determining which characteristics of home plumbing systems are associated with elevated lead in water levels in the Portland area, so that free lead-in-water testing can be offered to customers with the highest risk; and second, determining appropriate types and levels of assistance that can be provided to reduce the risk of elevated water lead levels. These would best be accomplished by a review of lead data from customers' homes, including resampling and inspections of plumbing systems of some homes with the highest standing water lead levels.

Also, an initial implementation plan, including program advertising, request processing, sample collection, laboratory analysis, communicating results and providing appropriate follow-up assistance would be developed in cooperation with the wholesale water customers.

This work would be accomplished by the Portland Water Bureau and/or a contracting agency and the OHD/Multnomah County Program Evaluation staff . Development of this component may require up to 6 months to complete.

4.3.4 Implementation

This program would be implemented for the first 3-6 months in the form of a pilot program to gauge customer demand for the program, and to identify changes that should be made in the implementation plan to improve effectiveness. The program would then be implemented throughout the entire Bull Run service area. An ongoing implementation evaluation will be made to summarize the positive response rate to the testing offer, the rate of elevated water lead occurrence and the characteristics of the plumbing systems they occur in; and responses to the offer of assistance to reduce risk.

This component would be implemented by the Portland Water Bureau or a contracting agency. Implementation evaluation would be provided by the OHD/Multnomah County Program Evaluation staff.

4.3.5 Outcome Evaluation

This component will be evaluated for its effectiveness in:

1) identifying homes with significantly elevated lead in water levels; and
2) reducing this risk by educating and/or otherwise providing assistance to the homeowner.

This evaluation will be conducted by the OHD/Multnomah County Program Evaluation staff.

4.4 Home Lead Hazard Reduction Component

4.4.1 Purpose

The purpose of this component is to reduce actual or potential risks of significant lead exposure from lead-based paint and other sources in at-risk homes in highest risk neighborhoods. This component is a cornerstone activity in the LHRP and could become one of the most substantial lead hazard reduction projects undertaken in the country.

Data from the Oregon Childhood Lead Poisoning Prevention Project (OCLPPP) for Multnomah County shows an strong positive relationship between increasing occurrence of elevated blood lead levels and increasing age of home. Prevalence of older homes and other risk factors would be used to identify highest risk neighborhoods within the service area.

A flow chart indicating the risk evaluation, risk reduction, and component evaluation protocol is shown in Exhibit 4-1. Eligible homes within the neighborhood would be offered an evaluation of lead risks in their home, to be conducted by trained "neighborhood peers". If appropriate, a plan for reducing or eliminating the hazard would be developed with the resident. Assistance could be offered in the form of low cost supplies and in some cases labor, to help the resident get the job done.

The "Community Mobilization Framework" (CMF) approach, used by the CDC in demonstration projects to prevent HIV infection in women and children (Person and Cotten, 1996), may be useful to consider for this project. The CMF includes becoming familiar with the organizations and individuals within the community to identify potential partners; asking them for support, ranging from simple endorsement to active participation in coalitions; and recruiting community residents ("peer networkers") to promote program messages and conduct intervention activities. This approach offers the potential advantages of 1) extending limited resources of single agencies; 2) maximizing exposure to program through collaboration; 3) building on unique strengths and access channels of organizations and individuals in the community; and 4) allowing agencies, such as state and county health departments to develop credible relationships with non-traditional community partners.

This component would be evaluated on an on-going basis to assess the program's effectiveness and would be modified as necessary for improvement.

This Home Lead Hazard Reduction Component is similar in concept to the Community Lead Education and Reduction Corps (CLEAR Corps) program established by the National Paint

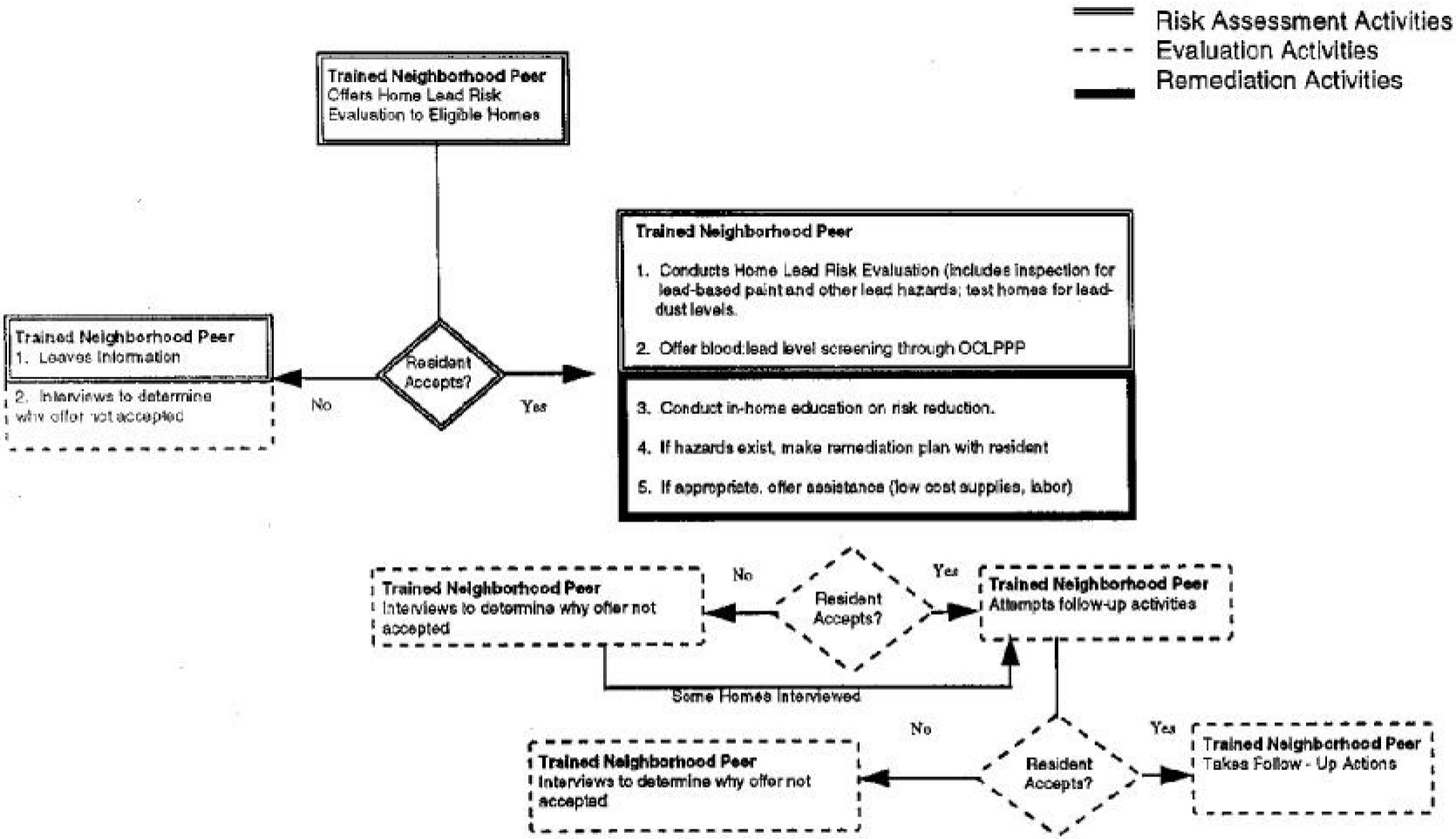
and Coatings Association and the University of Maryland through an Americorps grant. The CLEAR Corps demonstration project will operate in 3 cities and will focus on targeted, feasible and cost-effective solutions to reduce exposure in at-risk neighborhoods (EH, November 1996).

4.4.2 Activities

Identify Highest Risk Neighborhoods

The OHD Occupational, Environmental and Injury Epidemiology (OEI-EPI) Section has developed a preliminary index for lead exposure to identify high risk neighborhoods within the Bull Run service area.

Exhibit 4-1
Home Lead Hazard Reduction Component
Home Lead Risk Evaluation, Risk Reduction and Component Evaluation Protocol



This index evaluates 1990 census variables known to correlate with elevated blood lead levels. The census variables included:

Percentage under 6 population below the poverty level
Percentage of total occupied housing units built prior to 1950
- Percentage of rental housing units built prior to 1950

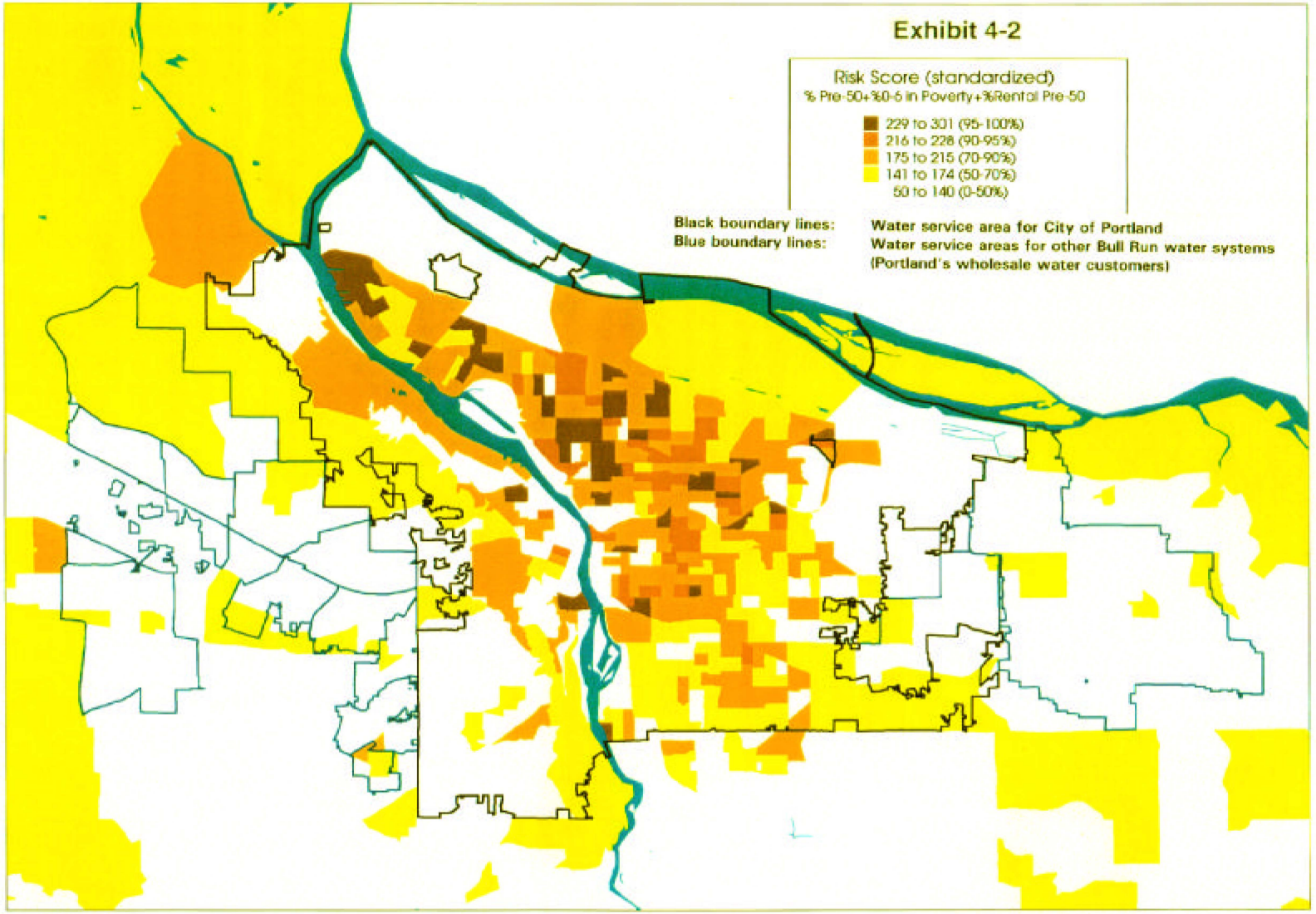
The individual percentages for each census block group within the three counties in the Bull Run Service Area were standardized by transformation to z-scores. The three resulting scores were then summed to create a risk index score for each census block group. Census block groups with the highest scores were considered to be at highest risk.

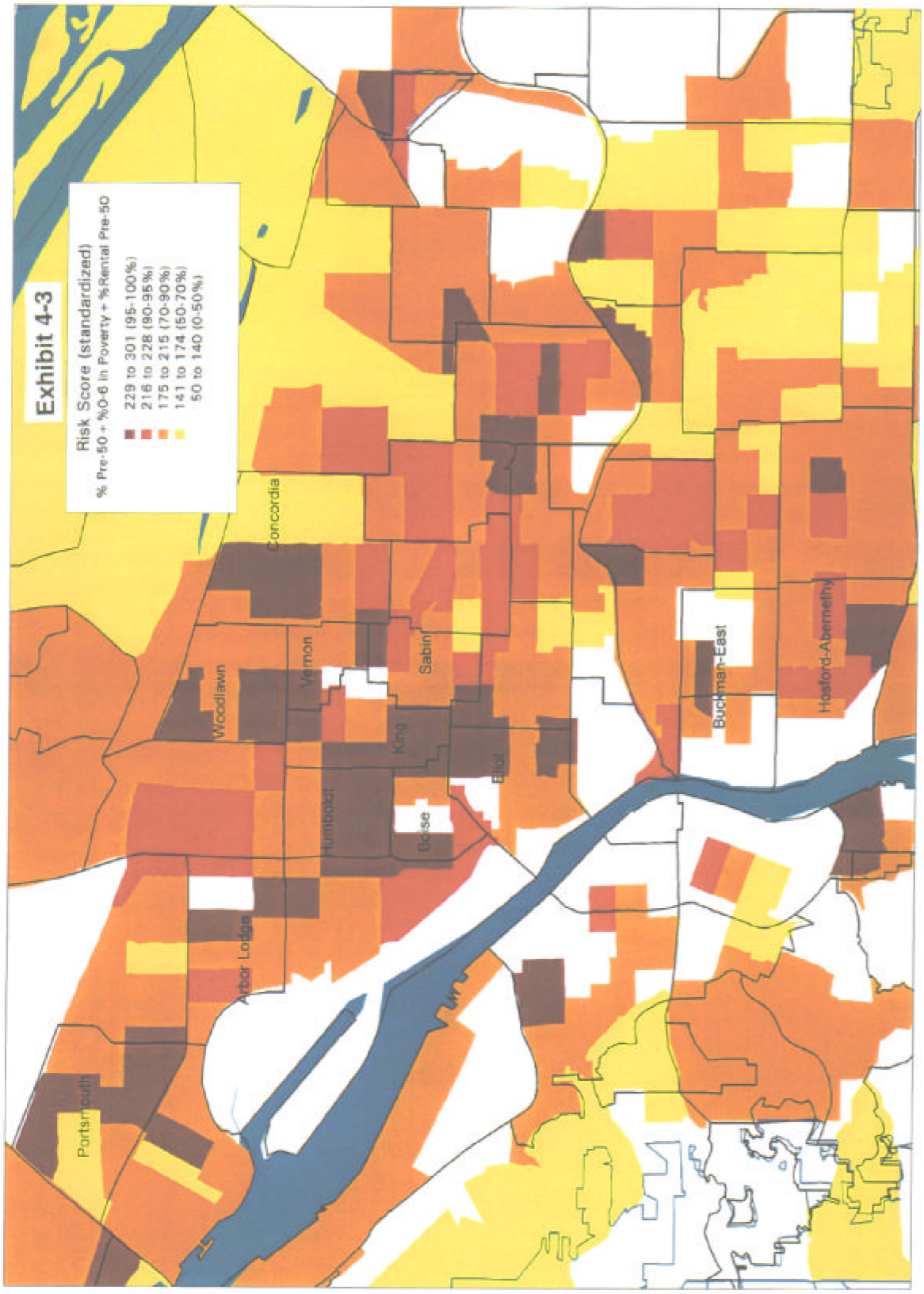
Exhibit 4-2 is a map which shows the distribution of risk index levels within the Bull Run Service Area. The legend shows the range of risk from white for the 50% of census block groups at lowest risk to dark red indicating the 5% at highest risk. As can be seen, the areas at highest risk are served directly by the Portland Water Bureau.

