# Lead-Contaminated Drinking Waters in the Public Buildings of Providence, RI

**Matthew Wheeler**
**Brown University**
**Department of Environmental Studies**
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Matthew Wheeler
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## Abstract

Lead exposure is a serious environmental health hazard, especially for children[1]. Due to its prevalence in plumbing, it is commonly ingested by drinking water from old pipes. Depending on the volume of water consumed, drinking water from public buildings may be a significant source of lead exposure for people[2]. This study surveys and evaluates the lead levels in the water supply of five highly trafficked Providence Public Buildings: the Providence Supreme Court, Kennedy Plaza Bus Station, Providence Place Mall, the Providence Train Station, and the Court House. Five samples were taken at intervals of 0 seconds, 5 seconds, 10 seconds 15 seconds, and a final flushed sample of 3 minutes. These intervals help to determine the variability of lead-contamination in relationship to the amount of water flush. These samples were put in an acidic solution, and analyzed in the Graphite Furnace-Atomic Absorption Spectrometer (AAS-GF) at Brown University to determine if the lead levels in these public buildings are acceptable according to the EPA action level of 15 parts per billion. Of the fifty samples taken from ten different water sources, 82% of the samples showed a mean water lead level of zero or one; virtually no trace of lead-

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[1] S. D. Bryant Journal of Toxicology
CLINICAL TOXICOLOGY
Vol. 42, No. 3, pp. 287–294, 2004

[2] S. D. Bryant,
Lead-Contaminated Drinking waters in the Public Schools of Philadelphia.
Informa Healthcare, issue 26. December 2004

contamination. 18% of the samples came from one water source in the city hall and were discovered to contain elevated lead levels. In addition to discussing these findings, a short review of the implications of lead exposure will be conducted, as well as a brief history of Providence's water supply and treatment.

**Introduction**

Lead-contamination is a preventable environmental health concern.[3] Various studies on lead have concluded that it is an extremely harmful substance to humans, and that it can cause a variety of health problems. Exposure to lead depends primarily on four major factors: duration of exposure, frequency of exposure, dose, and individual risks factor. Although the most common form of lead poisoning comes from exposure to decaying house paint, recent studies have concluded that drinking water is also a primary avenue for lead to come into contact with humans[4][5].

**Figure 1[6]**

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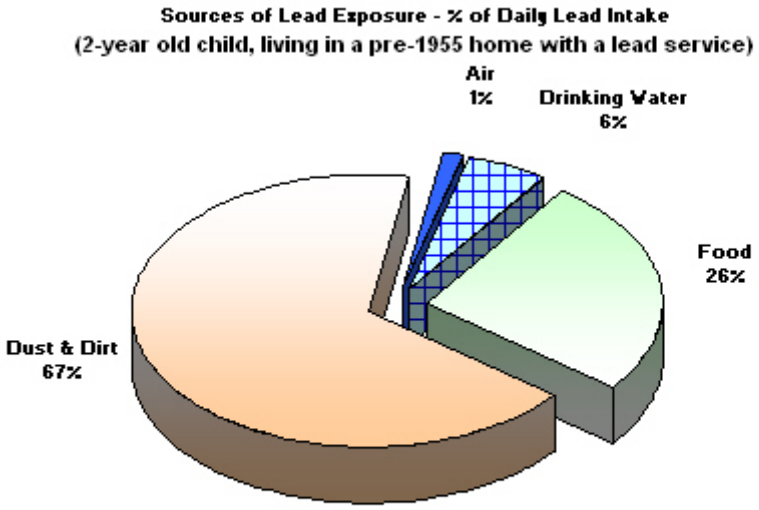
[3] S. D. Bryant Journal of Toxicology
CLINICAL TOXICOLOGY
Vol. 42, No. 3, pp. 287–294, 2004

[4] See figure 1

4 Houk VN, Ing RT, Falk H.
Assessing lead exposure from drinking water.
Am J Public Health July 1989; 79(9): 823-824

[6] City of Ottawa Research Group: What are major sources of lead exposure? Copyright 2001




Studies have revealed that lead traces can be found in many municipal water systems, due to the corrosion of pipes. Historically, lead has been a very common metal for plumbing due to its malleable properties. Before the health effects of lead exposure were known, it was not uncommon to see lead used as piping or solder. Buildings constructed before the 1930s often had completely lead plumbing systems.

