Lead Levels in Drinking Water at Middlebury Union Middle School, Middlebury, VT

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SUMMARY

Lead in drinking water was determined for all water outlets (n = 95) at Middlebury Union Middle School (MUMS) in Middlebury, VT. Samples were collected according to the U.S. Environmental Protection Agency (EPA) guidance document *3Ts for Reducing Lead in Drinking Water in Schools*. First draw (FD) and flush (FL) samples were collected, acidified (pH<2), and turbidity verified to be <1 NTU prior to Pb determination. Lead concentrations in FD samples were evaluated relative to two standards: the health-based 1-ppb American Academy of Pediatrics (AAP) safety recommendation for drinking fountains in schools, and the Vermont state action level for drinking water in schools of 4 ppb. FL samples were used to determine the likely source of any lead in the water.

Most outlets (85%) produced FD samples with detectable lead, but in 42% of these cases, the lead was at 1 ppb or lower and, therefore, met the AAP recommended safety level. Roughly a quarter of the FD samples hit the 4-ppb VT action level for lead, including 4 kitchen sinks/sprayers (4-9 ppb), 10 classroom or office sinks (4-80 ppb), 6 showers (19-391 ppb), and 4 utility sinks (4-55 ppb). The classroom, office, and kitchen sinks require remediation according to state law due to their reasonable or known use for consumption and are considered a *highest priority*. Researchers considered the showers and utility sinks a *medium* and *low priority*, respectively for remediation, because of their low likelihood of use for consumption but rather high lead levels.

An additional quarter of outlets produced water samples that exceeded the 1-ppb American Academy of Pediatrics safety recommendation but were below the state Action Level (i.e., 2-3 ppb), including 1 kitchen sink/sprayer; 21 classroom, bathroom, or office sinks; and 1 shower. Despite not triggering required action via state law, the kitchen sink is consider a *highest priority* for remediation due to its use for consumption and/or food preparation; the classroom, office, and bathroom sinks are considered a *high priority* for remediation due to their reasonable or known use for consumption. These low shower lead levels are considered a low priority for remediation.

Testing suggests that the predominant source of lead is the fixtures or their immediate connections, rather than more distal pipes or the incoming water supply. Recommended permanent remedial actions include replacing fixtures with “lead-free” fixtures/solder with follow-up testing to verify remediation efficacy or removing outlets entirely. Additionally, we recommend that MUMS communicate the findings of this work and remediation updates with the school community, as well as post this report and remediation updates in a readily accessible location (e.g., school website). A sample letter describing the results for a general audience is provided.

Table of Contents

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BACKGROUND

Lead exposures derive from a variety of sources including dust from older lead-based paint, soil contamination from earlier leaded gasoline, and water contamination from leaded pipes, solder, and fixtures [1]. Dust from leaded paint is believed to be the dominant source of lead exposure, but the EPA estimates that ~20% of lead exposure is through drinking water [2]. Health effects of lead include irreversible developmental neurotoxicity [3], disruption of the endocrine and reproductive systems [4], and gastrointestinal and cardiovascular issues [5]. Even at low levels (<5 µg-Pb/dL-blood), lead has been known to decrease IQ scores [3]. Because of the health risks posed by lead, including that it can bioaccumulate, the U.S. Environmental Protection agency has set a non-enforceable health standard (Maximum Contaminant Level Goal, MLCG) for lead in drinking water of zero [2]. While no level of lead exposure is considered to be safe for anyone, lead exposure is a particular concern in children. Whereas children absorb >50% of Pb that they ingest, adults absorb ~35-50% [6]. Furthermore, lead's chemical similarity to calcium promotes uptake into children's bones, which can leach out over time and serve as a long-term source of Pb exposure [7]. The American Academy of Pediatrics recommends a maximum lead level in drinking water of 1 µg/L (referred to as "ppb") [8]. Because developing children spend much of their time at school and the effects are largely irreversible, exposure to lead through drinking water in schools is a critical issue [9, 10].

In 1991, the United States Environmental Protection Agency (EPA) established the Lead and Copper Rule, which requires public water suppliers to monitor for lead in drinking water and sets an action level for the concentration of lead in drinking water to 15 parts per billion (ppb) and a maximum contaminant level *goal* of 0 ppb [11]. If lead concentrations exceed the 15 ppb action level in more than 10% of customer taps sampled, public water suppliers must take action to control corrosion and inform the public about steps they should take to protect their health. Importantly, this action level is used administratively to evaluate community exposure and is not a health-based standard. The American Academy of Pediatrics has issued a health-based recommendation that water fountains in schools not deliver water exceeding 1 ppb lead [8]. Schools are not generally required to test for lead in drinking water unless they rely on a private water supply and serve more than 25 people daily [12]. This results in water being tested for lead in only ~8-11% of schools nationwide [13].

While municipal water must be tested for lead at the site of distribution and at a small number of end-user (typically residential) outlets, lead can leach into the water at various points within the system, including from lead-containing pipes, solder, and individual outlet fixtures. The federal 1986 Safe Drinking Water Act limited the use of lead pipes and lead-containing solders in new drinking water systems, where "lead free" was defined as less than "0.2% lead for solders and fluxes and not more than 8% lead for pipes and pipe fittings" [14]. The amount of lead allowed in "lead-free" products installed after 2010 in Vermont [15] and after 2014 nationally was reduced through redefining "lead free" as products in which wetted surfaces of a pipe contain a weighted average of ≤0.25% lead and the wetted surfaces of solder and flux contain a weighted average of ≤0.2% lead. The 2011 federal revision also exempted from lead-free requirements certain products that are used exclusively for non-potable uses "such as irrigation, outdoor watering or any other uses where the water is not anticipated to be used for human consumption," as well as other products, including shower or water distribution main gate valves ≥2 inches in diameter [14]. Because of shifting "lead free" definitions, exemptions from lead-free requirements, and uncertainty regarding individual pipe and fixture composition and installation dates, direct testing of water from each outlet is the only way to understand the potential for lead exposure through drinking water.