Exhibit 4-3 is a map which shows the areas at highest risk in greater detail with neighborhood boundaries indicated by black lines. Table 4-1 shows the number of children under age 6 in poverty and the number of pre-1950 housing units in each of the ten neighborhoods with the highest concentration of high risk census block groups. The neighborhoods are listed in an approximate rank order of the calculated risk index. Refinement of the methodology used to calculate the risk index may result in some shifting in ranking of the neighborhoods.

Table 4-1
Preliminary Listing of 10 Highest Lead Risk Neighborhoods
Using 1990 U.S. Census Data

Neighborhood	# Pre-1950 Homes	# Children Under Age 6 in Poverty
Humboldt	1620	126
King	1750	221
Sabin	1117	51
Hosford-Abernethy	2832	59
Boise	841	140
Eliot	969	78
Portsmouth	1611	305
Buckman	3566	104
Overlook	2102	72
Arbor Lodge	2092	73





Develop a Home Lead Hazard Reduction Protocol

A workplan for the Home Lead Hazard Reduction Component would be developed based on concepts presented in this report, and any new information made available through literature searches, contact with other persons with expertise in lead hazard reduction, and/or contact with other organizations involved in similar efforts. The workplan would include protocols for:

neighborhood lead risk evaluation,
in-home lead risk evaluations,
- component evaluation,

data management, and
training and hiring staff.

The necessary "tools" would also be developed for this component, including training materials, promotional and educational materials, lead risk evaluation materials, arrangements with environmental testing laboratories and OCLPPP for blood lead level testing, materials for remediation assistance, and a project database.

Develop Neighborhood Support

Within each neighborhood, a base of support will be developed for the Home Lead Risk Reduction component. We would begin by contacting a variety of organizations and individuals within the neighborhood to introduce the component. Depending on the existing social and political climate in the neighborhood, the support for LHRP activities could be organized through an existing group or coalition, a new coalition, or a less formal network of organizations and individuals willing to support the program in various ways.

The neighborhood support group would be educated on lead exposure issues in general, how their neighborhood was identified as a high risk neighborhood, and the goals and proposed activities of the LHRP. The support group's assistance and advice would be sought in:

Reviewing the LHRP's approach to home lead risk evaluation and remediation, and identifying modifications that could be made to enhance its success;

preparing a specific neighborhood coverage plan for home lead risk evaluation;

advertising the LHRP (for example, by posting or distributing materials, hosting informational meetings);
recruiting neighborhood candidates for training and employment as peer risk evaluators;

conducting a neighborhood-specific lead risk evaluation, and

reviewing the LHRP's effectiveness in reducing risks of lead exposure in the neighborhood.

Conduct Neighborhood Lead Risk Evaluation

Within each neighborhood, a survey will be conducted to identify significant or potentially significant non-residential lead exposure sources for children in the neighborhood. (Residential risks will be evaluated in individual eligible homes). Non-residential lead sources may include active or abandoned industrial sites, play areas containing lead-based painted surfaces or lead-contaminated soil, bridges or other structures maintained with lead-based paint, and other sources. Testing of some environmental samples may be conducted. This work would be conducted by LHRP staff with active participation from the neighborhood support group. Management of any non-residential risks identified would be outside the scope of the Water Bureau's LHRP, and could be addressed by the neighborhood support group.

Conduct Home Lead Risk Evaluations

Home lead risk evaluations would be offered to all eligible homes in the neighborhood. Several people from the neighborhood ("neighborhood peers") would be hired and trained to offer and conduct these evaluations.

These home lead risk evaluations will consist primarily of 1) completing a checklist of questions about the home that are relevant to estimating the level of lead risk exposure in the home, 2) collecting a sample of household dust and/or soil for laboratory analysis, and 3) in-home education of potential lead exposure risks. Blood lead level testing for children age 6 or younger will be offered through the OCLPPP program. A packet of information would be left at each eligible residence, whether or not a risk evaluation was accepted by the residents.

Recommendations for hazard reduction would be offered to tenants or property owners in which an actual or potential lead hazard was identified. A range of potential in-home interventions would be recommended based on the nature and extent of hazards identified, taking into account any relevant circumstances associated with the particular residence.

Recommendations would be consistent with HUD/EPA recommended treatments for lead-based maintenance and hazard control in rental housing, such as correcting conditions in which painted surfaces could produce lead dust, specialized cleaning, and covering bare residential soil and performing essential maintenance (HUD, 1995).

LHRP staff will encourage the resident or rental property owner to control the hazard as recommended by developing a workplan with the resident, and offering assistance in the form of training and/or basic supplies (such as protective plastic sheeting, tape, respirator, access to HEPA vacuum cleaner). Additional resources in the form of financial assistance to low income families may be provided if the ongoing implementation evaluation indicates that lack of financial assistance poses an obstacle to reducing lead hazards and no other avenues for assistance are available.

Follow-up on Hazard Control Efforts

LHRP staff would follow-up with residents in homes where recommendations were made for lead hazard control. The purpose of this follow-up would be to encourage completion of the recommended work and collect samples to assess the intervention's effectiveness.

Outcome Evaluation

A detailed evaluation plan will be developed in conjunction with further development efforts for this component.

4.5 Public Education about Lead Health Risks

4.5.1 Purpose

The purpose of this component is to provide primary prevention of lead exposure through public education. The goal is to increase the awareness of the entire community about lead health risks and make special efforts to effectively provide relevant information to those at greatest risk of lead exposure. A well designed and implemented public education program has the potential to be the most effective means of preventing lead exposure.

The Lead and Copper Rule requires water systems that exceed the lead action level to carry out a prescribed public education program. This program consists of distributing mandatory text at specified frequencies to water system customers, various health care providers and social service agencies, schools, and the news media. These requirements are summarized in Table 4-2.

Table 4-2
Lead and Copper Rule - Required Public Education Program

Apparent Target	Item Ref.	Required Message	Required Medium	Required Delivery to	Required Delivery by	Required Frequency
General Public	1	EPA "long"	Written Notice	water system	mail with water	1/year
	2	EPA "long" message		editorial		1/year
	3	EPA Public Service		radio and TV		2/year
Health Care and/or Health Education	4	EPA "less long" message	Written Notice	public and private hospitals and		1/year
	5	"	"	family planning clinics		1/year
	6	"	"	pediatricians		1/year
	7	"	"	City or County Health		1/year
	8	"	"	WIC and/or Head Start agencies		1/year
	9	"	"	local welfare agencies		1/year
	10	"	"	public schools		1/year

The required public education program has a number of obstacles to optimum effectiveness. The mandatory message only addresses lead in drinking water, and does not address other sources of lead in the environment, such as lead-based paint, that are more likely to result in high levels of exposure. Sub-populations at significant risk to high lead exposure levels (such as "do-it-yourself" remodelers) do not receive relevant information as a part of this program. The mandatory message that water systems are required to distribute to customers is long (>1200 words) and complex (12th grade level reading level; a typical Hemingway short story is written at a 4th grade reading level). People who do not receive water bills (for example, people living in apartments) do not receive the mandatory message. Also, in the Portland metropolitan area, rarely has distribution of required information to the news media resulted in coverage of the issue of lead in drinking water.

4.5.2 Activities

The activities proposed in the public education component of the Lead Hazard Reduction Program are outlined in Table 4-3.

The proposed education component may be more effective than the required LCR program in preventing significant lead exposures in the community for a number of reasons. First, messages delivered in this program address multiple potential sources of lead exposure, not just water, and would be have the appropriate content level of complexity for their intended purpose and audience. Second, messages would be delivered to a larger set of target audiences, the most important of which may be those providing general care and health care to young children. Third, messages would be delivered to a potentially larger general audience by paid or donated advertising in newspapers and radio and mailings to targeted postal customers instead of water system customers. Last, messages to health care providers

and social service agencies would be delivered more effectively, primarily by visit from a health educator rather than by mailing brochures to an institution. For example, the public health educator may meet with the hospital education coordinators, present information to physicians through continuing education programs, and meet with school administrators to make them aware of a short lead safety program available to school health teachers.

In addition to the specific activities listed in Table 4-3, a Lead Hazard Reduction Resource Center would be developed and operated as part of this program to serve as a central source of information to the community.

4.5.3 Development

A public health educator would have the primary responsibility for development of the public education program, in coordination with OHD/Multnomah County Program Evaluation staff. Existing materials, such as brochures developed by the EPA or National Lead Information Center should be used when possible, and modified for local conditions if necessary. This development is estimated to require up to 6 months to complete.

4.5.4 Implementation

A public health educator will be charged with implementing the public education program. As implementation strategies are developed, consideration will be given to the use of the "Community Mobilization Framework" model (Person and Cotton, 1996).

Table 4-3
Public Education Component

Target Audience	Item		Message	Medium	Delivery to	Delivery by	Frequency
General Public	1	Required by LCR	"long version" of mandatory text	written notice	water system customers	mail with water bill	1/year
		Comments	Too long (>1200 words) and complex (12th grade			people who don't receive water bills	
		Proposed	simple, brief, but	brochure or small	"at-risk" residential postal	mail separate or with	1/year
	2	Required by LCR	"long version" of mandatory text		editorial departments of newspapers		1/year
		Comments	lacks information about significant sources of lead		newspapers not obligated to publish information		
		Proposed	proposed message for Item	paid or donated	advertising departments of		1/year
	3	Required by LCR	mandatory Public Service Announcement text		radio and TV stations		2/year
		Comments	lacks information about significant sources of lead		radio and TV stations not obligated to broadcast PSA		
		Proposed	proposed message for Item	paid or donated	advertising departments of		2/year

Table 4-3 (Continued)
Public Education Component

Target Audience	Item		Message	Medium	Delivery to	Delivery by	Frequency
Health Care and/or Education	4	Required by LCR	"less long" version of mandatory text	written notice	public and private hospitals and clinics		1/year
		Comments	lacks information about			mailed brochure	
		Proposed	comprehensive message	information	education departments of	public health	1/year
	5	Required by LCR	same as for Item 4	same as Item 4	family planning clinics		1/year
		Comments	same as for Item 4			same as for Item 4	
		Proposed	same as for Item 4	same as Item 4	family planning clinics	same as for Item 4	1/year
	6	Required by LCR	same as for Item 4	same as Item 4	pediatricians		1/year
		Comments	same as for Item 4		should include other medical	same as for Item 4	
		Proposed	same as for Item 4	same as Item 4	pediatricians	public health	1/year

Table 4-3 (Continued)
Public Education Component

Target Audience	Item		Message	Medium	Delivery to	Delivery by	Frequency
Health Care and/or Education	7	Required by LCR	same as for Item 4	same as Item 4	City or County Health Departments		1/year
		Comments			County Health Departments are		
		Proposed	none				
	8	Required by LCR	same as for Item 4	same as Item 4	WIC and/or Head Start agencies		1/year
		Comments	same as for Item 4			same as for Item 4	
		Proposed for LHRP	same as for Item 4	same as Item 4	WIC and/or Head Start agencies	same as for Item 4	1/year
	9	Required by LCR	same as for Item 4	same as Item 4	local welfare agencies		1/year
		Comments	same as for Item 4			same as for Item 4	
		Proposed	same as for Item 4	same as Item 4	local welfare agencies	same as for Item 4	1/year
	10	Required by LCR	same as for Item 4	same as Item 4	public schools and/or school boards		1/year
		Comments	same as for Item 4				
		Proposed	lead safety information for	short lead safety	public and private school	public health	1/year

Table 4-3 (Continued)
Public Education Component

Target Audience	Item		Message	Medium	Delivery to	Delivery by	Frequency
General Care Providers for	11	Required by LCR	no				
		Proposed	proposed message for	brochure or small	parents of newborns, via	by visit from public	1/year
	12	Required by LCR	no				
		Proposed	same as for Item 11	same as for Item 11	parents and staff at day care	day care facilities	1/year
Non-professional	13	Required	no				
		Proposed	Information to reduce lead	brochures and/or	remodelers via retail “home	retail home	
Non-English	14	Required	no				
		Proposed	Messages for Items 1, 2,	as for Items 1, 2, 3,	as for Items 1, 2, 3, 11 and 13,	community-based	

4.5.5 Outcome Evaluation

Evaluation will be conducted by the OHD/Multnomah County PDES. General evaluations of effectiveness will be conducted by surveying a cross-sectional representative sample of the general public in the Bull Run service area to determine baseline knowledge and attitudes about lead hazards and ascertain changes in knowledge as the program progresses. The mechanism used to conduct this survey will be through additional questions provided to the ongoing Behavior Risk Factor Surveillance Survey (BRFSS). Specific evaluation process will also take place for targeted groups. For example, a sample of people obtaining remodeling permits could be surveyed to determine what steps were taken to reduce lead exposure during remodeling.