Understanding of lead toxicity has advanced substantially over the past three decades, and focus has shifted from high-dose effects in clinically symptomatic individuals to the consequences of exposure at lower doses that cause no recognizable symptoms; the kind of exposure that is found through drinking water.

In the 1970’s, lead was discovered to be extremely harmful. Since then,

there have been several federal efforts to curb the exposure to lead[7]. These campaigns include regulating lead-based paint, banning leaded gasoline, and taking lead out of common items like pencils. However, the hazard of contaminated drinking water remains a problem at large. Although federal and legislative measures efforts were taken to help manage and reduce the growing problem of lead exposure, there were many loopholes regarding drinking water safety. Until the Safe Water and Drinking Act of1986[8], lead was consistently used as a solder. Due to corrosion of pipes, it is common that drinking water be a primary cause of lead exposure. Over the years, factors such hot temperatures, aged piping, and the acidity of water cause a leeching of lead into the drinking water of many municipal water systems. Although there have been movements to help reduce the amount of lead in our living environment, a large number of buildings still are at risk with old pipes.

The Safe Drinking Water Act of 1974 required public waters meet Environmental Protection Agency (EPA) regulations for both naturally occurring and man-made contaminants found in drinking water[9]. In 1986, lead exposure still posed as a major environmental health hazard, and federal regulations heightened with the Safe Water and Drinking Act. As is stands today, the EPA

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[7] Meyer PA, McGeehin MA, Falk H.
A global approach to childhood lead poisoning prevention. Journal of Toxicology 2003 Aug;206(4-5):363

[8] S. D. Bryant Journal of Toxicology
CLINICAL TOXICOLOGY
Vol. 42, No. 3, pp. 287–294, 2004

[9] Needleman H (2004). "Lead poisoning". *Annu Rev Med* 55: 209–22. doi:10.1146/annurev.med.55.091902.103653. PMID 14746518.

action level for lead amounts in public buildings is fifteen parts per billion (ppb). This is an extremely low amount, although it is commonly agreed that there is no safe amount of lead to be exposed to.

The dangers of lead exposure through drinking water have been well studied, but there is a serious lack of data regarding the lead-contamination in several public buildings In Providence, Rhode Island. Currently, there are limited studies mapping the lead levels in the Providence public buildings that are under investigation in this study. This study be a public resource, by offering a thorough recording of findings for lead levels in all of the public buildings in Providence, and concluding if, in fact, the buildings are up to the standards that were laid out by the EPA in 1986. Since much of the city business takes place in these buildings, it is of paramount importance that the employees and guests are assured that their drinking water is safe and contaminant free.

**Effects of Lead Poisoning**

The symptoms of chronic lead poisoning include neurological problems, such as reduced cognitive abilities, nausea, abdominal pain, irritability, and insomnia[10]. There are also several gastrointestinal problems associated with lead exposure, such as vomiting, poor appetite, and weight loss. It has also been found that lead can damage the tissue in nearly every major organ, including the kidneys, liver, and lungs. Lead exposure has been found to damage nervous connections (especially in young children), and can also cause blood and brain

[10] Fischer C (2007). *Kaplan Medical USMLE Steps 2 and 3 Notes: Internal Medicine, Hematology*. pp. 176–177.

disorders.[11] In 1991, the Center of Disease Control (CDC) established a blood lead level of 10 mcg/dl as an action level for lead poisoning.[12] Since then the amount of lead in the living environment has been vigorously monitored. Children in particular were found to be at risk, given their highly developmental stage of life. Studies reported that the effects of lead poisoning on children included a lower IQ, and a higher risk for antisocial and delinquent behavior.[13]

Unfortunately, there is no known cure for the effects of lead poisoning. Chelation Therapy can be used to reduce existing levels of lead in the blood by administering agents to remove heavy metals from the body. However, this kind of therapy is extremely expensive, making it inaccessible to many patients in need. Further, side effects from the therapy include a variety of ailments such as fever, headache, nausea and vomiting.