Data from the Vermont State Health Lab in 2015 indicate that ~5% of blood samples from Vermont children age 2-and-under exceed Vermont's 5 μg/dL standard [16]. Approximately, 150 Vermont schools who are on their own drinking water supply regularly test some water outlets, but few schools have ever had all of their outlets tested. In 2017, the Vermont Department of Health (VDH) and Agencies of Education and Natural Resources launched a pilot project to test all drinking water outlets in 16 Vermont public schools that are on municipal water supplies [17]. Results of that pilot showed substantial differences across schools in the frequency of lead detection and in lead levels [18]. Schools ranged from having 0% up to 54% of outlets exceeding the EPA action level for lead, and from 3-88% of outlets exceeding AAP safety level of 1-ppb.[1] In response to the VDH pilot and with the support of the Governor, the Vermont legislature took up a bill in 2019 to require testing of school drinking water for lead. Lawmakers passed S.40 in the spring 2019 session, after the testing in the current work was already complete, a bill that requires schools to test all water outlets that could reasonably be used for consumption for lead. The law requires that testing follow procedures set forth by the EPA's 3 Ts guidance [12] (methods used in the current study), and that schools remediate and demonstrate remediation efficacy for any outlets delivering water at ≥4 ppb lead.

Middlebury Union Middle School (MUMS) receives water through the municipal system, and therefore, was not required to test prior to the passage of S.40. The current study represents the first-time lead levels have been tested in water from all outlets at MUMS.

METHODS

Site Description

Middlebury Union Middle School (MUMS) is located in Middlebury, VT and provides 7th and 8th grade instruction [19]. MUMS is part of the Addison Central School District, which oversees public schools in the area. MUMS was constructed in 1998 with renovations (new walls) since then. Any replacement of fixtures and other water infrastructure was performed in compliance with the lead-free requirements of the 1986 Safe Drinking Water Act. Copper lines are used into and within the building. We worked with ACSD Facilities Manager, Eric Warren, on the study design, including completion of a plumbing questionnaire and mapping of flow paths.[2] All water outlets in the school (n = 95) were mapped by location and type. Outlets sampled at MUMS included sinks (conventional and floor/utility), water fountains, bottle fillers, showers, and an ice machine (**Figure 1**). Mapping included noting, as well as possible based on available information, the flow path of water from the initial water entry point to the school. Knowledge of the water flow path is critical to the integrity of water sampling, as outlets need to be sampled in sequence from upstream to downstream to avoid inadvertent flushing of pipes and fixtures prior to sampling. Because we had incomplete information regarding the water connectivity between first and second floors on the building, the floors were sampled independently (separate days) from each other.

[1] The AAP health-based recommendation is made specifically for water fountains, but would reasonably be applied to any outlet used for direct consumption by children. Information regarding use of outlets for consumption was not publicly available for statewide pilot.

[2] EPA Plumbing Profile Questionnaire can be found on p 96 of (EPA 2006), and includes questions regarding pipe and fixture type and composition, building age, and dates of renovation, among other information.