4.6 LHRP Summary and Schedule

Exhibit 4-4 presents a matrix that summarizes all of the activities to be conducted within the LHRP and incorporates a schedule showing when the component will be developed, when it will be implemented, evaluated and when reports will be prepared.

Section 5
Administration

The proposed administrative structure of the Lead Hazard Reduction Program is shown in Exhibit 5-1 and Table 5-1.

A steering committee will be developed to ensure that the objectives of the Lead Hazard Reduction Program are met. The steering committee should include representatives from the Portland Water Bureau, Water Managers Advisory Board, Oregon Health Division Occupational, Environmental and Injury Epidemiology (OEI-EPI) Section, Multnomah County Health Department, Washington County Health Department, Clackamas County Health Department, OHD/Multnomah County Program Design and Evaluation Services (PDES) Staff, and representatives from community-based organizations. A program manager will be designated by the Water Bureau to ensure that regulatory requirements are met throughout the LHRP.

The Water Treatment Component and the Lead-in-Water Testing Component would be conducted by the Water Bureau. The PDES staff will evaluate the effectiveness of the Lead-in-Water Testing Component.

A Principal Investigator will be responsible for the Home Lead Exposure Prevention component and the Lead Exposure Prevention Education component. The Home Lead Exposure Prevention component will be carried out by a Manager and a group of trained neighborhood peers who will conduct much of the field work. The Lead Exposure Prevention Education component will be carried out by a health educator and community based organizations (CBOs). The activities for both these components will be evaluated by a principal investigator and dedicated research assistant.

Contractual arrangements in the form of inter-agency agreements will be used to establish the working relationships and will include detailed workplans and budgets.

Exhibit 5-1
Responsibilities by Component

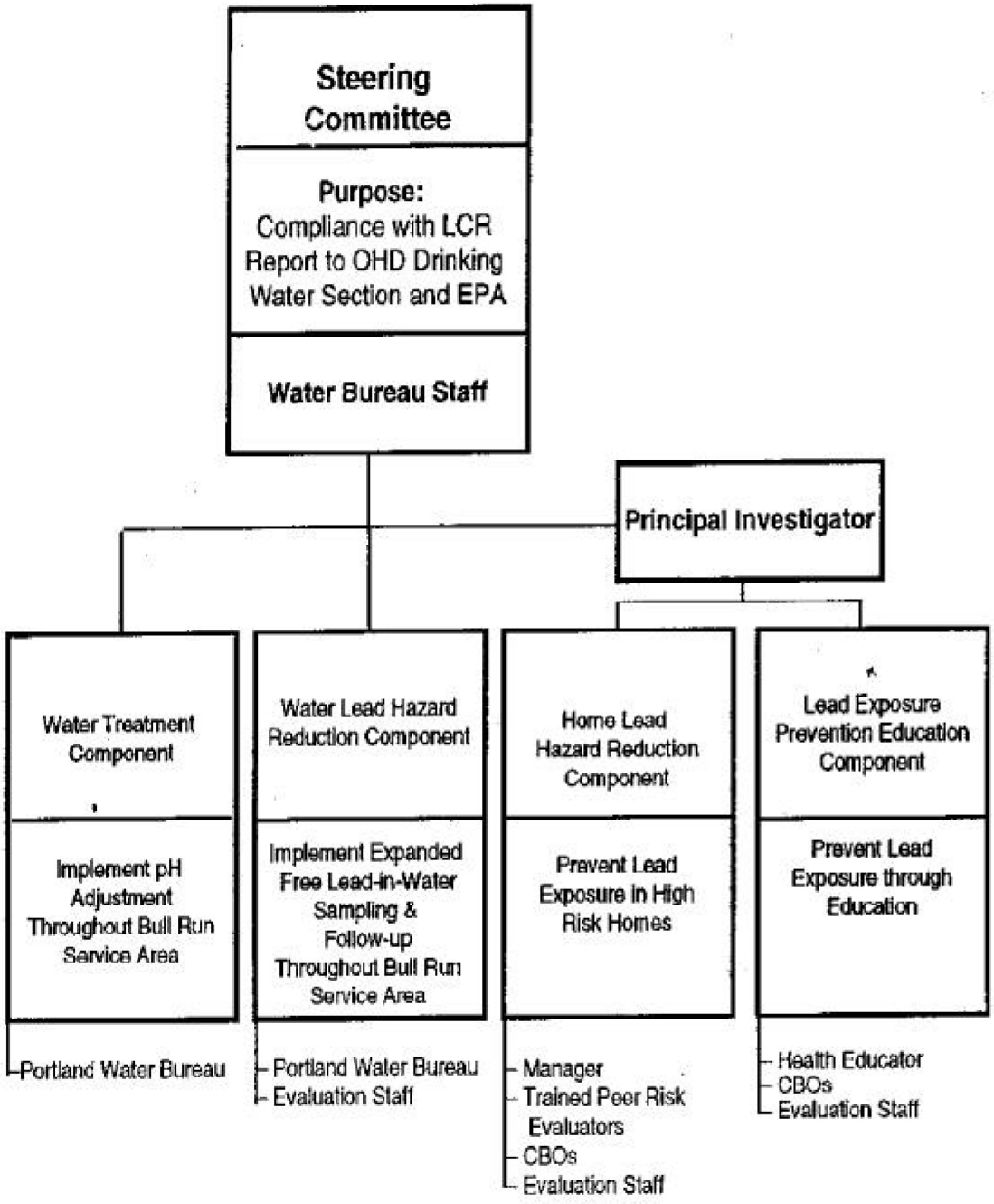


Table 5-1
LHRP - Organizational Responsibilities

Organization or Title	Water Treatment Component	Water Lead Risk Reduction Component	Home Lead Exposure Prevention Component	Lead Exposure Prevention Education Component	Overall LHRP Responsibility
Portland Water Bureau	Design, Implementation, Evaluation and Reporting of Activities	Design, Implementation and Reporting of Activities			Lead Steering Committee, Report to OHD Drinking Water Section
Water Managers Advisory Board					Participate in Steering Committee
Principal Investigator/ Evaluation Staff		Input to Design and Conduct Evaluations	Design, Monitor Implementation and Conduct Evaluations	Design and Conduct Evaluations	Participate in Steering Committee
Program Manager			Design and Implementation of Activities		Participate in Steering Committee
Health Educator			Provide Support for Educational Activities	Design and Implementation of Activities	Participate in Steering Committee

Section 6
Program Cost Estimate

Budget

A five year preliminary cost estimate for the LHRP has been developed and is summarized in Table 6-1. The budget for the water treatment components were developed by Montgomery Watson, 1996 and modified based on actual construction costs to date.. The preliminary cost estimates for the other three components of the LHRP were developed by the LHRP Development Committee.

The LCR required approach is estimated to cost an additional $2.00 million in capital costs and an additional $200,000 or more per year to operate as compared to the Lead Hazard Reduction Program.

It is estimated that LHRP development, implementation, and evaluation would require a period of about 5 years. The Portland Water Bureau and its wholesale water customers should commit to funding the LHRP for at least this amount of time. After this period of time, the future of the LHRP should be considered in terms of its value to the community (benefits achieved and potentially achievable), and value as an alternative to LCR optimal treatment and public education requirements.

References

Brody, D.J., et. al., 1994, Blood Lead Levels in the U.S. Population, Journal of the American Medical Association, v 272, no. 4, pp. 277-283.

Centers for Disease Control, 1991 Preventing Lead Poisoning in Young Children, U.S. Department of Health and Human Services.

EES, 1995, Comprehensive Evaluation of Alternatives for Lead and Copper Rule Compliance.

EH Update, 1996, CLEAR Corps, Reducing Lead Exposure in At-Risk Neighborhoods, Environmental Health, November 1996.

HUD, 1995, Summary Lead-Based Paint Hazard Reduction and Financing Task Force.

EPA, 1995 Review of Studies Addressing Lead Abatement Effectiveness, Washington, D.C.

Federal Register, 1991, Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper; Final Rules, Federal Register, v. 56, no. 110.

Montgomery Watson and EES, 1994, Lead and Copper Rule Corrosion Control Study for the City of Portland Bureau of Water Works and Participating Wholesale Customers.

Montgomery Watson, 1996, Corrosion Control Treatment Facility Preliminary Design Report.

OCLPPP, 1994 Status Reports to OCLPPP Lead Task Force.

Person, B. and Cotton, D., 1996, A Model of Community Mobilization for the Prevention of HIV in Women and Infants, Public Health Reports, v. 111, Supplement 1, pp. 89-98.

Pirkle, J.L., et. al., 1994, The Decline in Blood Lead Levels in the United States, Journal of American Medical Association v 272 no. 4, p. 284-291.

186513

Portland, Oregon

FINANCIAL IMPACT and PUBLIC INVOLVEMENT STATEMENT
For Council Action Items

(Deliver original to Financial Planning Division. Retain copy.)

1. Name of Initiator	2. Telephone No.	3. Bureau/Office/Dept.
Michelle Cheek	503-823-4790	Water / Engineering Services / Design

4a. To be filed (date):	4b. Calendar (Check One)	5. Date Submitted to Commissioner's office and CBO Budget Analyst: March 5, 2014
March 13, 2014	Regular ☒ Consent ☐ 4/5ths ☐	

6a. Financial Impact Section:	6b. Public Involvement Section:
☒ Financial impact section completed	☒ Public involvement section completed

1) Legislation Title:
Authorize a contract with Black & Veatch Corporation for a Water Quality Corrosion Study in the amount of $240,000 (Ordinance)

2) Purpose of the Proposed Legislation:
The Water Bureau plans to conduct a Water Quality Corrosion Study to evaluate the impacts of water quality changes on lead corrosion in the distribution system. This study will help the Bureau determine if changes in the corrosion control program are needed to reduce lead levels and ensure compliance with the United States Environmental Protection Agency's Lead and Copper Rule.

Exposure to lead in drinking water in Portland is primarily from corrosion of household plumbing. The rate of lead corrosion is dependent on multiple water quality parameters including pH, alkalinity, water temperature, and disinfection residuals. The water system will be undergoing multiple system changes (physical and operational) over the next 10 to 15 years which may produce changes in these water quality parameters and lead corrosion rates.

The water system is also experiencing more pronounced seasonal changes in water quality that may influence lead corrosion. It is important to take a proactive approach to evaluating the combined water quality effects of these system changes. Evaluating the potential impacts of these system changes now will help ensure compliance with the Lead and Copper Rule during transition periods and after all system changes are in place. A proactive approach will establish solid baseline water quality data that will be used to identify potential water quality changes; evaluate the impact of water quality changes, either positive or negative, on lead corrosion; identify the need for any operational changes or adjustments to pH and alkalinity to control lead corrosion; and plan for and identify the proper timing for any recommended improvements.

3) Which area(s) of the city are affected by this Council item? (Check all that apply—areas are based on formal neighborhood coalition boundaries)?

☒ City-wide/Regional	☐ Northeast	☐ Northwest	☐ North
☐ Central Northeast	☐ Southeast	☐ Southwest	☐ East
☐ Central City			

FINANCIAL IMPACT

4) Revenue: Will this legislation generate or reduce current or future revenue coming to the City? If so, by how much? If so, please identify the source.
No.

5) Expense: What are the costs to the City as a result of this legislation? What is the source of funding for the expense? *(Please include costs in the current fiscal year as well as costs in future year, including Operations & Maintenance (O&M) costs, if known, and estimates, if not known. If the action is related to a grant or contract please include the local contribution or match required. If there is a project estimate, please identify the* ***level of confidence****.)*

The total not to exceed value of the contract is $240,000. This project will be funded through the Capital Planning Program Regulatory Monitoring/Compliance Program. Partial funding of $50,000 is available in the FY 2013-14 Budget. Additional funding of $128,000 has been requested in the FY 2014-15 Budget and $62,000 in the FY 2015-16 Budget. The total project cost including internal costs is $380,000. This action will not result in a change to the forecast water rates.

6) Staffing Requirements:

- **Will any positions be created, eliminated or re-classified in the current year as a result of this legislation?** *(If new positions are created please include whether they will be part-time, full-time, limited term, or permanent positions. If the position is limited term please indicate the end of the term.)*
  No.

- **Will positions be created or eliminated in *future years* as a result of this legislation?**
  No.

(Complete the following section only if an amendment to the budget is proposed.)

7) Change in Appropriations *(If the accompanying ordinance amends the budget please reflect the dollar amount to be appropriated by this legislation. Include the appropriate cost elements that are to be loaded by accounting. Indicate "new" in Fund Center column if new center needs to be created. Use additional space if needed.)*

Fund	Fund Center	Commitment Item	Functional Area	Funded Program	Grant	Sponsored Program	Amount

[Proceed to Public Involvement Section — REQUIRED as of July 1, 2011]

PUBLIC INVOLVEMENT

8) Was public involvement included in the development of this Council item (e.g. ordinance, resolution, or report)? Please check the appropriate box below:

☐ **YES**: Please proceed to Question #9.
☒ **NO**: Please, explain why below; and proceed to Question #10.

The project is a water quality study and does not require public involvement.

9) If "YES," please answer the following questions:

a) What impacts are anticipated in the community from this proposed Council item?

b) Which community and business groups, under-represented groups, organizations, external government entities, and other interested parties were involved in this effort, and when and how were they involved?

c) How did public involvement shape the outcome of this Council item?

d) Who designed and implemented the public involvement related to this Council item?

e) Primary contact for more information on this public involvement process (name, title, phone, email):

10) Is any future public involvement anticipated or necessary for this Council item? Please describe why or why not.
If this study results in recommended changes to the Water Bureau's corrosion control strategies, a public information notice may be necessary prior to implementation of the recommended changes.

David G. Shaff, Administrator

APPROPRIATION UNIT HEAD (Typed name and signature)

CITY OF PORTLAND
AGREEMENT FOR PROFESSIONAL, TECHNICAL, OR EXPERT SERVICES

CONTRACT NUMBER 30003222

TITLE OF WORK PROJECT
Water Quality Corrosion Study

This contract is between the City of Portland ("City," or "Bureau") and **Black & Veatch Corporation**, hereafter called Consultant. The City's Project Manager for this contract is **Michelle Cheek**.

Effective Date and Duration
This contract shall become effective on **April 14, 2014**. This contract shall expire, unless otherwise terminated or extended, on **December 1, 2015**.

Consideration
(a) City agrees to pay Consultant a sum not to exceed **$240,000** for accomplishment of the work.
(b) Interim payments shall be made to Consultant according to the schedule identified in the STATEMENT OF THE WORK AND PAYMENT SCHEDULE.