The absolute best way to deal with lead is to avoid exposure to it as much as possible. Although the primary avenue by which lead comes into contact with people is through decaying lead-based paint, new studies are increasingly showing that drinking water is a viable source for lead exposure, and is one that should be carefully monitored.

**Background of Providence Municipal Water**

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[11] Masters, Roger D.. "Water treatment with silicofluorides and lead toxicity". International Journal of Environmental Studies, Volume 56, Issue 4 June 1999, pages 435 - 449. Retrieved on 2008-06-07.

[12] S.D. Bryant Journal of Toxicology
CLINICAL TOXICOLOGY
Vol. 42, No. 3, pp. 287–294, 2004

[13] Dietrich KN, Ris MD, Succop PA, Berger OG, Bornschein RL. Early exposure to lead and juvenile delinquency. Neurotoxicol Teratol Nov – Dec 2001; 23(6):511 – 518.

Before looking at the lead content of water within buildings. It is important to understand where the water comes from, and what processes the water undergoes before being distributed throughout Providence. Aside from painting a more accurate picture for the quality of Providence water, this background also provides insight into the greater application of this study, and the greater quality of water within the Providence area.

According to the Providence Municipal services directory, the Providence Water Supply Board (PWSB) is responsible for the collection and storage of raw water; treatment and transmission of potable water; and the quality control of the final product within the Providence Water system[14]. Their websites declares their mission to ensure that the water is treated, tested, and readied for distribution in adequate quantity to satisfy demand while meeting all the health and safety-related standards and regulations as mandated by the State of Rhode Island and established by the previously mentioned. Further, they are responsible for customer satisfaction for taste and quality of the Providence drinking supply.

The PWSB owns and operates their own water treatment and filtration plant, which began operation on august 22, 1962. The plant employees state-of-the-art chemical treatment, combined with rapid sand filtration to purify raw water prior to the distribution to customers.

Providence obtains its water from a surface supply located on the north branch of the Pawtucket River. The watershed contains 928 square miles of land,

[14] Providence Water Supply Board Press Release
Rhode Island Public Water Authority.
Retrieved on 2007-06-06.

an area that is almost five times the area of the City of Providence. The PWSB owns approximately 25 square miles of land. The largest portion of the watershed lies in the town of Scituate, with smaller portions located within various adjacent neighborhoods such as Smithfield and Cranston,

Water from the Scituate Reservoir is drawn through one of three separate intakes at the Gate House located at Gainer Dam. The water is conveyed by gravity through twin 60-inch aqueducts, which converge into a single 94-inch aqueduct into the plant, where Ferric Sulfate is added as a coagulant to get rid of detritus material. The chemically treated water then enters aerators, which oxidize the water and are designed to remove carbon dioxide, taste and odors from the raw water. From the aerators, the water continues into a circular tank known as the Tangential Mixer.

It is at this phase where the most critical step takes place in regard to lead-contamination. Just prior to entering the mixer, lime is added to raise the pH and make the water non-corrosive to metals such as lead. The raising of pH makes the water slightly more basic, and less reactive when being transported through pipes that may contain traces of lead.