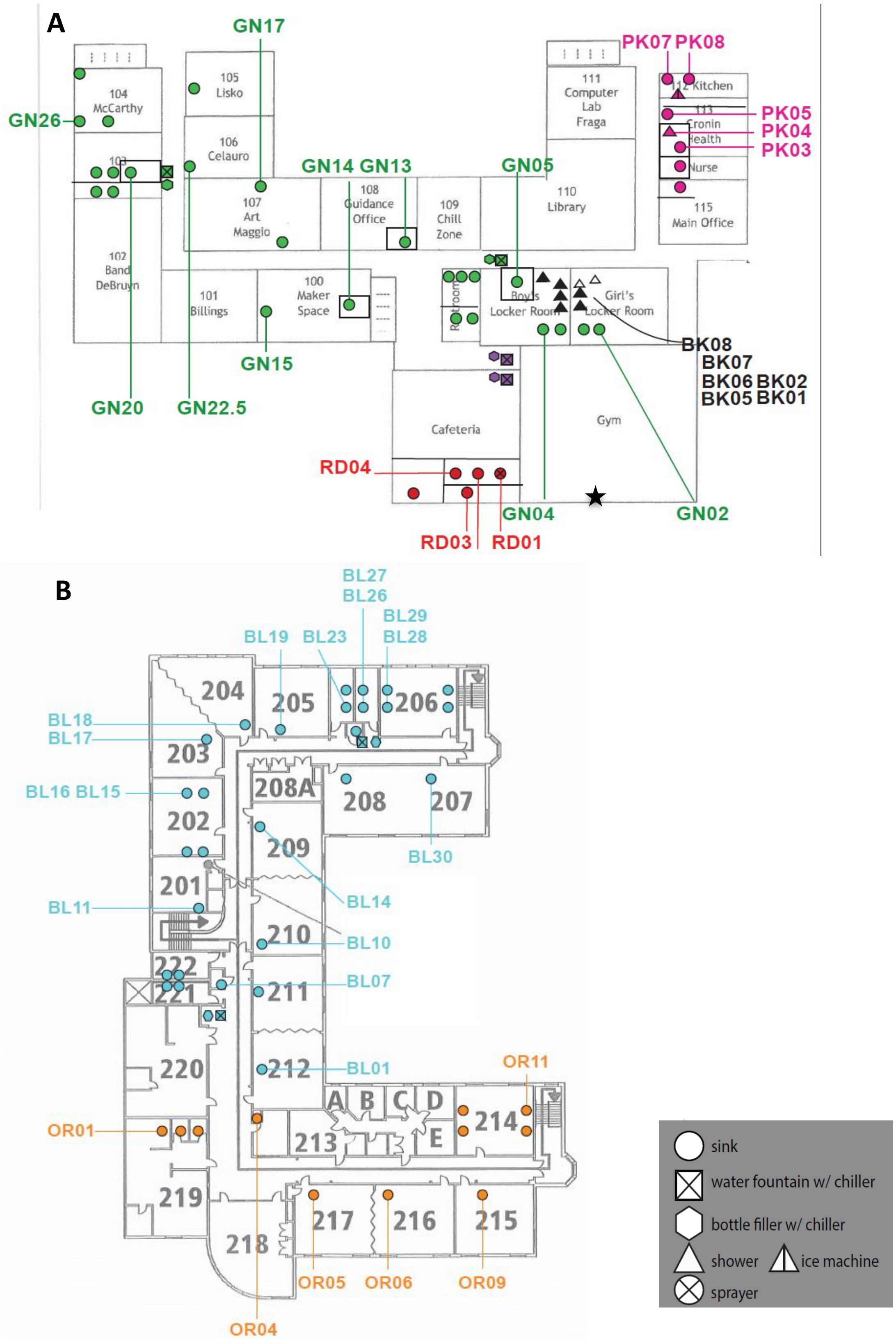

Figure 1. Middlebury Union Middle School (A) first floor and (B) second floor water outlet (sample) locations, with colors representing main water branch lines. The location of water input to the school (first floor) is in the marked with a star. Marker shapes indicate fixture type. The sample-naming scheme associated with outlets is provided in (**Appendix A**).

Sample Collection

Water was sampled from the first and second floors of the building on consecutive Saturday mornings (January 19 (1st floor) and January 26, 2019 (2nd floor) during the regular school year and prior to any use for the day.[3] Water samples were collected in certified clean HDPE Nalgene bottles (250 mL).[4] Two types of samples were collected: first draw (FD) and flush samples (FL) (**Table 1**). The two types of samples collectively provide information on the source of lead in the water and therefore, on appropriate remediation measures. First draw (FD) samples were obtained by collecting the first 250 mL of water from each outlet. After all FD samples were collected, FL samples were obtained by flushing water out of the outlets for 30 seconds and then collecting another 250 mL. Two field blanks were collected at Middlebury College the day before sample collection using ultra-purified water and were exposed to the sampling conditions of MUMS. The sample-naming scheme is described in **Appendix A**.

Table 1. Types, descriptions, and rationale for samples collected.

Sample Type	Description and Rationale
First Draw (FD)	First 250 mL of water to exit outlet after sitting stagnant in pipes for 8-12 hours (see footnote 2 on p. 3). Provides information on Pb in the drinking water from all sources, including water coming in to the school, water pipes, and the outlet fixtures and connections.
Flush (FL)	First 250 mL of water to exit outlet after sitting stagnant in pipes for 8-12, having taken a FD sample, and *subsequently having been flushed for 30 seconds*. Provides information on Pb in the drinking from all sources *excluding* the outlet fixtures and immediate connections (i.e., from more distant connections, pipes, and/or incoming water).

Sample Preparation and Lead Analysis

After collection, samples were placed in a cooler and within 48 hours were acidified to 0.5% (1.25 mL trace-metal grade HNO_3) for preservation. After 16 h or more, sample turbidity was verified to be <1 NTU and acidity pH<2. One sample had high turbidity and its lead level is considered as a low estimate of actual total lead.[5] Samples were analyzed for lead using inductively coupled plasma mass spectrometry, manufacturer-recommended conditions, and conventional quality control and quality assurance methods.[6] Lead concentrations are reported to the nearest part-per-billion (ppb, i.e., µg-Pb/L-water) for samples at/above the limit of quantification (LOQ, 0.5 ppb); as <0.5 ppb for samples with detectable lead below the LOQ; and as non-detect (n.d.) for samples with lead levels below the limit of detection (0.1 ppb)

A health-based prioritization of outlet remediation (highest, high, or moderate priority) is made based on the measured lead levels in FD samples and the potential use of the outlet for direct consumption. Lead levels are evaluated relative to two standards: the American Academy of Pediatrics health-based safety standard for school water fountains of 1 ppb and the recently passed Vermont state

[3]The U.S. EPA (2006) recommends against sampling during holidays or periods that the school is not in regular use in order to avoid collecting samples that have non-representative high levels of lead.

[4] School samples are smaller than the 1-L sample collected by public water suppliers for compliance with the Lead and Copper Rule. A smaller sample is more effective at identifying the sources of lead at an outlet because lead sample is also more representative of water per serving consumed by a child. (EPA 2006)

[5] The FD sample from the maker space classroom sink (GN14) had high turbidity (6 NTU) that was not reduced upon extended acidification. This sample was filtered (0.2 µm nylon) prior to lead determination and, therefore, represents a lower limit for its total lead content.

[6] Reliability was ensured by use of a 7-point calibration (r^2>0.999) with use of internal standards; analysis of field and calibration blank samples; analysis in triplicate (±10%); and Pb recovery for a National Institutes of Standards and Technology certified reference material (±10%) after every 10 samples.

action level for drinking water in schools of 4 ppb.

RESULTS & DISCUSSION

Lead Level Summary

Water from 95 outlets was sampled, including collecting one FD and one FL sample from each outlet. FD samples are used to evaluate lead exposures, while FL samples are used to evaluate the potential source of any lead found. Complete sample data are provided in **Appendix B**. Summary results for FD samples are shown in **Figure 2**. Most outlets produced FD samples with detectable lead (85%), but in 42% of these cases, the lead was at 1 ppb or lower and, therefore, met the AAP recommended safety level. Roughly a quarter of the FD samples hit the 4-ppb VT action level, with those reasonably used for consumption legally requiring remediation, while an additional quarter exceeded the 1-ppb AAP recommendation but did not trigger legal requirements for remediation. The potential health concerns posed, and therefore, the prioritization of outlets for remedial action, depend on the measured lead concentration and the potential use of the outlet for direct consumption.