CONSULTANT DATA AND CERTIFICATION

Name (print full legal name): Black & Veatch Corporation

Address: 5885 Meadows Road, Suite 700, Lake Oswego, OR 97035

Employer Identification Number (EIN): 431833073
[INDEPENDENT CONTRACTORS: DO NOT PROVIDE SOCIAL SECURITY NUMBER (SSN) – LEAVE BLANK IF NO EIN]

City of Portland Business Tax Registration Number: 652440

Citizenship: Nonresident alien ____ Yes _X_ No

Business Designation (check one): ____ Individual ____ Sole Proprietorship ____ Partnership _X_ Corporation

____ Limited Liability Co (LLC) ____ Estate/Trust ____ Public Service Corp. ____ Government/Nonprofit

Payment information will be reported to the IRS under the name and taxpayer I.D. number provided above. Information must be provided prior to contract approval.

TERMS AND CONDITIONS

1. Standard of Care
Consultant shall perform all services under this contract using that care, skill, and diligence that would ordinarily be used by similar professionals in this community in similar circumstances.

2. Effect of Expiration
Passage of the contract expiration date shall not extinguish, prejudice, or limit either party's right to enforce this Contract with respect to any default or defect in performance that has not been corrected.

3. Order of Precedence
This contract consists of these Terms and Conditions, the Statement of Work and Payment Schedule, and any exhibits that are attached. Any apparent or alleged conflict between these items will be resolved by using the following order of precedence: a) these Terms and Conditions; b) Statement of Work and Payment Schedule; and c) any exhibits attached to the contract.

4. Early Termination of Contract
(a) The City may terminate this Contract for convenience at any time for any reason deemed appropriate in its sole discretion. Termination is effective immediately upon notice of termination given by the City.
(b) Either party may terminate this Contract in the event of a material breach by the other party that is not cured. Before termination is permitted, the party seeking termination shall give the other party written notice of the breach, its intent to terminate, and fifteen (15) calendar days to cure the breach. If the breach is not cured within 15 days, the party seeking termination may terminate immediately by giving written notice that the Contract is terminated.

5. Remedies and Payment on Early Termination

(a) If the City terminates pursuant to 4(a) above, the City shall pay the Consultant for work performed in accordance with the Contract prior to the termination date. No other costs or loss of anticipated profits shall be paid.

(b) If the City terminates pursuant to 4(b) above, the City is entitled all remedies available at law or equity. In addition, Consultant shall pay the City all damages, costs, and sums incurred by the City as a result of the breach.

(c) If the Consultant justifiably terminates the contract pursuant to subsection 4(b), the Consultant's only remedy is payment for work prior to the termination. No other costs or loss of anticipated profits shall be paid.

(d) If the City's termination under Section 4(b) was wrongful, the termination shall be automatically converted to one for convenience and the Consultant shall be paid as if the Contract was terminated under Section 4(a).

(e) In the event of early termination the Consultant's work product before the date of termination becomes property of the City.

6. Assignment

Consultant shall not subcontract, assign, or transfer any of the work scheduled under this agreement, without the prior written consent of the City. Notwithstanding City approval of a subconsultant, the Consultant shall remain obligated for full performance hereunder, and the City shall incur no obligation other than its obligations to the Consultant hereunder. The Consultant agrees that if subconsultants are employed in the performance of this Agreement, the Consultant and its subconsultants are subject to the requirements and sanctions of ORS Chapter 656, Workers' Compensation.

7. Compliance with Applicable Law

Consultant shall comply with all applicable federal, state, and local laws and regulations. Consultant agrees it currently is in compliance with all tax laws. Consultant shall comply with Title VI of the Civil Rights Act of 1964 and its corresponding regulations as further described at: http://www.portlandoregon.gov/bibs/article/446806.

8. Indemnification for Property Damage and Personal Injury

Consultant shall indemnify, defend, and hold harmless the City, its officers, agents, and employees, from all claims, losses, damages, and costs (including reasonable attorney fees) for personal injury and property damage arising out of the intentional or negligent acts or omissions of the Consultant, its Subconsultants, suppliers, employees or agents in the performance of its services. Nothing in this paragraph requires the Consultant or its insurer to indemnify the City for claims of personal injury or property damage caused by the negligence of the City. This duty shall survive the expiration or termination of this contract.

9. Insurance

Consultant shall obtain and maintain in full force at Consultant expense, throughout the duration of the Contract and any warranty or extension periods, the required insurance identified below. The City reserves the right to require additional insurance coverage as required by statutory or legal changes to the maximum liability that may be imposed on Oregon cities during the term of the Contract.

(a) Workers' compensation insurance as required by ORS Chapter 656 and as it may be amended. Unless exempt under ORS Chapter 656, the Consultant and all subconsultants shall maintain coverage for all subject workers.

_X_ Required and attached or ___ Proof of exemption (i.e., completion of Workers' Compensation Insurance Statement)

(b) General commercial liability (CGL) insurance covering bodily injury, personal injury, property damage, including coverage for independent contractor's protection (required if any work will be subcontracted), premises/operations, contractual liability, products and completed operations, in per occurrence limit of not less than $1,000,000, and aggregate limit of not less than $2,000,000.

_X_ Required and attached or ___ waived by Bureau Director or designee

(c) Automobile liability insurance with coverage of not less than $1,000,000 each accident, and an umbrella or excess liability coverage of $2,000,000. The insurance shall include coverage for any auto or all owned, scheduled, hired and non-owned auto. This coverage may be combined with the commercial general liability insurance policy.

_X_ Required and attached or ___ waived by Bureau Director or designee

(d) Professional Liability and/or Errors & Omissions insurance to cover damages caused by negligent acts, errors or omissions related to the professional services, and performance of duties and responsibilities of the Consultant under this contract in an amount with a combined single limit of not less than $1,000,000 per occurrence and aggregate of $3,000,000 for all claims per occurrence. In lieu of an occurrence based policy, Consultant may have claims-made policy in an amount not less than $1,000,000 per claim and $3,000,000 annual aggregate, if the Consultant obtains an extended reporting period or tail coverage for not less than three (3) years following the termination or expiration of the Contract.

_X_ Required and attached or ___ waived by Bureau Director or designee

Continuous Coverage; Notice of Cancellation: The Consultant agrees to maintain continuous, uninterrupted coverage for the duration of the Contract. There shall be no termination, cancellation, material change, potential exhaustion of aggregate limits or non renewal of coverage without thirty (30) days written notice from Consultant to the City. If the insurance is canceled or

terminated prior to completion of the Contract, Consultant shall immediately notify the City and provide a new policy with the same terms. Any failure to comply with this clause shall constitute a material breach of Contract and shall be grounds for immediate termination of this Contract.

Additional Insured: The liability insurance coverages, except Professional Liability, Errors and Omissions, or Workers' Compensation, shall be without prejudice to coverage otherwise existing, and shall name the City of Portland and its bureaus/divisions, officers, agents and employees as Additional Insureds, with respect to the Consultant's activities to be performed, or products or services to be provided. Coverage shall be primary and non-contributory with any other insurance and self-insurance. Notwithstanding the naming of additional insureds, the insurance shall protect each additional insured in the same manner as though a separate policy had been issued to each, but nothing herein shall operate to increase the insurer's liability as set forth elsewhere in the policy beyond the amount or amounts for which the insurer would have been liable if only one person or interest had been named as insured.

Certificate(s) of Insurance: Consultant shall provide proof of insurance through acceptable certificate(s) of insurance, including additional insured endorsement form(s) and all other relevant endorsements, to the City prior to the award of the Contract if required by the procurement documents (e.g., request for proposal), or at execution of Contract and prior to any commencement of work or delivery of goods or services under the Contract. The Certificate(s) will specify all of the parties who are endorsed on the policy as Additional Insureds (or Loss Payees). Insurance coverages required under this Contract shall be obtained from insurance companies acceptable to the City of Portland. The Consultant shall pay for all deductibles and premium. The City reserves the right to require, at any time, complete, certified copies of required insurance policies, including endorsements evidencing the coverage the required.

Subconsultant(s): Consultant shall provide evidence that any subconsultant, if any, performing work or providing goods or service under the Contract has the same types and amounts of coverages as required herein or that the subconsultant is included under Consultant's policy.

10. Ownership of Work Product
All work product produced by the Consultant under this contract is the exclusive property of the City. "Work Product" includes, but is not limited to: research, reports, computer programs, manuals, drawings, recordings, photographs, artwork and any data or information in any form. The Consultant and the City intend that such Work Product shall be deemed "work made for hire" of which the City shall be deemed the author. If for any reason a Work Product is deemed not to be a "work made for hire," the Consultant hereby irrevocably assigns and transfers to the City all right, title and interest in such work product, whether arising from copyright, patent, trademark, trade secret, or any other state or federal intellectual property law or doctrines. Consultant shall obtain such interests and execute all documents necessary to fully vest such rights in the City. Consultant waives all rights relating to work product, including any rights arising under 17 USC 106A, or any other rights of authorship, identification or approval, restriction or limitation on use or subsequent modifications. If the Consultant is an architect, the Work Product is the property of the Consultant-Architect, and by execution of this contract, the Consultant-Architect grants the City an exclusive and irrevocable license to use that Work Product.

Notwithstanding the above, all pre-existing trademarks, services marks, patents, copyrights, trade secrets, and other proprietary rights of Consultant are and will remain the exclusive property of Consultant.

11. EEO Certification
In the event Consultant provides in excess of $2,500.00 for services to the City in any fiscal year, Consultant shall obtain EEO certification from the City.

12. Equal Benefits
Consultant must comply with the City's Equal Benefits program as prescribed by Chapter 3.100 of the Code of the City of Portland. The required documentation must be filed with Procurement Services, City of Portland, prior to contract execution.

13. Successors in Interest
The provisions of this contract shall be binding upon and shall inure to the benefit of the parties hereto, and their respective successors and approved assigns.

14. Severability
The parties agree that if any term or provision of this contract is declared by a court of competent jurisdiction to be illegal or in conflict with any law, the validity of the remaining terms and provisions shall not be affected, and the rights and obligations of the parties shall be construed and enforced as if the contract did not contain the particular term or provision held to be invalid.

15. Waiver
The failure of the City to enforce any provision of this contract shall not constitute a waiver by the City of that or any other provision.

16. Errors
The Consultant shall promptly perform such additional services as may be necessary to correct errors in the services required by this contract without undue delays and without additional cost.

17. Governing Law/Venue
The provisions of this contract shall be interpreted, construed and enforced in accordance with, and governed by, the laws of the State of Oregon without reference to its conflict of laws provisions that might otherwise require the application of the law of any other jurisdiction. Any action or suits involving any question arising under this contract must be brought in the appropriate court in Multnomah County Oregon.

18. Amendments
All changes to this contract, including changes to the scope of work and contract amount, must be made by written amendment and approved by the Chief Procurement Officer to be valid. Any amendment that increases the original contract amount by more than 25% must be approved by the City Council to be valid.

19. Business Tax Registration
The Consultant shall obtain a City of Portland business tax registration number as required by PCC 7.02 prior to beginning work under this Contract.

20. Prohibited Conduct
The Consultant shall not hire any City employee who evaluated the proposals or authorized the award of this Contract for two years after the date the contract was authorized without the express written permission of the City and provided the hiring is permitted by state law.

21. Payment to Vendors and Subconsultants
The Consultant shall timely pay all subconsultants and suppliers providing services or goods for this Contract.

22. Access to Records
The Consultant shall maintain all records relating to this Contract for three (3) years after final payment. The City may examine, audit and copy the Consultant's books, documents, papers, and records relating to this contract at any time during this period upon reasonable notice. Copies of these records shall be made available upon request. Payment for the reasonable cost of requested copies shall be made by the City.

23. Audits
(a) The City may conduct financial and performance audits of the billings and services specified in this agreement at any time in the course of the agreement and during the three (3) year period established by paragraph 22. Audits will be conducted in accordance with generally accepted auditing standards as promulgated in Government Auditing Standards by the Comptroller General of the United States Government Accountability Office.
(b) If an audit discloses that payments to the Consultant exceed the amount to which the Consultant was entitled, the Consultant shall repay the amount of the excess to the City.

24. Electronic Signatures
The City and Consultant may conduct this transaction, including any contract amendments, by electronic means, including the use of electronic signatures.

25. Merger Clause
This Contract encompasses the entire agreement of the parties, and supersedes all previous understandings and agreements between the parties, whether verbal or written.

26. Dispute Resolution/Work regardless of disputes
The parties shall participate in mediation to resolve disputes before conducting litigation. The mediation shall occur at a reasonable time after the conclusion of the Contract with a mediator jointly selected by the parties. Notwithstanding any dispute under this Contract, the Consultant shall continue to perform its work pending resolution of a dispute, and the City shall make payments as required by the Contract for undisputed portions of the work. In the event of litigation no attorney fees are recoverable. No different dispute resolution paragraph(s) in this contract or any attachment hereto shall supersede or take precedence over this provision.

27. Progress Reports: /_X_/ Applicable /___/ Not Applicable
If applicable, the Consultant shall provide monthly progress reports to the Project Manager as described in the Statement of the Work and Payment Schedule.

28. Consultant's Personnel: /_X_/ Applicable /___/ Not Applicable
If applicable, the Consultant shall assign the personnel listed in the Statement of the Work and Payment Schedule for the work required by the Contract and shall not change personnel without the prior written consent of the City, which shall not be unreasonably withheld.

29. Subconsultants
The Consultant shall use the subconsultants identified in its proposals. The Consultant shall not change subconsultant assignments without the prior written consent of the Chief Procurement Officer. The City will enforce all social equity contracting and Minority, Women and Emerging Small Business (M/W/ESB) subcontracting commitments submitted by the

Consultant in its proposals. Failure to use the identified M/W/ESB subconsultants without prior written consent is a material breach of contract.
For contracts valued $50,000 or more, the Consultant shall submit a Monthly Subconsultant Payment and Utilization Report (MUR), made part of this contract by reference, reporting ALL subconsultants employed in the performance of this agreement. An electronic copy of the MUR may be obtained at: http://www.portlandoregon.gov/bibs/45475.

30. Third Party Beneficiaries
There are no third party beneficiaries to this contract. Enforcement of this contract is reserved to the parties.