Once being treated with lime, the water enter the coagulation and sedimentation basins, the water will settle, leaving clear water at the top. The combined capacity of both basins is 162.1 million gallons, which provides for a two to three day retention time. Once this process is complete, the water moves on to the filters, where is enters the final stages of purification. The filters consist of concrete tanks with a serious of collector pipes located at the bottom of the

filter. The pipes are covered by large gravel, and the by layers of successively smaller sizes of gravel. Located at the top of the gravel is a fine layer of sand, which captures stray particles. Water flows through the layers of sand and gravel into a clearwell, where it is temporarily kept. The final step before distribution is the adding of Fluorosilicic acid, also known as fluoride (which is added to help prevent tooth decay). After this whole process, water leaves the plant by a 78-inch and 90-inch aqueduct, and flows into the distribution system, which is divided into two areas called high and low service. In many cases, the PWSB will tend to repairing and updating the plumbing systems of high-risk areas of Providence.[15]

For our purposes, the high service supplies all of the buildings downtown, including the Providence Supreme Court, Kennedy Plaza, Providence Place Mall, Providence Station, and the Providence City Hall.

**Figure 3:**


**Description of Study Sites**

I tested five heavily trafficked Providence public buildings.[16] They are spread across downtown, and lie within walking distance of any downtown pedestrian. The following is a short description of the five buildings sampled, the sample locations, building ages, human traffic, and initial risk due to age of building.

***Providence Supreme Court***
***Providence, RI 02903***
***250 Benefit St # 7***

The Providence Supreme Courthouse is one of the most important public institutions in the city. Founded in 1747, the court is the last resort in the U.S.

[16] See figure 3

State of Rhode Island and Providence Plantations. Over 75 employees work there regularly, with daily access to the drinking supply. Due to the old age of the building, the Supreme Court plumbing system is at high risk for lead contaminated plumbing.

Two water sources were sampled from the Providence Supreme Court. The first was a drinking fountain located on the first floor by the main entrance, and the second was a drinking fountain located on the second floor among a group of offices. Both these fountains maintain common use by the employees.

***Kennedy Plaza at Berth***
***Providence, RI 02903***
***25 Dorrance St Ste 1***

Kennedy Plaza is the hub for all bus use in Providence. Nearly every route begins at Kennedy Plaza. According to the Rhode Island Department of Transportation, Kennedy Plaza serves around 69,000 people a day.[17] The plaza began its service as a bus hub in the mid 1970's.

Two water sources were sampled from Kennedy Plaza. The first was a drinking fountain located in the central ticket office next to the main window. The second was a drinking fountain located in the central ticket office, located next to the bathrooms.

***Providence Place Mall***
***Providence, RI 02903***
***1 Providence Pl***

Providence Place, opened on August 20, 1999, is an urban shopping mall

[17] ripta.com "RIPTA Accomplishments in FY2006". Rhode Island Public Transportation Authority. Retrieved on 2007-06-06. 25,296,132 boardings / 365 days = 69,304 daily.

in the central part of Providence, Rhode Island, in between the Rhode Island State House and the Providence Train Station. There are 160 stores located in the mall, including a 16-screen cinema. Hundreds of employees and thousands of customers use the mall and it's drinking supply daily. Due to the recent development, its plumbing system is at relatively low risk.

Two water sources were sampled from the Providence Place Mall. The first was a heavily used water fountain located in the food court, right at the base of the movie theater entrance. The second was a drinking fountain located just inside the entrance, and next to the central bathrooms.

***Providence City Hall***
***Providence, RI 02903***
***25 Dorrance St Ste 1***

The Providence City Hall is a center for municipal government in Providence, Rhode Island. The City Hall is a work place to over a hundred city employees. Built in 1878, Providence City Hall is at high risk for old pipes, and lead contaminated plumbing.

Two water sources were sampled from Providence City Hall. The first was a heavily trafficked drinking fountain located just inside the main entrance. The second was a drinking fountain located on the second floor, in between a row of bathrooms, and a group of offices.

**Providence Station**
**Providence, RI 02903**
***100 Gaspee St***

Providence Station is a railroad station that is served by Amtrak and the

Massachusetts Bay Transportation Authority. The modern building was completed in 1986. The station has four tracks for passenger service, and is ranked to be the 17th busiest Amtrak station in the country. Due to its relatively recent completion, the building is at moderate risk for lead-contaminated plumbing.