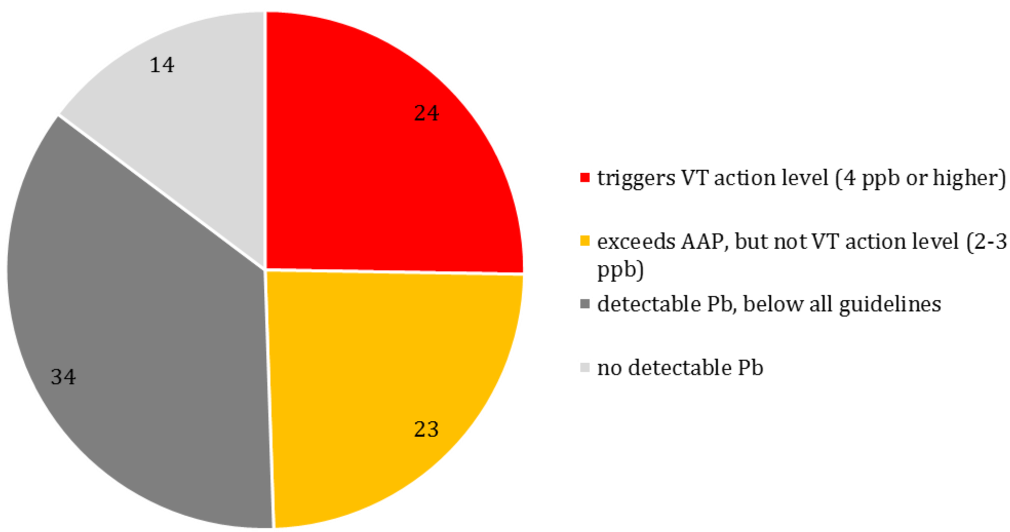

Figure 2. Summary of lead levels in Middlebury Union Middle School FD samples. Numbers represent the number of outlets producing FD samples in each lead concentration category.

All water fountains and bottle fillers at MUMS were non-detect for lead, thereby meeting the AAP safety level and VT requirements.

The 24 outlets that produced FD lead levels that exceeded the AAP recommendation and the Vermont action level included 10 classroom or office sinks (4-80 ppb), 4 kitchen sinks/sprayers (4-9 ppb), 6 showers (19-391 ppb), and 4 utility sinks (4-55 ppb). The classroom, office, and kitchen sinks require remediation (*highest priority*) due to their reasonable or known use for consumption. Showers are not intended for consumption and dermal absorption of lead is low; observation also suggests that the showers are not in routine use. Nevertheless, the very high levels in many showers suggest that care should be taken prior to returning showers to use, including extended flushing and retesting. Overall, we consider the showers a *medium priority* for remediation. We consider the utility sinks as a *low priority* for remediation, because they are not use nor reasonably used for consumption. Outlets that are reasonably used for consumption and hit the VT action level, thereby legally requiring actions are shown in **Figure 3 (red)**. Priority outlets for remediation are summarized and appropriate remedial actions are discussed below in the *Summary & Recommendations* section.