STATEMENT OF THE WORK AND PAYMENT SCHEDULE

PROJECT GOALS

The current water quality and lead corrosion study is designed to meet the following goals and objectives:

1. Document existing baseline distribution system water quality as it relates to lead release.
2. Identify data gaps and additional distribution system sampling required to better understand the role of pH, alkalinity, nitrification, groundwater operations, the open reservoirs, and other water quality parameters on lead release.
3. Identify causes of lead release in the distribution system and whether the causes are uniform or localized.
4. Assess the location, extent, and impact of nitrification on lead release in the distribution system.
5. Assess the impact of the open reservoirs on water quality and lead release in the distribution system.

For the purposes of this study, the words "distribution system" refers to both the City of Portland Water Bureau (PWB) and its wholesale customers' distribution systems.

PROJECT PHASING

The project shall be structured in two phases:

1. Base Tasks.
2. Mitigation Services. **Mitigation Services, described in further detail in Task 800 below, shall only be performed upon execution of a signed amendment to this Contract which clearly identifies the statement of work, schedule, and budget for said services.**

TASKS TO BE COMPLETED

This statement of work describes the base tasks, Phase 1. Optional tasks, if authorized by the PWB Project Manager (PM), shall be performed as described under Task 800 – Mitigation Services, which is Phase 2.

TASK 100 – Project Management

Task 101: Management

The Consultant shall perform the following services:
Provide overall management for the project. Prepare budget, schedule, and quality assurance and quality control plan. Review ongoing activities. Monitor schedule and budget. Manage technical resources, including work performed by subcontractors and outside laboratories. Prepare monthly invoices, including a status report covering work completed during the current billing period and work anticipated for the upcoming period. Review progress with PWB on a regular basis.

Task 102: Project Kickoff Meeting

The Consultant shall perform the following services:
Conduct a project initiation meeting with PWB PM; discuss pertinent available data, review project staffing (including selection of up to two additional Technical Advisory Committee (TAC) members) and organization, present initial work plan and initial work schedule. Once selected, the TAC members will be added to this contract via a written amendment.

Task 103: Monthly Progress Meetings

The Consultant shall perform the following services:
Conduct monthly review meetings with PWB PM to discuss current project status and to solicit input from PWB staff regarding current work activities. One person from the Prime Consultant Staff shall attend the meetings in person, others shall call in as required. Provide the PWB PM with written summaries of each meeting.

Consultant Deliverables for Task 100 – Project Management:

- Monthly invoice and status report.
- Quality Assurance / Quality Control plan.
- Project Schedule.
- Monthly Meeting Notes. Notes shall be provided to the PWB PM within 10 business days. Business days are defined as Monday – Friday, 8:00 am -5:00 pm.

Work Performed by PWB for Task 100 – Project Management:

- Review monthly invoice and status report.
- Participate in monthly progress meetings.
- Review and comment on meeting notes. The PWB PM shall provide comments to the Consultant within five business days.

TASK 200 – Existing Information Review

Task 201: Data Request

The Consultant shall perform the following services:
Prepare water quality data request, including for wholesale customers. Data and reports shall be available electronically in Microsoft (MS) Excel format for evaluation and processing.

Task 202: Data Review

The Consultant shall perform the following services:
Review available water quality data. Specifically, the following shall be reviewed:

- Relevant historical distribution system water quality data;
- Lead profiling data from customer homes;
- All available nitrification data;
- Past corrosion control studies, reports, memorandums;
- Maps and other information indicating distribution system materials, components and operations if available. It is anticipated that gathering this information shall involve up to 8 hours of in-person meetings with PWB Operations staff to gain a better understanding of the distribution system layout and operations;
- Water quality data related to the open reservoirs; and,
- The components of the lead hazard reduction program.

Consultant Deliverables for Task 200 – Existing Information Review:

- Water quality data request specifying the data needed from the PWB PM.

Work Performed by PWB for Task 200 – Existing Information Review:

- Provide all requested water quality data in MS Excel format; and,
- Contact wholesale customers and obtain requested water quality data.

TASK 300 – Pipe Loop Evaluation

Task 301: Evaluation of Existing PWB Pipe Loops

The Consultant shall perform the following services:
PWB has two copper pipe loops and up to five brass blocks located in the distribution system. Their suitability for use in this study shall be evaluated. The evaluation shall consider at a minimum the pipe loop design, materials of construction, physical condition, and available water quality data.

Task 302: Evaluation of Other Available Pipe Loops

The Consultant shall perform the following services:
The Process Research Solutions (PRS) Monitoring Stations shall be evaluated for their suitability for this study. A literature search shall be conducted to determine if additional pipe loops are available which would be suitable for use in this study.

Work Performed by PWB for Task 300 – Pipe Loop Evaluation:

- Complete recommended modifications to PWB's existing pipe loops or brass blocks.
- Purchase and install additional pipe loops or monitoring stations as recommended by the Consultant.

TASK 400 – Technical Memorandum #1

Task 401: Prepare Technical Memorandum #1

The Consultant shall perform the following services:
Prepare a draft technical memorandum summarizing at a minimum the following information:

- The relevant historical and distribution system information and water quality data;
- The findings of the pipe loop evaluation; and,
- A preliminary set of conclusions and observations based upon existing information.

The Technical Memorandum shall be reviewed by the TAC members and by the PWB. Comments shall be incorporated and a final Technical Memorandum shall be prepared by the Consultant. This technical memorandum shall serve as the basis for development of the Distribution System Sampling Plan. Five hard copies and one electronic Portable Document Format (.PDF) of the draft and final Technical Memorandum shall be delivered to the PWB PM.

Consultant Deliverables for Task 400 – Technical Memorandum #1:

- Draft and Final Technical Memorandum #1. Technical Memorandum shall be delivered to PWB PM per schedule attached as Exhibit B.

Work Performed by PWB for Task 400 – Technical Memorandum #1:

- Provide one set of reconciled review comments on Technical Memorandum #1.

TASK 500 – Technical Advisory Committee

Task 501: Assembly and Management of Technical Advisory Committee (TAC)

The Consultant shall perform the following services:
Assemble a TAC panel. The TAC shall consist of a maximum of five individuals. Optional subconsultants for this task are included to this contract. If any TAC members are required that are not included to this contract, they shall be added via a written amendment. At this time, potential added TAC members shall consist of Public Utilities or Universities.

The time and expenses for the review of materials as outlined in Tasks 602, 603, 604, and 703 and attendance at two workshops by TAC members shall be covered under this scope and budget. TAC members shall be reviewed and agreed upon with PWB as an initial task. Once the TAC members are identified, a work order shall be issued listing the TAC members and including a budget detail identifying the work to be performed, the hours to perform the work, the total cost of each of the work tasks, and the overall work tasks. This information shall be provided to the PWB Contract Administration Branch to issue the work order. The final documentation to support the work order shall be e-mailed to Andrew Urdahl at Andrew.urdahl@portlandoregon.gov and the PWB PM at Michelle.Cheek@portlandoregon.gov

The work order shall be substantially in accordance with the sample attached to this contract as Exhibit C. Any changes must be agreed to by the Consultant and the City in writing as an amendment to the work order. Work orders require each party's approval in writing to proceed. PWB's approving authority is the Engineering Services Group Director.

Work Performed by PWB for Task 500 – Technical Advisory Committee:

- Provide input and make final decision on TAC members.

TASK 600 – Distribution System Sampling Plan

Task 601: Definition of Objectives

The Consultant shall perform the following services:
Define objectives of sampling plan. Develop an outline of the sampling plan to be discussed at Workshop #1.

TASK 602: Workshop #1

The Consultant shall perform the following services:
Organize and conduct a full-day workshop at PWB facilities in Portland, OR to discuss the historical information and the Distribution System Sampling Plan. The goal of the workshop is to develop the framework required to finalize preparation of the Distribution System Sampling Plan. The TAC members, as well as key Consultant and PWB project team members, will be present in person. Others may phone in as necessary. A written log of decision and action items shall be provided to the PWB PM by the Consultant within ten business days after the conclusion of the workshop.

TASK 603: Technical Memorandum #2

The Consultant shall perform the following services:
Prepare a draft Technical Memorandum which defines the Distribution System Sampling Plan and summarizes the information developed from Workshop #1. The Technical Memorandum shall be reviewed by the TAC members and by the PWB PM. Comments provided by the PWB and TAC shall be incorporated by the Consultant and a final Technical Memorandum shall be prepared. Five hard copies and one electronic .PDF of the draft and final Technical Memorandum shall be delivered to the PWB PM. The Technical Memorandum shall be due and provided to the PWB PM per the attached Exhibit B, Project Schedule.

TASK 604: Sample and Data Analysis

The Consultant shall perform the following services:
Data collected by PWB (as recommended in the Distribution System Sampling Plan) shall be provided electronically to the Consultant. A 12-month sampling effort has been budgeted in the Contract. Data shall be reviewed, evaluated, and presented to PWB on a monthly basis at the monthly progress meetings. Quarterly progress reports shall be prepared and submitted to the TAC. The TAC shall provide review and analysis of the quarterly data and progress report, recommend changes to the sampling plan or execution of the sampling plan if needed, and summarize their observations, review, and analysis in written form to the Consultant on a quarterly basis. TAC comments shall be compiled by the Consultant, submitted to the PWB PM and reviewed with PWB at a monthly progress meeting. Monthly and quarterly data reports shall be presented in electronic format.

There will be identified sample analyses conducted by the PWB laboratory. The specialized sample analysis that shall be conducted and the responsibility of the Consultant have been identified on Exhibit A, Budget Detail as "Specialized Laboratory" services.

Consultant Deliverables for Task 600 – Distribution System Sampling Plan:

- Meeting notes from Workshop #1 including log of decision and action items;
- Draft and Final Technical Memorandum #2;
- Monthly and quarterly data reports in MS Excel format; and,
- TAC comments on quarterly progress reports.

All deliverables shall be due and provided to the PWB PM per the attached Exhibit B, Project Schedule.

Work Performed by PWB for Task 600 – Distribution System Sampling Plan:

- Participate in Workshop #1;
- Provide one set of reconciled review comments on Technical Memorandum #2;
- Conduct recommended water quality sampling with direction and training provided by the Consultant;
- Perform recommended laboratory analyses at PWB Water Quality lab with the exception of specialized laboratory analyses identified in Task 604; and,
- Provide collected water quality data in MS Excel format.

TASK 700 – Water Quality Summary Report

Task 701: Data Analysis and System Investigation

The Consultant shall perform the following services:
Evaluate trends in the data to identify problem areas and specific water quality concerns. Review associations between water quality and distribution system components and layout.

Task 702: Preparation of Water Quality Summary Report

The Consultant shall perform the following services:
A draft Water Quality Summary Report shall be prepared which summarizes the data collected during the 12-month Distribution System Sampling Plan. The report shall include at a minimum:

- Summary of historical water quality data;
- Summary of data collected as part of the Distribution System Sampling Plan; and,
- Conclusions regarding the identification of water quality issues and problem areas that affect lead release in Portland's system. Recommendations for continuation of sampling or initiation of further (optional) tasks.

The Water Quality Summary Report shall be reviewed by the TAC members and by the PWB. Comments shall be incorporated by the Consultant and a final report prepared. Five hard copies and one electronic .PDF of the draft and final Water Quality Summary Report shall be delivered by the Consultant to the PWB in accordance with the schedule attached as Exhibit B, Project Schedule.

TASK 703: Workshop #2

The Consultant shall perform the following services:
Organize and conduct a full-day workshop at PWB facilities in Portland, OR to discuss the Water Quality Summary Report. Discuss recommendations for continuation of sampling or initiation of further tasks. Coordinate on schedule of the workshop with PWB PM. Comments from workshop shall be incorporated into Water Quality Summary Report. The TAC members, as well as key Consultant and PWB project team members, will be present in person. Others may phone in as necessary. A written log of decision and action items shall be provided to the PWB PM by the Consultant within ten business days after the conclusion of the workshop.

Consultant Deliverables for Task 700 – Water Quality Summary Report:

- Meeting notes from Workshop #2 including log of decision and action items; and,
- Draft and Final Water Quality Summary Report.

All deliverables shall be provided to the PWB PM per the attached Exhibit B, Project Schedule.

Work Performed by PWB for Task 700 – Water Quality Summary Report:

- Schedule PWB personnel and facility for Workshop #2;
- Participate in Workshop #2; and,
- Provide one set of reconciled review comments on the Water Quality Summary Report.

TASK 800 – Mitigation Services - OPTIONAL

Identified mitigation services and/or funds shall only be performed by the Consultant under the direction of the PWB Project Manager and via written amendment to the Contract approved by both parties. Authorization to complete any of the mitigation services work tasks shall be issued via an amendment to the Contract. At the time that the work task is issued the Consultant shall provide the PWB Project Manager with a budget detail identifying the work to be performed, the hours to perform the work along with the total cost of each of the work tasks and the overall work tasks. This information shall be provided to the Contract Administration Branch to implement an amendment. The amendment will include revised Budget Details, attached to this contract as Exhibit A, that reflect the distribution of Task 800 funds. The final documentation to support the amendment shall be e-mailed to Andrew Urdahl at Andrew.urdahl@portlandoregon.gov and the PWB PM at Michelle.Cheek@portlandoregon.gov
As directed by the PWB PM the Consultant shall perform additional services and work tasks that are identified during the course of the project, including but not limited to, a similar system review, operational and/or treatment evaluations, bench scale studies, pilot scale studies, or any unanticipated tasks that may arise as the project progresses. This work shall be completed after receiving a written amendment to the contract.

All work shall be performed and deliverables received in accordance with the schedule attached to this Contract as Exhibit B, Project Schedule unless otherwise directed in writing by the PWB PM.

All deliverables shall be in a Microsoft Office compatible format unless otherwise noted or directed in writing by the PWB PM.

CONSULTANT PERSONNEL

The Consultant shall assign the following personnel to do the work in the capacities designated:

NAME	ROLE ON PROJECT
Dave Carlson	Project Director
Pat Van Duser	Project Manager
Cathy DiPietro	Quality Control
Sunny Wang	Technical Lead
Jamie DuBois	Staff Engineer
Theresa Jones	Administrative Support

SUBCONSULTANTS

The Consultant shall assign the following subconsultants to perform work in the capacities designated:

NAME	ROLE ON PROJECT	SUBCONTRACT AMOUNT
Montana State University	Distribution System / Water Quality	$10,712
Process Research Solutions, LLC	Corrosion Control Monitoring Programs	$25,235
Andrew Jacque	Specialty Laboratory	$7,725
Barry Maynard	Specialty Laboratory	$7,725
San Francisco Public Utilities Commission; New York City Department of Environmental Protection; Washington University in St. Louis	Technical Advisory Committee	$37,492 to be distributed among the three listed subconsultants via Work Order.