Two water sources were sampled from Providence Station. The first was a drinking fountain located next to the main ticket window. The second was a faucet located in the bathrooms next to the food court, within the main train terminal.

**Method:**

The procedure consisted of sampling only sources that were heavily used as drinking suppliers; primarily drinking fountains. All samples were collected in the morning hours, between 8:00 and 10:00 AM. Samples were collected using standard lead testing protocol[18]. In order to get an idea of the flush effect, samples were collected at time intervals of 0 seconds, 5 seconds, 10 seconds 15 seconds, and a final flushed sample of 3 minutes. These intervals help to determine the variability of lead-contamination in relationship to the amount of time water sources have flushed. Each individual sample beaker had an ID stating its specific building, water source, and time interval. There were five samples from each water source, and a replicate set of samples from the Providence Place mall, taken on different days.

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[18] See appendix A

After the samples were collected, they were put in an acidic solution, and analyzed in the Graphite Furnace-Atomic Absorption Spectrometer (AAS-GF) at Brown University. Through a process of shooting photons through the acidified water solution, this machine will measure the amount of lead in the water by determining how much of the photons were absorbed before reading the censer. The machine is then calibrated by reading standard samples with given lead amounts. The AAS-GF machine gives measurements in terms of ppb, and will determine if the samples contain an acceptable amount of lead in them. The legal amount of lead in drinking water, according to the Environmental Protection Agency, is 15 ppb.

**Results**

Of the fifty samples taken from ten different water sources, table one shows 82% of the samples showed a mean water lead level of zero or one; virtually no trace of lead-contamination. Of the samples with traces of lead, only 8% had levels exceeding the EPA action level of 15 parts per billion.[19] All of these samples came from a single drinking source located on the second floor of the Providence City Hall.

**Table 1**

| **Train Station—First Source** | **Train Station—Second Source** |
|---|---|
| 0 seconds…….1 ppb | 0 seconds…….1 ppb |
| 5 seconds…….0 ppb | 5 seconds…….0 ppb |
| 10 seconds……0 ppb | 10 seconds……1 ppb |
| 15 seconds……0 ppb | 15 seconds……6 ppb |
| flush sample……0 ppb | flush sample……..1 ppb |

| **Providence Place—First Source** | **Providence Place—Second Source** |
|---|---|

[19] See Figure 4

| | |
|---|---|
| 0 seconds…….0 ppb | 0 seconds…….0 ppb |
| 5 seconds…….0 ppb | 5 seconds……..…0 ppb |
| 10 seconds…….0 ppb | 10 seconds…..……..…0 ppb |
| 15 seconds…….0 ppb | 15 seconds……..…0 ppb |
| flush sample……..0 ppb | flush sample……1 ppb |

| **Kennedy Plaza—First Source** | **Kennedy Plaza—Second Source** |
|---|---|
| 0 seconds……..0 ppb | 0 seconds……..0 ppb |
| 5 seconds…….0 ppb | 5 seconds……..0 ppb |
| 10 seconds…….0 ppb | 10 seconds……..0 ppb |
| 15 seconds…….0 ppb | 15 seconds……..0 ppb |
| flush sample……..0 ppb | flush sample……..…0 ppb |

| **City Hall—First Source** | **City Hall—Second Source** |
|---|---|
| 0 seconds…….1 ppb | 0 seconds……..37 ppb |
| 5 seconds…….1 ppb | 5 seconds……..29 ppb |
| 10 seconds… …1 ppb | 10 seconds……..45 ppb |
| 15 seconds…….0 ppb | 15 seconds……10 ppb |
| flush sample……..0 ppb | flush sample…….43 ppb |

| **Court House—First Source** | **Court House—Second Source** |
|---|---|
| 0 seconds…….1 ppb | 0 seconds……..5 ppb |
| 5 seconds…….0 ppb | 5 seconds……1 ppb |
| 10 seconds…….0 ppb | 10 seconds……1 ppb |
| 15 seconds…….1 ppb | 15 seconds……0 ppb |
| flush sample……..0 ppb | flush sample…….0 ppb |

Table one shows the intervals in which the samples were taken. Since nine of the water sources came up with virtually no trace of lead, the only trend identified was that of the second floor drinking fountain in the city hall, where the number failed to decrease, even after being flushed.