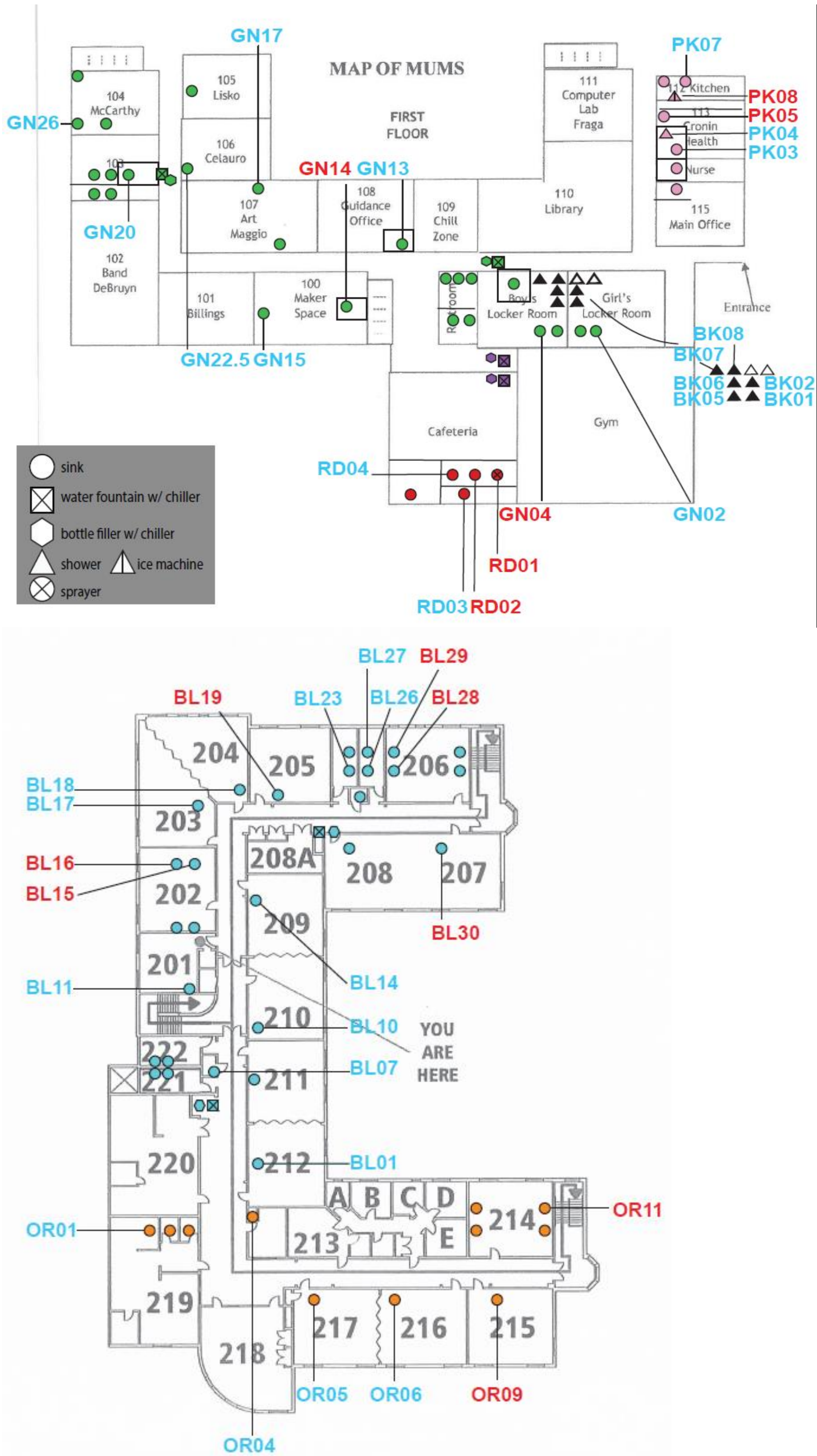

Figure 3. Floor plan showing locations and lead levels for Middlebury Union Middle School outlets reasonably used for consumption and which hit the 4-ppb VT action level, thereby legally requiring remediation (red), and which did not meet the legal requirement for action but exceeded the 1-ppb AAP safety level (blue).

The 23 outlets that produced FD lead levels that exceeded the AAP recommendation but did not trigger the VT action level (i.e., 2-3 ppb) included 15 classroom or office sinks, 6 bathroom sinks, 1 kitchen sinks, and 1 shower. The kitchen sink is consider a *highest priority* for remediation due to its use for consumption and/or food preparation. The classroom, office, and bathroom sinks are considered a *high priority* for remediation due to their reasonable or known use for consumption. Showers are not intended for consumption and dermal absorption of lead is low; observation also suggests that the showers are not in routine use. Consequently, the showers a *low priority* for remediation. Outlets that exceed the AAP safety level but not the VT action level are shown in **Figure 3 (blue)**. Priority outlets for remediation are summarized and appropriate remedial actions are discussed below in the *Summary & Recommendations* section.

Source of Lead in Water

FL samples had substantially lower lead levels as compared to their associated FD sample, which suggests that the predominant source of the lead in FD samples is the outlet fixtures or immediate connections (e.g., solder), rather than incoming water or pipes within the school. A small number of very high lead outlets had FL samples that exceeded the VT action level, likely because the outlets are not in regular use and stagnant water had stood for an extended time in the lines.

SUMMARY & RECOMMENDATIONS

Most outlets produced FD samples with detectable lead (85%), but in 42% of these cases, the lead was at 1 ppb or lower and, therefore, met the AAP recommended safety level. Roughly a quarter of the FD samples hit the 4-ppb VT action level with those reasonably used for consumption legally requiring remediation, while an additional quarter exceeded the 1-ppb AAP recommendation but did not trigger legal requirements for remediation. A summary of outlets and either their legal requirement to be remediated or simply our evaluation of health-based priority is provided in Table 2.

Table 2. Summary of Middlebury Union Middle School outlets that hit the Vermont action level or exceeded the AAP recommended safety level (i.e., "priority outlets"), with prioritization for remediation based on lead level and likelihood and frequency of use for consumption.

Required to remediate	Health-based priority level	Rationale	Outlet ID	Outlet type & location	First Draw (ppb)	Flush (ppb)
Yes	**Highest**	Hit VT Action Level and known or reasonably used for consumption	BL29	classroom sink	80	1
			GN14	maker space sink	≥50	1
			BL15	classroom sink	17	2
			OR09	classroom sink	16	1
			OR11	classroom sink	15	1
			BL28	classroom sink	15	2
			BL16	classroom sink	10	1
			PK05	health office sink	9	1
			RD01	kitchen sprayer	9	2
Yes *(cont.)*	**Highest *(cont.)***	Hit VT Action Level and known or reasonably used for consumption *(cont.)*	RD04	kitchen hand wash sink	6	2
			RD02	kitchen sink	4	2
			BL30	classroom sink	4	1
			BL19	classroom sink	4	1
			PK08	classroom kitchen sink	4	1

No	**Highest**	Exceeds AAP safety level and intended for consumption or food preparation	PK07	classroom kitchen sink	2	1
	High	Exceeds AAP safety level and reasonably used for consumption	BL23	girls bathroom sink	3	1
			PK03	nurses bathroom sink	2	1
			BL27	boys bathroom sink	2	1
			GN02	girls locker room sink	2	2
			GN04	boys locker room sink	2	2
			BL26	boys bathroom sink	2	1
			GN15	classroom sink	3	1
			GN22.5	classroom sink	3	1
			GN26	classroom sink	3	1
			OR05	classroom sink	2	1
			BL14	classroom sink	2	1
			BL10	classroom sink	2	1
			BL17	classroom sink	2	1
			BL11	classroom sink	2	1
			BL01	classroom sink	2	1
			GN13	office sink	2	1
			BL18	classroom sink	2	1
			OR06	classroom sink	2	1
			OR01	kitchenette sink	2	1
			GN17	art classroom sink	2	<0.5
			OR04	classroom sink	2	1
	Medium	Hit VT Action Level but not intended nor likely to be used for consumption	BK07	boys locker room shower	391	7
			BK08	boys locker room shower	188	2
			BK05	boys locker room shower	72	3
			BK02	girls locker room shower	70	12
			BK01	girls locker room shower	35	3
			BK06	boys locker room shower	19	2
	Low	Either not used for consumption or low lead and unlikely to be used for consumption	GN20	custodial sink	55	1
			RD03	floor sink	52	5
			BL07	utility floor sink	4	1
			PK04	Health office bathroom shower	2	2

Results suggest that the predominant source of the lead in the FD samples is the outlet fixtures or immediate connections (e.g., solder), rather than incoming water or pipes within the school.