The City will enforce all social equity contracting and Minority, Women and Emerging Small Business (M/W/ESB) subcontracting commitments submitted by the Consultant in its Proposal. For contracts valued $50,000 or more, the Consultant shall submit a Monthly Subconsultant Payment and Utilization Report (MUR), made part of this contract by reference, reporting ALL subconsultants employed in the performance of this agreement. An electronic copy of the MUR may be obtained at: http://www.portlandoregon.gov/bibs/45475.

COMPENSATION

The maximum that the Contractor shall be paid on this contract is **$240,000** (hereafter the "not to exceed" amount.) as described in the attached Exhibit A – Budget Detail. The "not to exceed" amount includes all payments to be made pursuant to this contract, including reimbursable expenses, if any. Nothing in this contract requires the City to pay for work that does not meet the Standard of Care or other requirements of the Contract. The actual amount to be paid Contractor may be less than that amount.

The City shall pay Consultant based on submitted invoices for acceptable work performed and approved until the "not to exceed" amount is reached thereafter, Consultant must complete work based on the Contract without additional compensation.

Any estimate of the hours necessary to perform the work is not binding on the City. The Contractor remains responsible if the estimate proves to be incorrect. Exceeding the number of estimated hours of work does not impose any liability on the City for additional payment.

If work is completed before the "not to exceed" amount is reached, the Contractor's compensation shall be based on the Contractor's bills previously submitted for acceptable work performed and approved.

PAYMENT TERMS: Net 30 Days

Hourly Rates

The billing rates shall not exceed those set forth below:

Prime Consultant Staff:
Project Director: $309 / hour
Project Manager: $185 / hour
Technical Lead: $149 / hour
Quality Control: $165 / hour
Staff Engineer: $113 / hour
Administrative Support: $85 / hour

Subconsultants:
Montana State University: $210 / hour
Process Research Solutions, LLC: $131.25 / hour
Andrew Jacque: Price per sample – estimate to be $1,545 per sample
Barry Maynard: Price per sample – estimate to be $1,545 per sample

Compensation for subconsultants shall be limited to the same restrictions imposed on the Contractor. The maximum markup on subconsultant services shall not exceed 5% for the total term of the Contract.

Billing rates shall remain constant throughout the duration of this Contract.

Hourly Rate Multiplier

Direct labor shall be charged as staff salary times a multiplier, using a multiplier no greater than 3.1. This multiplier shall include profit and overhead expenses, including but not limited to: employee benefits, bonuses, autos and other perquisites; parking fees; local delivery/courier services and postage, telecommunications and facsimile services; licensing fees; business and other taxes; general business and professional liability insurance; accounting and advertising costs; leasing of office space; leased or owned office and information technology equipment (including use of computers, CAD workstations, plotters, printers, and related equipment); travel costs within a 100-mile radius of Portland; and all other direct costs not identified below as reimbursable.

Reimbursable Costs

All allowable reimbursable direct costs, with the exception of subconsultant costs, shall be billed with no mark-up. Reimbursable direct costs include pre-approved travel beyond a 100-mile radius of Portland, document reproduction costs requiring outsourcing (for example, printing of drawings and specifications), and the purchase, rental or leasing of specialized field equipment and the cost of disposable field equipment. All reimbursable costs shall be subject to prior authorization and approval by the City.

Travel Costs

Any travel must comply with all the requirements set forth in this section and must be for official City business only. Personal expenses shall not be authorized at any time. Travel expenses shall be reimbursed for airfare and rental vehicles only if the Consultant is acting within the course and scope of his/her duties under this contract. Receipts shall be required for all travel expenses. The Consultant and any subconsultants shall fly "coach class," unless the Consultant personally pays the difference. The Consultant and any subconsultants shall be limited to economy or compact size rental vehicles, unless the Consultant personally pays the difference. Any Travel (transportation, lodging and per diem), for the Consultant as requested by PWB to a location outside a 100 mile radius of the Consultant's Project office shall be reimbursed. The approved mileage rate follows the current United States General Services Administration (GSA) federal rate. Meal per diem is based on the GSA per diem rates. Per Diem Rates for Oregon may be found at the GSA website. That website address is: http://www.gsa.gov/perdiem. All travel must be pre-authorized by the City's PM in writing prior to conducting that travel.

Progress Payments

On or before the 15th of each month, the Consultant shall submit to the **Water Bureau's Accounts Payable department** an invoice for work performed by the Consultant during the preceding month. The invoice shall contain the City's Contract Number, City of Portland Bureau Name, City Project Manager and set out all items for payment including, but not limited to: Task number/subtask completed, the name of the individual, labor category, direct labor rate, hours worked during the period, deliverable/worked performed, the percentage of work successfully completed for the task, and the percentage of work still required with remaining dollars available. The Consultant shall also attach photocopies of claimed reimbursable expenses. The Consultant shall stamp and approve all subconsultant invoices and note on the subconsultant invoice what they are approving as "billable" under the contract. The billing from the Consultant must clearly roll up labor and reimbursable costs for the Consultant and subconsultants– matching the subconsultant invoices.

Invoices shall be e-mailed to: wbaps@portlandoregon.gov.

The City shall pay all amounts to which no dispute exists within 30 days of receipt of the invoice. Payment of any bill, however, does not preclude the City from later determining that an error in payment was made and from withholding the disputed sum from the next progress payment until the dispute is resolved.

The Consultant shall make full payment to its subcontractors within 10 business days following receipt of any payment made by the Bureau to Consultant.

ACH Payments

It is the City's policy to pay its Consultant invoices via electronic funds transfers through the automated clearing house (ACH) network. To initiate payment of invoices, Consultants shall execute the City's standard ACH Vendor Payment Authorization Agreement which is available on the City's website at http://www.portlandoregon.gov/bfs/article/409834?.

Upon verification of the data provided, the Payment Authorization Agreement will authorize the City to deposit payment for services rendered directly into Consultant accounts with financial institutions. All payments shall be in United States currency.

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WORKERS' COMPENSATION INSURANCE STATEMENT

IF YOUR FIRM HAS CURRENT WORKERS' COMPENSATION INSURANCE, CONTRACTOR MUST SIGN HERE:

I, undersigned, am authorized to act on behalf of entity designated below, and I hereby certify that this entity has current Workers' Compensation Insurance.

Contractor Signature: _____ Date: 2-13-19 Entity: Black Wood Carpentry

IF YOUR FIRM DOES NOT HAVE CURRENT WORKERS' COMPENSATION INSURANCE, CONTRACTOR MUST COMPLETE THE FOLLOWING INDEPENDENT CONTRACTOR CERTIFICATION STATEMENT:

As an independent contractor, I certify that I meet the following standards:

1. The individual or business entity providing labor or services is registered under ORS Chapter 701, if the individual or business entity provides labor or services for which such registration is required;

2. Federal and state income tax returns in the name of the business or a business Schedule C or form Schedule F as part of the personal income tax return were filed for the previous year if the individual or business entity performed labor or services as an independent contractor in the previous year; and

3. The individual or business entity represents to the public that the labor or services are to be provided by an independently established business. Except when an individual or business entity files a Schedule F as part of the personal income tax returns and the individual or business entity performs farm labor or services that are reportable on Schedule C, an individual or business entity is considered to be engaged in an independently established business when four or more of the following circumstances exist.
Contractor: check four or more of the following:

_____ A. The labor or services are primarily carried out at a location that is separate from the residence of an individual who performs the labor or services, or are primarily carried out in a specific portion of the residence, which portion is set aside as the location of the business;

_____ B. Commercial advertising or business cards as is customary in operating similar businesses are purchased for the business, or the individual or business entity has a trade association membership;

_____ C. Telephone listing and service are used for the business that is separate from the personal residence listing and service used by an individual who performs the labor or services;

_____ D. Labor or services are performed only pursuant to written contracts;

_____ E. Labor or services are performed for two or more different persons within a period of one year; or

_____ F. The individual or business entity assumes financial responsibility for defective workmanship or for service not provided as evidenced by the ownership of performance bonds, warranties, errors and omission insurance or liability insurance relating to the labor or services to be provided.

_____ _____
Contractor Signature Date

FOR CITY USE ONLY

PROJECT MANANGER-COMPLETE ONLY IF CONTRACTOR DOES NOT HAVE WORKER'S COMPENSATION INSURANCE
ORS 670.600 Independent contractor standards. As used in various provisions of ORS Chapters 316, 656, 657, and 701, an individual or business entity that performs labor or services for remuneration shall be considered to perform the labor or services as an "independent contractor" if the standards of this section are met. The contracted work meets the following standards:

1. The individual or business entity providing the labor or services is free from direction and control over the means and manner of providing the labor or services, subject only to the right of the person for whom the labor or services are provided to specify the desired results;

2. The individual or business entity providing labor or services is responsible for obtaining all assumed business registrations or professional occupation licenses required by state law or local government ordinances for the individual or business entity to conduct the business;

3. The individual or business entity providing labor or services furnishes the tools or equipment necessary for performance of the contracted labor or services;

4. The individual or business entity providing labor or services has the authority to hire and fire employees to perform the labor or services;

5. Payment for the labor or services is made upon completion of the performance of specific portions of the project or is made on the basis of an annual or periodic retainer.

_____ _____
City Project Manager Signature Date

CONSULTANT SIGNATURE:

This contract may be signed in two (2) or more counterparts, each of which shall be deemed an original, and which, when taken together, shall constitute one and the same Agreement.

The parties agree the City and Consultant may conduct this transaction, including any contract amendments, by electronic means, including the use of electronic signatures.

I, the undersigned, agree to perform work outlined in this contract in accordance to the STANDARD CONTRACT PROVISIONS, the terms and conditions, made part of this contract by reference, and the STATEMENT OF THE WORK made part of this contract by reference; hereby certify under penalty of perjury that I/my business am not/is not in violation of any Oregon tax laws; hereby certify that my business is certified as an Equal Employment Opportunity Affirmative Action Employer and is in compliance with the Equal Benefits Program as prescribed by Chapter 3.100 of Code of the City of Portland; and hereby certify I am an independent contractor as defined in ORS 670.600.

Black & Veatch Corporation

BY: _____ Date: 2-13-19

Name: David J. Carlson

Title: Vice President

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CONTRACT NUMBER: 30003222

CONTRACT TITLE: Water Quality Corrosion Study

CITY OF PORTLAND SIGNATURES:

By: _____ Date: _____
Bureau Director

By: _____ Date: _____
Chief Procurement Officer

By: _____ Date: _____
Elected Official

Approved:

By: _____ Date: _____
Office of City Auditor

Approved as to Form: APPROVED AS TO FORM

By: _____ Date: 2/18/14
Office of City Attorney

CITY ATTORNEY

Contract 30003222
Exhibit A - Budget Detail

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Black & Veatch
Portland Water Bureau - Water Quality and Corrosion Study
Scope and Fee Summary

TASK DESCRIPTION	BLACK & VEATCH KEY TEAM MEMBER / GROUP LABOUR HOURS									SUBCONSULTANTS						TOTAL CONTRACT COSTS
	Dave Carlson Project Director	Pat Van Duser Project Manager	Sunny Wang Technical Lead	Cathy DiPietro Quality Control	Jamie DuBois Staff Engineer	Theresa Jones Admin Support	Total B&V Labor Hours	Total B&V Labor Costs	Expenses As Incurred	Montana State University Anne Camper Specialist	Process Research Solutions Abigail Cantor Specialist	TAC Panel	Dr. Andrew Jacque Specialized Laboratory	Dr. Barry Maynard Specialized Laboratory	Subconsultant markup	
Rate	309	185	149	165	113	85									5%	
Base Services - Task A through Task F																
100 Project Management	10	64	48	0	0	34	156	$24,972	$300	$ -	$ -	$ -		$ -	$ -	$25,272
101 Management / Invoicing	10	36				32	78	$12,470	$100						$ -	$12,570
102 Project Kickoff Meeting		4	8			2	14	$2,102	$100						$ -	$2,202
103 Monthly Progress Meetings		24	40				64	$10,400	$100						$ -	$10,500
200 Existing Information Review	0	0	108	4	16	2	130	$18,730	$200	$ 1,236	$ 1,287	$ -		$ -	$ 126	$21,579
201 Data Request			12	2		2	16	$2,288	$100	$ 412	$ 257				$ 33	$3,090
202 Data Review			96	2	16		114	$16,442	$100	$ 824	$ 1,030				$ 93	$18,489
300 Pipe Loop Evaluation	0	0	24	4	0	0	28	$4,236	$200	$ -	$ 5,150	$ -		$ -	$ 258	$9,844
301 Evaluation Existing PWB Pipe Loops			16	2			18	$2,714	$100	$ -	$ 2,060	$ -			$ 103	$4,977
302 Evaluation of Other Available Pipe Loops			8	2			10	$1,522	$100	$ -	$ 3,090	$ -			$ 155	$4,867
400 TM 1 - Summary of Tasks 200, 300, and 400	0	2	80	8	16	8	114	$16,098	$250	$ 824	$ 5,150	$ -		$ -	$ 299	$22,621
401 Preparation of TM 1		2	80	8	16	8	114	$16,098	$250	$ 824	$ 5,150				$ 299	$22,621
500 Technical Advisory Committee	0	2	8	0	0	4	14	$1,902	$100	$ -	$ -	$ 37,492		$ -	$ 1,875	$41,369
501 Assembly and Management of TAC		2	8			4	14	$1,902	$100			$ 37,492			$ 1,875	$41,369
600 Distribution System Sampling Plan	0	10	144	22	32	12	220	$31,572	$1,500	$ 4,738	$ 5,408	$ -	$ 7,725	$ 7,725	$ 1,280	$59,948
601 Definition of objectives			16	2			18	$2,714		$ 618	$ 515	$ -			$ 57	$3,904
602 Workshop #1		8	8	8	8	4	36	$5,236	$1,250	$ 1,648	$ 1,030				$ 134	$9,298
603 **Technical Memorandum #2**		2	40	8	8	8	66	$9,234	$250	$ 1,236	$ 2,575				$ 191	$13,486
604 Sample and Data Analysis			80	4	16		100	$14,388		$ 1,236	$ 1,288		$ 7,725	$ 7,725	$ 899	$33,261
700 Water Quality Summary Report	0	8	128	8	40	12	196	$27,412	$600	$ 3,914	$ 8,240	$ -		$ -	$ 608	$40,774
701 Data Analysis and System Investigation			24		8		32	$4,480	$100	$ 1,236	$ 2,575	$ -			$ 191	$8,582
702 Preparation of water quality summary report			96	8	24	8	136	$19,016	$250	$ 1,030	$ 4,635				$ 283	$25,214
703 **Workshop 2 - WQ Summary & Next Steps**		8	8		8	4	28	$3,916	$250	$ 1,648	$ 1,030				$ 134	$6,978
800 Mitigation Services	0	0	0	0	0	0	0	$0	$0	$ -	$ -	$ -		$ -	$ -	[illegible]
Grand Total	10	86	540	46	104	72	858	$ 124,922	$ 3,150	$ 10,712	$ 25,235	$ 37,492	$ 7,725	$ 7,725	$ 4,444	$ 240,000