The results show a high variance within the Court Hall, the only building with any lead-contamination. Even though the first floor showed virtually no trace of lead, the second floor clearly had enough lead to raise concern. Even after being flushed for 3 minutes, it is clear that the water coming from the 2$^{nd}$ source

within the Court House would require an additional filter to get its lead concentration below that of EPA standards.

Further, the results suggest that even if the municipal water supply is clean, lead-contamination can still occur after the water is distributed throughout the building, particularly to the higher floors where the water travels through more piping.

**Discussion**

Overall, Providence did very well. Compared many other cities like Philadelphia or New York[20], which numerous studies have identified as having major lead-contamination problems, Providence came up with having virtually no lead in four out of five of the public buildings tested. Of the one building with lead-contamination, only one water source contained hazardous water.

Part of the success of Providence may be due to the proactive legislation recently passed. On March 6, 2009, the Providence water Board released a press statement identifying possible sites of contamination all over the city (see figure 3), stating their schedule to replace and monitor possible sites for contamination. Since 2007, Providence Water has been working to eliminate more than 25,000 lead water service connections to customers' homes and businesses remaining in the original water system. The program was initiated in 2007 when 11 lead-connected homes in a 100 home sampling exceeded the EPA action level and required the Providence Water Board to replace their

[20] S. D. Bryant, Lead-Contaminated Drinking waters in the Public Schools of Philadelphia. Informa Healthcare, issue 26. December 2004

plumbing systems. The city's municipal water quality is reflected in the results of this study.

Providence, overall, succeeded in satisfying EPA standards in nine out of ten water sources, which is commendable considering the strict guidelines put forth by the EPA. One reason that the EPA was successful in implementing such an expensive regulation was that it provided detailed estimates of the health and welfare benefits that would accrue and the monetary value of some of the benefits. The EPA cost-benefit analysis demonstrated that the monetary benefits of its regulation far exceeded the costs. That neutralized the cost issue and focused the debate over the regulation on questions of timing. A detailed benefit analysis of reducing lead in drinking water has caused the EPA to consider tighter water lead standards than initially envisioned[21]. Even with these guidelines, providence still planned to fare well.

In fact, following their initial plan, the 3,600 Lead Service Replacements mandated for replacement by September 30, 2008 were actually completed a month-and-a-half ahead of schedule on August 14, 2008. By September 30, 4,276 lead services had been replaced. Throughout this program, Providence Water has provided informational material to customers through mailings to customers, press releases, advance notifications in the LSR neighborhoods, and detailed information on the Providence Water website.

This action plan is a result of the sway felt by the community in response to lead detection within homes. The quality of the municipal water supply is a direct

**1.** [21] Schwartz J. Societal benefits of reducing lead exposure. Department of Social and Preventive Medicine, University of Basal, Switzerland. 1994 Jul;66(1):105-24.

reflection of the care Providence takes with the residential and public buildings.

As far as deciding whether or not to act in response to this study, there are a few factors to consider. Lead is an extremely hazardous material, and it has been proven that the least amount of exposure is always preferable[22]. Therefore, it would be the recommendation of this study to place filters on this water to get the level lower than EPA standards, given the fact that there is no amount of lead that is safe to be exposed to. Filtering the water on the second floor of the courthouse would be an easy fix to slightly curb lead exposure.

In 1991, the Center of Disease Control established a blood lea level of 10mcg/dl as an action level for lead poisoning. Given the results of this study, even drinking from the single source found to be contaminated would not result in a seriously dangerous situation. Although it is very important to monitor lead exposure through drinking water, this study suggests for the employees and citizens that frequent these buildings, it would make more sense to keep track of the other avenues of lead poisoning such as decaying lead-based paint, or aerosolized lead in dust particles or soil.