We recommend that MUMS pursue the following *permanent* remediation approaches for *highest* and *high priority* outlets:

1) replace with "lead-free" fixture/solder <u>or</u> remove the outlet entirely, avoiding where possible

dead-end lines that hold stagnant water
2) if fixtures are replaced, verify remediation efficacy via follow-up lead testing

Until the priority outlets are permanently remediated, we recommend the following *temporary* approaches:

1) disconnect (or turn off) *highest* and *high priority* outlets
2) for priority outlets that are required for non-consumption/food preparation uses and cannot be disconnected without replacement, place signage instructing against its use for consumption or food preparation and conduct educational outreach regarding the policy and its rationale

Finally, we recommend that MUMS communicate the findings of this work and remediation updates with the school community, as well as post this report and remediation updates in a readily accessible location (e.g., school website). A draft letter describing the results for a general audience is provided as **Appendix C**.

ACKNOWLEDGEMENTS

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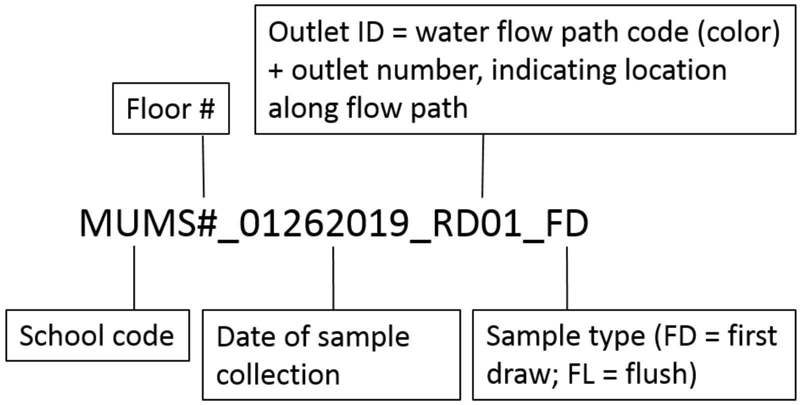
REFERENCES

1. CDC. *Sources of lead*. 2013 [cited 2018; Available from: https://www.cdc.gov/nceh/lead/tips/sources.htm.
2. EPA. *Basic information about lead in drinking water*. 2018; Available from: https://www.epa.gov/ground-water-and-drinking-water/basic-information-about-lead-drinking-water.
3. WHO. *Lead poisoning and health*. 2017 [cited 2018; Available from: http://www.who.int/mediacentre/factsheets/fs379/en/.
4. Sanborn, M., et al., *Identifying and managing adverse environmental health effects: 3. lead exposure.* Canadian Medical Association Journal, 2002. **166**: p. 1287-1292.
5. WHO. *Exposure to lead: a major public health concern*. 2010; Available from: http://www.who.int/ipcs/features/lead..pdf?ua=1.
6. Ellenhorn, M., *Lead epidemiology, industrial exposure, immunotoxicology*, in *Ellenhorn's medical toxicology, diagnosis and treatment of human poisoning*. 1997, Williams & Wilkins: Philadelphia. p. 159-160.
7. Mahaffey, K., J. McKinney, and J.R. Reigart, *Lead and compounds*, in *Environmental toxicants, human exposure and their health effects*. 2000, John Wiley & Sons: New York. p. 481-482.
8. AAP, *Prevention of childhood lead toxicity.* Pediatrics, 2016. **138**(1): p. 17.
9. Edwards, M., T. S., and D. Best, *Elevated blood lead in young children due to lead-contaminated drinking water: Washington DC 2001-2004.* Environmental Science & Technology, 2009. **43**: p. 1618-1623.
10. Laidlaw, M., et al., *Children's blood lead seasonality in Flint, MI (USA), and soil-sourced lead hazard risks.* International Journal of Environmental Research and Public Health, 2016. **13**: p. 358.
11. EPA. *Lead and Copper Rule*. 1991; Available from: https://www.epa.gov/dwreginfo/lead-and-copper-rule.
12. EPA, *3Ts for reducing lead in drinking water in schools*. 2006, U.S. Environmental Protection Agency.

13. Lambrinidou, Y., S. Triantafyllidou, and M. Edwards, *Failing our children: lead in U.S. school drinking water.* New Solutions, 2010. **20**: p. 25-47.
14. Tiemann, M., *Safe drinking water act (SDWA): A summary of the Act and its major requirements*. 2017, Congressional Research Service.
15. *Lead in Consumer Products Law, Act 193*, Vermont, Editor. 2010.
16. VDH, *Environmental Public Health Tracking: Vermont Tracking Portal*, V.D.o. Health, Editor. 2015.
17. VDH, *Vermont launches initiative to help schools test drinking water for lead*. 2017: Vermont Digger.
18. VDH, *Lead in School Drinking Water Initiative Test Results*. 2018.
19. *Middlebury Union Middle School*. 2019; Available from: https://www.acsdvt.org/mums.

Appendix A – Sample Naming Scheme

Samples collected at MUMS were assigned unique sample IDs as presented below. The IDs are composed of the school code, sampling date, flow path identification, outlet ID, and the type of sample.