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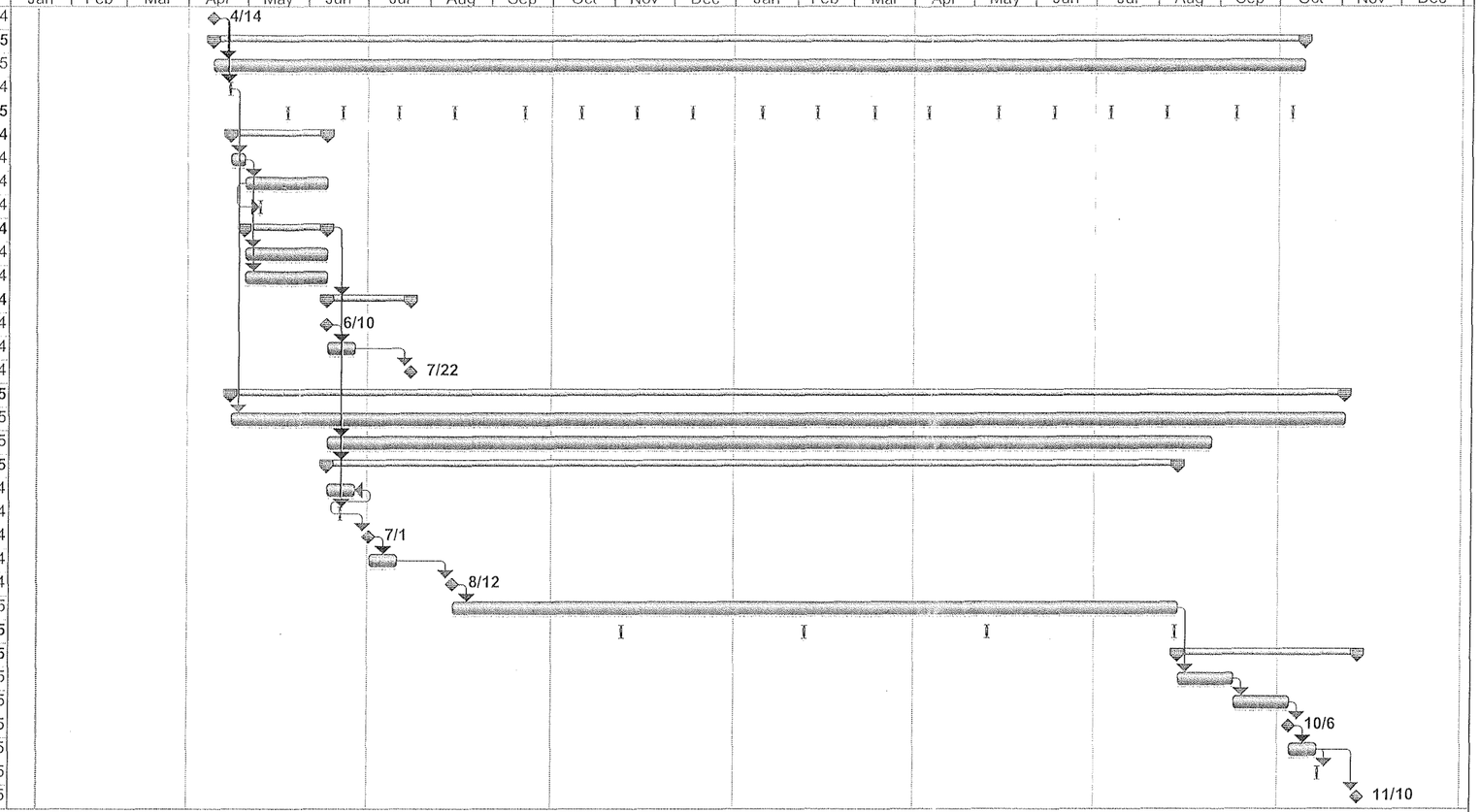
ID	Task Name	Duration	Start	Finish
1	Notice to Proceed	0 days	Mon 4/14/14	Mon 4/14/14
2	**Task 100 - Project Management**	**392 days**	**Mon 4/14/14**	**Tue 10/13/15**
3	Project Management	392 days	Mon 4/14/14	Tue 10/13/15
4	Kickoff Meeting	1 day	Tue 4/22/14	Tue 4/22/14
5	**Monthly Progress Meetings**	**361 days**	**Wed 5/21/14**	**Wed 10/7/15**
24	**Task 200 - Existing Information Review**	**35 days**	**Wed 4/23/14**	**Tue 6/10/14**
25	Data Request	5 days	Wed 4/23/14	Tue 4/29/14
26	Data Review	30 days	Wed 4/30/14	Tue 6/10/14
27	System Operation Review Meeting	1 day	Wed 5/7/14	Wed 5/7/14
28	**Task 300 - Pipe Loop Evaluation**	**30 days**	**Wed 4/30/14**	**Tue 6/10/14**
29	Evaluation of Existing PWB Pipe Loops	30 days	Wed 4/30/14	Tue 6/10/14
30	Evaluation of Other Available Pipe Loops	30 days	Wed 4/30/14	Tue 6/10/14
31	**Task 400 - Technical Memorandum #1**	**30 days**	**Tue 6/10/14**	**Tue 7/22/14**
32	Draft Technical Memorandum #1	0 days	Tue 6/10/14	Tue 6/10/14
33	PWB and TAC Review	10 days	Wed 6/11/14	Tue 6/24/14
34	Final Technical Memorandum #1	0 days	Tue 7/22/14	Tue 7/22/14
35	**Task 500 - Technical Advisory Committee**	**400 days**	**Wed 4/23/14**	**Tue 11/3/15**
36	Assembly and Management of TAC	400 days	Wed 4/23/14	Tue 11/3/15
37	TAC Engaged in Review of Work, Attending Workshops	318 days	Wed 6/11/14	Fri 8/28/15
38	**Task 600 - Distribution System Sampling Plan**	**305 days**	**Wed 6/11/14**	**Tue 8/11/15**
39	Definition of Objectives	10 days	Wed 6/11/14	Tue 6/24/14
40	Workshop #1	1 day	Tue 6/17/14	Tue 6/17/14
41	Draft Technical Memorandum #2	0 days	Tue 7/1/14	Tue 7/1/14
42	PWB and TAC Review	10 days	Wed 7/2/14	Tue 7/15/14
43	Final Technical Memorandum #2	0 days	Tue 8/12/14	Tue 8/12/14
44	Sample and Data Analysis	13 mons	Wed 8/13/14	Tue 8/11/15
45	**Quarterly Reports**	**199 days**	**Wed 11/5/14**	**Mon 8/10/15**
50	**Task 700 - Water Quality Summary Report**	**65 days**	**Wed 8/12/15**	**Tue 11/10/15**
51	Data Analysis and System Investigation	20 days	Wed 8/12/15	Tue 9/8/15
52	Preparation of Draft Water Quality Summary Report	20 days	Wed 9/9/15	Tue 10/6/15
53	Draft Water Quality Summary Report	0 days	Tue 10/6/15	Tue 10/6/15
54	PWB and TAC Review	10 days	Wed 10/7/15	Tue 10/20/15
55	Workshop #2	1 day	Wed 10/21/15	Wed 10/21/15
56	Final Water Quality Summary Report	0 days	Tue 11/10/15	Tue 11/10/15



Project: PWB Water Quality Schedule.
Date: Wed 1/15/14

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Contract 30003222
Exhibit C
Sample Work Order

186513

AGREEMENT FOR PROFESSIONAL, TECHNICAL OR EXPERT SERVICES
WORK ORDER # (insert work order number)
Contract (insert contract number)

The Contract between the City of Portland Water Bureau (PWB) and (insert Consultant name) provides for assistance of the undersigned firm on (insert project type) projects.

This Work Order shall require the Consultant to perform (insert type of work) as directed in the Contract. The specific scope of tasks to be performed by Consultant, including schedule and budget, are outlined below.

Scope of Work: The Consultant shall (insert detailed scope of work).

Deliverables: The Consultant shall provide the PWB Project Manager with (insert detailed deliverables).

Schedule: The work described in this Work Order shall be completed no later than MM/DD/YYYY, absent any unanticipated issues.

Budget: The maximum compensation relating to these services shall not exceed $XXX and as referenced in Exhibit XX Budget Detail, attached to this Work Order. Unless authorized by a written Amendment to the Work Order no additions or changes shall be made to this Work Order. The hourly rates shall be as indicated in the Contract. The Water Bureau's Engineering Services Group Director shall approve all Work Orders and Work Order amendments when amending the Work Order to increase compensation is greater than 25% of the original Work Order amount.

The hourly rates for this work order shall be as directed in the Contract.

All provisions of the Contract shall remain in full force and effect.

In witness hereof, the parties have duly executed this Work Order as of the date written below.

Consultant:

By: _____ Date:

City of Portland:

By: _____ Date:

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Drinking Water Requirements for States and Public Water Systems

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Lead and Copper Rule

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Rule Summary

Highlights

- Memo regarding sample sites and triennial monitoring
- EPA sends response to LCR Implementation Letters from the States
- Tap Sampling Procedures Memo
- Optimal Corrosion Control Treatment Document

Lead and copper enter drinking water primarily through plumbing materials. Exposure to lead and copper may cause health problems ranging from stomach distress to brain damage.

In 1991, EPA published a regulation to control lead and copper in drinking water. This regulation is known as the Lead and Copper Rule (also referred to as the LCR). Since 1991 the LCR has undergone various revisions, see the Rule History section below.

The treatment technique for the rule requires systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb or copper concentrations exceed an action level of 1.3 ppm

in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Relevant Information

- Learn About Lead
- Protect Your Family
- Lead Information for Consumers
- Lead Outreach, Partnerships and Grants

If the action level for lead is exceeded, the system must also inform the public about steps they should take to protect their health and may have to replace lead service lines under their control.

While the LCR rule applies to water utilities, the Reduction of Lead in Drinking Water Act sets standards for:

- pipe,
- plumbing fittings,
- fixtures,
- solder
- and flux

Everyone can take part in the reduction of lead and copper in drinking water. View Actions You Can Take To Reduce Lead in Drinking Water(PDF) (4 pp, 567 K, About PDF) EPA 810-F-93-001

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Rule History

The Lead and Copper Rule can be found in the Code of Federal Regulations.

- 40 CFR Part 141 Subpart I

Long Term Revisions

EPA is considering Long-Term Revisions to the Lead and Copper Rule to improve public health protection by making substantive changes and to streamline the rule requirements.

- Lead and Copper Rule Long-Term Revisions

Short Term Revisions

In 2007, EPA revised the Lead and Copper Rule to enhance implementation in the areas of monitoring, treatment, customer awareness, and lead service line replacement. The update also enhanced public

education requirements and ensured drinking water consumers receive is: meaningful, timely and useful information. These changes are also known as the "Short-Term Revisions to the Lead and Copper Rule."

- Federal Register Notice - Final Rule, October 10, 2007 (PDF) (39 pp, 340 K, About PDF)
  - 2007 Fact Sheet: Revisions to Regulations Controlling Lead in Drinking Water (PDF) (4 pp, 175 K, About PDF) EPA 815-F-07-003
  - Economic and Supporting Analyses: Short-Term Regulatory Changes to the Lead and Copper Rule (PDF) (191 pp, 556 K, About PDF) EPA 815-R-07-022, September 2007

Minor Revisions

In 2004, EPA published minor corrections to the LCR to reinstate text that was inadvertently dropped from the rule during previous revisions.

- June 29, 2004 - National Primary Drinking Water Regulations: Minor Corrections and Clarification to Drinking Water Regulations; National Primary Drinking Water Regulations for Lead and Copper (PDF) (10 pp, 202 K, About PDF).

In 2000, EPA published revisions to the LCR to address implementation issues arising from legal challenges to the 1991 rule. The revisions also streamlined and reduced monitoring and reporting burden.

- Federal Register Notice of Final Rule, January 12, 2000(PDF) (66 pp, 497 K, About PDF)
- Lead and Copper Rule Minor Revisions: Fact Sheet (PDF) (3 pp, 31 K, About PDF) EPA 815-F-99-010, December 1999
- 1998 Notice of Data Availability on the minor revisions to the Lead and Copper Rule
- Fact Sheets supporting the 2000 revisions
  - LCR Minor Revisions Fact Sheet for Public Water Systems that Serve more than 50,000 Persons (PDF) (10 pp, 450 K, About PDF) EPA 816-F-00-009, February 2001
  - LCR Minor Revisions Fact Sheet for Public Water Systems that serve 3301-50000 Persons (PDF) (9 pp, 528 K, About PDF) EPA 816-F-00-008, February 2001
  - LCR Minor Revisions Fact Sheet for Public Water Systems that serve 3300 or fewer Persons (PDF) (10 pp, 839 K, About PDF) EPA 816-F-00-007, March 2000
  - LCR Minor Revisions Fact Sheet for Tribal Water System Owners and Operators (PDF) (9 pp, 355 K, About PDF) EPA 816-F-00-010, February 2001
- Using DWSRF Set-Aside Funds for Capacity Development (PDF) (2 pp, 27 K, About PDF) EPA 816-F-00-11, March 2000

The 1991 Rule

In 1991, EPA published the LCR to minimize lead and copper in drinking water. The rule replaced the previous standard of 50 ppb, measured at the entry point to the distribution system.

The rule established a maximum contaminant level goal (MCLG) of zero for lead in drinking water and a treatment technique to reduce corrosion of lead and copper within the distribution system.

Lead and Copper Rule Historical Documents

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Additional Resources

Quick Reference Guides

These documents provide a simple and straightforward description of the Rule. It includes deadlines and requirements for public water systems (PWSs) and states, and information on monitoring requirements.