An important finding of this study is how there can be a large amount of variance within a single building. The City Hall, for example, had perfectly clean water samples on the ground floor, but samples with three times the EPA action level on the second floor. A possible explanation for this would be the distribution throughout the building. Since the water on the 2nd floor must travel through

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**2.** [22] S. D. Bryant Journal of Toxicology Clinical Toxicology Vol. 42, No. 3, pp. 287–294, 2004

additional pipes. It makes sense to place water sources on the higher floors of buildings at greater risk for lead-contamination, and to consider adding additional filters to drinking fountains located on the higher floors of these buildings. The Providence water supply appears to be clean and well processed, but this variance within the City Hall suggests that water sources should be carefully monitored, even if the overall water supply is clean.

Even though there are still plumbing systems that need to be monitored or replaced, Providence has proven to have an effective and clean water management system. Compared to cities like Philadelphia or New York, Providence can be shown as a model for effective ways to process, treat, and distribute water throughout the city, as well as a good role model for swift action in response to detecting lead-contaminated problem areas.

**Conclusion**

These findings suggest that for the most part, Providence has an effective management and distribution system throughout the downtown water supply. There was one water source within the Providence City Hall with detectable amounts of lead contamination. There was not enough to justify raising the alarm or causing a panic. Since studies have found that it is always desirable to be exposed to as little lead as possible, it is the recommendation of this study to place a filter on the drinking fountain of the 2$^{nd}$ floor, in order to get the water under the EPA standard of 15ppb.

These findings further suggest that even though Providence treats its water well, it is still possible to have elevated levels of lead within individual buildings, or individual floors of buildings. Since the only detectable amount of lead was found on the higher floor of the building, it is hypothesized that significant lead-based plumbing exists in the building. This study suggests that it would be desirable to rigorously test the drinking water in buildings constructed before the 1980's, and that the necessary steps should be taken to reduce lead levels and help avoiding the exposure to contaminated water. This study further suggests that there could be a health concern due to sporadic presence of lead-based pipes and drinking water high in lead.

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## Appendix A:

**Protocol for sampling natural waters for metals:**

Sterile gloves should be used when taking samples to minimize sample contamination

1) use either new 60 or 125 ml bottles or acid-cleaned and rinsed bottles located in cabinets in MacMillan room 109 to collect sample. Use 30 ml acid-cleaned bottles to store filtered sample.
2) Label all bottles using permanent markers writing on lab tape affixed to bottles. Label bottles before going into the field using simple numbering scheme and include your section/project number in the ID.
3) In field use notebook or prelabeled lab sheets to record bottle ID's and sample locations.
4) Add some of the water to be sampled to the bottle and swirl it and discard (2-3 times-if possible).
5) Fill bottle then cap.

6) take one 20 ml subsample of your water sample using a syringe and push it through a 0.4 µm acrodisc filter dispensing it into a labeled 30 ml bottle (HCl or Nitric acid cleaned).
7) Upon returning from the field, put samples in Room 109 and contact David Murray. He will add 0.5 ml nitric acid to the samples and move them to Room 221 for analysis.

**Protocol for sampling water from of faucets for metals analysis:**

Sterile gloves should be used when taking samples to minimize sample contamination

1) Prelabel 30 or 60 ml bottles obtained from cabinets in MacMillan room 109.
2) Depending on your experiment, you will either need to run the faucet for a while before filling (standard protocol) or start filling as soon as the faucet is turned on.
3) Fill bottle to rim and cap
4) Enter sample information in your field notebook, including location and protocol used to collect water.
5) Upon returning from the field, put samples in Room 109 and contact David Murray. He will add 0.5 ml nitric acid to the samples and move them to Room 221 for analysis.

Prior to analysis, a set (5) of standards with elements/compounds of interest spanning the range of expected concentrations will need to be made and analyzed.