Appendix B – Complete Lead Concentration Results for MUMS

Samples were collected as described in the Methods; sample names are as described and located in **Appendix A** and **Figure 1**, respectively. Lead concentrations are reported in parts-per-billion (ppb, i.e., µg-Pb/L-water) for samples at/above the limit of quantification (LOQ, 0.5 ppb); as <0.5 ppb for samples with detectable lead below the LOQ; and as non-detect (n.d.) for samples with lead levels below the limit of detection (i.e., <0.1 ppb). * indicates that a sample was not collected. Samples that hit the VT Action Level are shown in red; those that exceed the American Academy of Pediatrics safety level are shown in blue.

School	Outlet ID	Outlet Type	Outlet Description/Location	First Draw Lead Conc (ppb)	Flush Lead Conc (ppb)
MUMS1	BL01	classroom/office sink	classroom sink	2	1
MUMS1	BL02	water fountain or bottle filler	water fountain on bottle filler	n.d.	n.d.
MUMS1	BL03	water fountain or bottle filler	bottle filler	n.d.	n.d.
MUMS1	BL04	bathroom sink	boys bathroom sink	1	1
MUMS1	BL05	bathroom sink	bathroom sink	1	1
MUMS1	BL06	classroom/office sink	classroom sink	1	1
MUMS1	BL07	utility sink	utility floor sink	4	1
MUMS1	BL08	bathroom sink	girls bathroom sink	1	1
MUMS1	BL09	bathroom sink	girls bathroom sink	1	1
MUMS1	BL10	classroom/office sink	classroom sink	2	1
MUMS1	BL11	classroom/office sink	classroom sink	2	1
MUMS1	BL12	classroom/office sink	classroom sink	1	<0.5
MUMS1	BL13	classroom/office sink	classroom sink	1	<0.5
MUMS1	BL14	classroom/office sink	classroom sink	2	1
MUMS1	BL15	classroom/office sink	classroom sink	17	2
MUMS1	BL16	classroom/office sink	classroom sink	10	1
MUMS1	BL17	classroom/office sink	classroom sink	2	1
MUMS1	BL18	classroom/office sink	classroom sink	2	1
MUMS1	BL19	classroom/office sink	classroom sink	4	1
MUMS1	BL20	water fountain or bottle filler	water fountain on bottle filler	n.d.	n.d.
MUMS1	BL21	water fountain or bottle filler	bottle filler	n.d.	n.d.
MUMS1	BL22	classroom/office sink	classroom sink	n.d.	1
MUMS1	BL23	bathroom sink	girls bathroom sink	3	1
MUMS1	BL24	bathroom sink	girls bathroom sink	1	2
MUMS1	BL25	utility sink	utility floor sink	1	1
MUMS1	BL26	bathroom sink	boys bathroom sink	2	1
MUMS1	BL27	bathroom sink	boys bathroom sink	2	1
MUMS1	BL28	classroom/office sink	classroom sink	15	2
MUMS1	BL29	classroom/office sink	classroom sink	80	1
MUMS1	BL30	classroom/office sink	classroom sink	4	1
MUMS1	BL31	classroom/office sink	classroom sink	1	<0.5
MUMS1	BL32	classroom/office sink	classroom sink	1	<0.5
MUMS1	OR01	classroom/office sink	kitchenette sink	2	1
MUMS1	OR02	bathroom sink	bathroom sink	1	1
MUMS1	OR03	bathroom sink	bathroom sink	1	1
MUMS1	OR04	classroom/office sink	classroom sink	2	1
MUMS1	OR05	classroom/office sink	classroom sink	2	1
MUMS1	OR06	classroom/office sink	classroom sink	2	1
MUMS1	OR07	classroom/office sink	classroom sink	1	1
MUMS1	OR08	classroom/office sink	classroom sink	1	1
MUMS1	OR09	classroom/office sink	classroom sink	16	1
MUMS1	OR10	classroom/office sink	classroom sink	1	1
MUMS1	OR11	classroom/office sink	classroom sink	15	1
MUMS2	BK01	other	girls locker room shower	35	3
MUMS2	BK02	other	girls locker room shower	70	12
MUMS2	BK05	other	boys locker room shower	72	3
MUMS2	BK06	other	boys locker room shower	19	2
MUMS2	BK07	other	boys locker room shower	391	7
MUMS2	BK08	other	boys locker room shower	188	2