- Lead and Copper Rule: A Revised Quick Reference Guide
  (PDF) (2 pp, 125 K, About PDF) EPA 816-F-08-018, June 2008
- Lead and Copper Rule: A Quick Reference Guide for Schools and Child Care Facilities that Are Regulated Under the Safe Drinking Water Act
  (PDF) (5 pp, 546 K, About PDF) EPA 816-F-05-030, October 2005

Drinking Water Regulations Under Development or Review

- Lead and Copper Rule Long-Term Revisions
- Prohibition on Use of Lead Pipes, Solder, and Flux - Implementing Revisions to Section 1417 of the Safe Drinking Water Act

You will need the free Adobe Reader to view some of the files on this page. See EPA's PDF page to learn more. If you need help accessing these PDF documents below, please contact EPA's Safe Drinking Water Hotline at 1-800-426-4791.

Water Supply Guidance Manual

EPA periodically issues memorandums which clarify drinking water policies and regulations. These policy memos have been collected into a water supply guidance (WSG) manual which is made available to states and public water systems to assist in implementation of the Safe Drinking Water Act.

- Water Supply Guidance

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Compliance

EPA provides guidance documents to help states and public water systems (PWSs) implement the Lead and Copper Rule. The materials below can assist in complying with requirements of the Rule.

- Compliance Help for Primacy Agencies (States, Tribes, and EPA Regions)
- Compliance Help for Public Water Systems

EPA has also developed background information and guidance materials regarding lead in drinking water in schools and child care facilities.

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Was Portland's lead crisis preventable?

By **Brad Schmidt | The Oregonian/OregonLive**
Email the author | **Follow on Twitter**
on October 09, 2016 at 6:01 AM, updated October 09, 2016 at 6:02 AM

The lead crisis that gripped Portland's largest school district this summer might have been avoided if city leaders followed federal rules to minimize lead exposure in drinking water.

An investigation by The Oregonian/OregonLive found state regulators let Portland off the hook two decades ago as federal officials turned a blind eye.

In November 1997, state officials approved a one-of-a-kind deal that let Portland ignore rules other cities across the country had to follow. New federal guidelines would have required Portland to add chemicals to its water to **minimize pipe corrosion and the release of lead.**

But the city effectively bet it could reduce overall health risks -- and save money -- by focusing on lead paint instead of aggressively targeting lead in water.

That decision affected not only schools but also thousands of homes, apartments and offices across the region connected to Portland's water supply.

Now 19 years later, it's impossible to say whether Portland's workaround has lived up to its promise. The Oregonian/OregonLive commissioned independent testing of lead in homes and reviewed hundreds of pages of documents that suggest, in many cases, the program has fallen short of its goals.

LEAD IN PPS WATER

Long a mess, Portland Public Schools starts to fix confusion at the top

Know someone who can run a school district? Portland wants to hear from you

Portland must reduce lead in water now, state says

Portland school board faces uphill battle with trust

Was Portland's lead crisis preventable?

All Stories

Among the findings:

- The program's so-called "cornerstone," lead-paint fixes in homes with young children, was pitched as a national model. Although the work substantially cuts lead dust levels, several studies show reductions are short-lived. In homes with follow-up testing, about half had at least one sample topping hazard levels months or years later.
- Most of the more than 1,800 homes with lead-paint or soil work have never been retested. An independent analysis of select homes for The Oregonian/OregonLive shows both water and paint hazards previously identified by the city remain today - unbeknownst to residents.
- The U.S. Environmental Protection Agency challenged the premise of Portland's program in 1997, saying expected benefits rested on uncertain assumptions. Water regulators from the Oregon Health Authority dismissed those concerns.
- Likewise, state regulators discounted federal objections about a lack of benchmarks for measuring success. Since then, state regulators have never independently evaluated Portland's program.

At any point since 1997, Portland could have built a water treatment plant to minimize lead while still pursuing the rest of its reduction plan. One estimate pegged construction costs at just $3 million.

Instead, as other water systems sharply brought down lead levels, Portland became an outlier.

Lead levels in **Portland's high-risk homes** test the **highest among the nation's largest water providers**. Portland has exceeded the federal "action level" **eight times since 1997**, most recently in 2013.

And tests this summer found lead-tainted water in virtually every Portland Public Schools building. The fallout prompted high-profile resignations, including Superintendent Carole Smith.

Lead levels across Portland -- and its schools -- would be "dramatically lower" with stronger treatment, said Marc Edwards, a Virginia Tech engineering professor who helped **expose the 2015 lead scandal in Flint, Michigan**. Every problem wouldn't disappear, but the scope and severity would be reduced.

"It's frankly kind of scapegoating," Edwards said. "Why are these school officials taking the brunt of the blame here when the city utility and the state essentially failed to follow the law?"

To be clear, federal regulators have never found Portland in violation of lead rules. But they now say Portland's levels "aren't good enough." They want the city to minimize lead, pushing levels as low as possible, beyond simply reducing it.

Dave Leland, Oregon's drinking water program manager, argues stronger corrosion control would have made no difference for Portland Public Schools.

"It's a different problem," said Leland, blaming district plumbing and fixtures. "The water treatment level wouldn't have solved this."

No amount of lead exposure is considered safe, according to the World Health Organization.

Locally, no children have been found with elevated blood lead levels this year because of water exposure, according to Multnomah County health authorities. State officials declined to say whether school district employees have tested high for lead, citing privacy concerns.

City leaders and state regulators defend their decisions. They say the lead program is successful but don't have an overarching analysis to back it up.

Among other things, they say lead levels have dropped by about two-thirds in water tests at high-risk homes. They tout increased testing for children. And they note blood lead levels have dropped in Multnomah County, even though national numbers have fallen, too.

"You're looking for proof," said Yone Akagi, Portland's water quality compliance manager. "These children are being tested who would not have gotten tested. I feel strongly that there's been a benefit to public health."

EPA concerned with program

When the EPA tightened its lead rules in 1991, Portland officials balked.

City leaders didn't believe lead exposure was a major problem in water. Portland's Bull Run watershed was considered lead-free. The city's delivery system never included lead service lines.

But Portland's water was corrosive enough to leach lead from pipes and faucets. Testing from 10 percent of sampled high-risk homes revealed lead levels of at least 53 parts per billion; the EPA wanted it no higher than 15.

The EPA set a deadline to start treatment in 1997. By June 1994, city officials were laying the groundwork for "flexibility." They pitched regulators on a "better approach" that would target plumbing instead of injecting chemicals into everyone's water.

A weighty factor in Portland's hesitancy: the business community.

Officials didn't want to upset companies using city water to clean microchips or concoct microbrews. The estimated cost for Intel

alone to treat its water would be $670,000 up front plus $310,000 a year, according to records from city archives.

Portland's water director flew to Washington, D.C., to lobby federal leadership. His takeaway, according to an internal memo: Portland had a shot, "but it is a very difficult proposition."

In 1995, Portland studied its options and settled on a new path: light chemical treatment and a program to reduce lead paint dangers.

Portland secured endorsements from a broad base of public health experts - including Grant Higginson, the state health officer who also served as Portland's water regulator.

Over the next two years, Portland devised an **official Lead Hazard Reduction Program**, without pinning down how it would be monitored or measured. The plan included water treatment, education for residents, free water testing and paint repairs.

City officials could have settled for state approval. Instead, they aimed higher.

In March 1997, Portland hoped to join a federal pilot program for innovative approaches to environmental regulations. City leaders formally **asked the EPA to approve its program "as a substitute" for minimizing lead levels.**

The EPA wasn't impressed.

None of Portland's estimates on lead exposure was "sufficiently accurate" to be used as the program's underlying basis, EPA's then-assistant administrator for policy, David Gardiner, wrote in November 1997. Assumptions about paint fixes were **"highly uncertain,"** he added, without being specific.

Federal officials urged Portland to **"clearly define" and measure success** for the program. Regulators later wrote that approval would not be credible **"without a meaningful evaluation and monitoring program."**

But state regulators, also considering Portland's program, didn't share those concerns.

That month, the Oregon Health Authority approved the same documents Portland submitted to the EPA.

State officials declared the program was as good as minimizing lead levels in water. And even though federal officials could have overturned Oregon's decision, they stood pat. Portland **withdrew its federal application**.

Looking back, Oregon and the EPA faced "different kinds of decisions," Gardiner stressed in an interview. The EPA's concerns centered on the federal pilot program's standards. But state officials were free to ignore them. Oregon's criteria for lead-compliance were less rigorous.

"Our view was that you wanted to be able to monitor and measure and evaluate the impact," said Gardiner, who left the EPA in 1999.

A regional spokeswoman for the EPA declined to say why the agency let Oregon's decision stand given its well-documented concerns.

As for the EPA, said Leland, the state's drinking water manager, "Everybody has different views."

'Hazardous levels' return

Evaluating success today is difficult because state regulators never set clear expectations for Portland.

After federal officials made noises about cracking down in 2002, Portland again pledged to "develop cost-effective criteria" for evaluating its program. But state regulators never pushed it.

"These are very difficult things to measure," said Kari Salis, a state drinking water manager. "They're not really quantifiable."

But a review of some two dozen reports spanning 18 years spells out several problems - including with the city's prized paint program.

In its first few years, Portland handed community groups too much responsibility for getting the work done. "This model floundered," according to an undated city report.

By 2001, crews made fixes at just 235 homes - 108 units below the initial goal.

Portland has fallen behind again. Three years ago, officials pledged to finish repairs on 310 units by February 2017. With four months to go, only 142 have received improvements. The paint program relies on federal housing grants.

Officials also knew early on that paint fixes were temporary. Levels dropped dramatically when work wrapped up. But in 44 percent of homes retested in 2001, "hazardous levels" of lead showed in at least one sample just 10 to 17 months later.

"Our reaction isn't going to be to question the success of the Lead Hazard Reduction Program" based on one report, said Jonathan Modie, a spokesman for the Oregon Health Authority.

Portland found similar results three different times between 2007 and 2013. About 100 of 1,800 homes were retested over the years. According to the most recent review, "significant sources of lead contamination" remained in 47 percent of homes that received follow-up testing three years ago.

Bedroom floors at some retested homes during that last report had lead levels 10 to 72.5 times greater than the federal hazard level, which is **40 micrograms per square foot.**

Jonathan Wilson, research director for the National Center for Healthy Housing, praised Portland for conducting follow-up testing. But he said such high levels are a concern.

"The program should be trying to figure out how they could get these levels lower," he said.

Martha Calhoon, a city spokeswoman, said officials use different numbers to gauge success.

In the past three years, officials found 13 children with elevated levels of lead in their blood because of problems in their homes. The city's program paid for fixes.

"The children we are able to protect from lead-based paint hazards are the measure of this program's success," Calhoon wrote in an email.

Lead levels remain high at Nicole Ball's bungalow in Northeast Portland.

In 2009, Ball received a roughly $15,000 grant to replace her lead-caked windows. With kids 4 and 7 years old, she considered it a "huge gift."

But follow-up testing months later found a high lead sample on a bedroom floor. The Oregonian/OregonLive returned last month -- seven years later -- and found continued problems.

The news organization gathered dust samples from eight locations throughout the house. Two floor samples recorded levels double and triple hazard standards.

"I'm inclined to do something about it," she said.

Portland wins award; homeowners at risk

Progress has been mixed in other areas.

In 2004, the U.S. Government Accountability Office praised Portland's education work. A year later, the EPA gave Portland an

award for raising awareness about lead hazards facing children.

But there were challenges, too.

As early as 2003, officials said education efforts were "effective in some areas but not others." In 2007, a report recommended better customer service for a lead hotline after nearly half of surveyed callers expressed negative comments. A program to raise awareness about water in high-risk homes "does not appear to be very successful," the same report read.

Portland's free water testing program hasn't reached its potential, either.

Testing requests are high in the first half of the year but then plummet by about two-thirds. The reason: Portland promotes the service in water bills only at the start of the year.

Why not advertise more often?

"Cost logistics," said Scott Bradway, Portland's lead hazard reduction manager.

Records show Portland's annual spending on education, outreach and testing has hovered at $450,000 since 2002, even as the bureau's operating budget swelled. Only now, with an influx of testing requests, have costs spiked to $666,000.

Wiley Wyss and Rachel Conrad could have benefited from testing - and aggressive water treatment.

The 20-somethings bought a Southwest Portland starter home in 2013. Portland used to test water at the home, built in 1985, as part of compliance requirements. It repeatedly found high levels until it stopped testing there in 2002.

Fourteen years later, lead levels in the home remain high. Water from the bathroom tested above the federal action level, at 17.7 parts per billion according to an analysis performed for The Oregonian/OregonLive.

Wyss said the couple probably wouldn't have bought the house if they'd known. Conrad said she's frustrated Portland hasn't minimized its lead levels.

"It kind of feels like it was swept under the rug a little bit," she said. "I would have liked to have known this would have been a risk for us."

Time to re-evaluate

Portland could minimize lead in its water by adding more chemicals to increase pH and alkalinity. That change would reduce corrosion.

Those standards were confirmed by outside technical experts in 2003. The city sought the advice because early attempts at light treatment failed to keep levels low enough.

Building a temporary facility, with enough chemical capacity to actually minimize lead levels, would have cost just $3 million at the time.

But experts didn't recommend moving forward. They figured Portland could save money and wait until it dealt with other federal mandates: shutting down open-air reservoirs and treating water for a parasite called cryptosporidium.

Those improvements were expected by 2012. But Portland fought them. The city won an exception for cryptosporidium. And work on its underground reservoirs won't finish until 2020.

"When people realized they weren't going to build the additional facilities," said Rhodes Trussell, an engineer on the advisory committee, "they could have re-evaluated."

On Tuesday, the Portland City Council will consider long-term treatment options, with a decision expected next summer. Officials

say improvements wouldn't be ready until 2022. Construction could cost $15 million.

Portland Commissioner Nick Fish, in charge of the Water Bureau since 2013, declined to address past decisions or concerns from the EPA.

Fish said any decision about water treatment, "if we can do better," will be based on "good science and Portland values."

Boston offers a likely glimpse into Portland's future.

In the 1990s, Portland and Boston shared similarly high lead levels in high-risk homes. Both had corrosive water. Both stored water in open reservoirs.

Both considered alternatives.

Ultimately, Boston's water provider agreed to minimize lead. Water in the top 10 percent of Boston's high-risk homes tested above 6.2 parts per billion last fall. Portland was more than double this spring, at 13.1.

"We're satisfied," said Stephen Estes-Smargiassi, director of planning and sustainability for the Massachusetts Water Resources Authority.

Why didn't Boston pitch an alternative? Because when it came to creativity, regulators "were not as enthused as the folks out west."

"You can't get in trouble as a regulator," he said, "if you just stick with the rule."

-- Brad Schmidt

Reporter Rob Davis contributed to this report.

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