School	Outlet ID	Outlet Type	Outlet Description/Location	First Draw Lead Conc (ppb)	Flush Lead Conc (ppb)
MUMS2	GN01	bathroom sink	girls locker room sink	1	2
MUMS2	GN02	bathroom sink	girls locker room sink	2	2
MUMS2	GN03	bathroom sink	boys locker room sink	<1	<1
MUMS2	GN04	bathroom sink	boys locker room sink	2	2
MUMS2	GN05	utility sink	custodial closet floor sink	4	1
MUMS2	GN06	water fountain or bottle filler	hallway water fountain	n.d.	n.d.
MUMS2	GN07	water fountain or bottle filler	hallway bottle filler	n.d.	n.d.
MUMS2	GN08	bathroom sink	girls bathroom sink	1	<1
MUMS2	GN09	bathroom sink	girls bathroom sink	<1	<1
MUMS2	GN10	bathroom sink	girls bathroom sink	<1	<1
MUMS2	GN11	bathroom sink	boys bathroom sink	1	1
MUMS2	GN12	bathroom sink	boys bathroom sink	1	1
MUMS2	GN13	classroom/office sink	office sink	2	1
MUMS2	GN14	classroom/office sink	maker space sink	≥50	1
MUMS2	GN15	classroom/office sink	classroom sink	3	1
MUMS2	GN16	classroom/office sink	art classroom sink	1	1
MUMS2	GN17	classroom/office sink	art classroom sink	2	<0.5
MUMS2	GN18	bathroom sink	girls bathroom sink	1	1
MUMS2	GN19	bathroom sink	girls bathroom sink	1	1
MUMS2	GN20	utility sink	custodial sink	55	1
MUMS2	GN21	water fountain or bottle filler	hallway water fountain	n.d.	n.d.
MUMS2	GN22	water fountain or bottle filler	hallway bottle filler	n.d.	n.d.
MUMS2	GN22.5	classroom/office sink	classroom sink	3	1
MUMS2	GN23	bathroom sink	boys bathroom sink	<1	1
MUMS2	GN24	bathroom sink	boys bathroom sink	1	1
MUMS2	GN25	classroom/office sink	classroom sink	<1	<0.5
MUMS2	GN26	classroom/office sink	classroom sink	3	1
MUMS2	GN27	classroom/office sink	classroom sink	<1	<0.5
MUMS2	GN28	classroom/office sink	classroom sink	1	<0.5
MUMS2	PK01	classroom/office sink	office sink	<1	1
MUMS2	PK02	bathroom sink	bathroom sink	1	1
MUMS2	PK03	bathroom sink	nurses bathroom sink	2	1
MUMS2	PK04	other	nurses bathroom shower	2	2
MUMS2	PK05	classroom/office sink	nurses office sink	9	1
MUMS2	PK06	other	ice machine	n.d.	*
MUMS2	PK07	kitchen sink/sprayer	classroom kitchen sink	2	1
MUMS2	PK08	kitchen sink/sprayer	classroom kitchen sink	4	1
MUMS2	PU01	water fountain or bottle filler	cafeteria water fountain	n.d.	n.d.
MUMS2	PU02	water fountain or bottle filler	cafeteria bottle filler	n.d.	n.d.
MUMS2	PU03	water fountain or bottle filler	hallway water fountain	n.d.	n.d.
MUMS2	PU04	water fountain or bottle filler	hallway bottle filler	n.d.	n.d.
MUMS2	RD01	kitchen sink/sprayer	kitchen sprayer	9	2
MUMS2	RD02	kitchen sink/sprayer	kitchen sink	4	2
MUMS2	RD03	utility sink	floor sink	52	5
MUMS2	RD04	kitchen sink/sprayer	kitchen hand wash sink	6	2
MUMS2	RD05	kitchen sink/sprayer	kitchen sink	1	<1

[a] this sample had high turbidity (6 NTU) even after acidification for an extended time; thus, this value is considered as a low estimate of total lead concentration.

Appendix C – Sample Letter to the MUMS Community Regarding Study Results

We provide here a sample letter for sharing the study results with the school community.

Dear Parents,
As we shared earlier this year, Middlebury Union Middle School (MUMS) partnered with students and faculty researchers from Middlebury College to test all the sources of drinking water at MUMS for lead, including water from water fountains, bottle fillers, sinks, and showers -- a total of 95 outlets.

Why is it important to screen to test the school's drinking water for lead?
Although most lead exposure occurs when people eat paint chips and inhale dust, the U.S. Environmental Protection Agency (EPA) estimates that up to 20% of lead exposure may come from drinking water. Even though the public water supply to the school meets EPA's lead standards, lead can still get into a school's drinking water. As water moves through a school's plumbing system, lead can leach into the drinking water from plumbing materials and fixtures that contain lead. Testing is the best way to know if there are elevated levels of lead in the school's drinking water.

What were the results of the study?
Roughly, 1/3 of outlets (35%) produced water samples that met the AAP recommended safety level. Roughly a quarter of the FD samples hit the 4-ppb VT action level for lead, including 4 kitchen sinks/sprayers (4-9 ppb), 10 classroom or office sinks (4-80 ppb), 6 showers (19-391 ppb), and 4 utility sinks (4-55 ppb). The classroom, office, and kitchen sinks require remediation according to state law due to their reasonable or known use for consumption and are considered a *highest priority*. Researchers considered the showers and utility sinks a *medium* and *low priority*, respectively for remediation, because of their low likelihood of use for consumption but rather high lead levels.

An additional quarter of outlets produced water samples that exceeded the 1-ppb American Academy of Pediatrics safety recommendation but were below the state Action Level (i.e., 2-3 ppb), including 1 kitchen sink/sprayer; 21 classroom, bathroom, or office sinks; and 1 shower. Despite not triggering required action via state law, the kitchen sink is consider a *highest priority* for remediation due to its use for consumption and/or food preparation; the classroom, office, and bathroom sinks are considered a *high priority* for remediation due to their reasonable or known use for consumption. These low shower levels are considered a low priority for remediation. Testing suggests that the predominant source of lead is the fixtures or their immediate connections, rather than more distal pipes or the incoming water supply.

What comes next?
We have accepted the researchers' recommendations that we:
(1) replace the kitchen sink sprayer with a new lead-free spray fixture
(2) verify remediation efficacy via follow-up lead testing after fixture replacement

[INSERT LANGUAGE ON TIMELINE FOR RESPONSE/IMPLEMENTATION AND OF FOLLOWUP AFTER CHANGES HAVE BEEN MADE/IMPLEMENTED]

Where can I get more information?
For more information regarding the testing project or sampling results:
- Call Bruce MacIntire at 802-382-1500
- Access the full report at [INSERT URL FOR ACCESSING THE FULL REPORT]

For information about the health effects of lead:
- Call the Health Department at 800-439-8550
- Visit http://healthvermont.gov/drinking-water/lead
- Visit http://healthvermont.gov/environment/children/prevent-lead-poisoning -parents

To request a drinking water test kit:
- Call the Health Department Laboratory at 802-338-4736 or 800-660-9997