Lead Levels in Drinking Water at Bridport Central School, Bridport, VT

Molly Costanza-Robinson, Ph.D* and Jennifer Ortega
Dept. of Chemistry & Biochemistry; Program for Environmental Studies, Middlebury College, Middlebury, VT. *Prof. of Environ. Chemistry, mcostanz@middlebury.edu
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SUMMARY
Lead in drinking water was determined for all water outlets (n = 24) at Bridport Central School (BCS) in Bridport, 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 voluntary standards: the administrative (not health-based) 15-ppb EPA action level for residential water and the health-based 1-ppb American Academy of Pediatrics (AAP) safety recommendation for drinking fountains in schools. FL samples were used to determine the likely source of any lead in the water.

Most outlets (79%) produced FD samples that met the AAP recommended safety level. Two FD samples exceeded the EPA action level, including a classroom water fountain and a classroom sink, and were considered as a *highest priority* for remediation. Three other classroom or office sinks exceeded the AAP recommended safety level and were considered a *high priority* for remediation. FL samples suggest that the predominant source of lead was the fixtures or their immediate connections, rather than more distal pipes or the incoming water supply, which may simplify potential remediation approaches.

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 BCS 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.

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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 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]. National legislative efforts, including those by former Vermont Senator Jim Jeffords, to direct the EPA to require states to develop school testing programs and to address any problems found have been unsuccessful. 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 (in effect through 2014) 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 2014 has been reduced, with the 2011 Reduction of Lead in Drinking Water Act 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 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 [15]. 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 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 [16]. Results of that pilot showed substantial differences in the frequency of lead detection and in lead levels [17]. 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]

Bridport Central School (BCS) receives water through Tri-Town water utility and, therefore, federal law does not require it to test for lead. Under Vermont state law, BCS does test water for lead in early education (preschool) classrooms [18]. The current study represents the first-time lead levels have been tested in water from all outlets at BCS.

METHODS

Site Description

Bridport Central School (BCS) is located in the town of Bridport, VT and serves ~90 pre-kindergarten through 6th grade students each year [19]. BCS is part of the Addison Central School District, which oversees public schools in the area. BCS was constructed in 1959 with an additional wing added in 1987 [20]. During the 1987 addition and for renovations since then, some fixtures from the original building were replaced. The replacement of the fixtures and the solder used are compliant with the lead-free requirements of the 1986 Safe Drinking Water Act. 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 that could potentially be used for consumption (n = 24), even if not intended for that purpose, were mapped by location and type. Outlets at BCS included sinks (conventional and floor/utility) and water fountains (**Figure 1**). Mapping included noting 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. We did not independently verify information provided regarding plumbing and water flow in the school. Prior to commencing sampling, ACSD Superintendent Dr. Peter Burrows agreed to share information about the water testing with the school community (**Appendix A**).

[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.

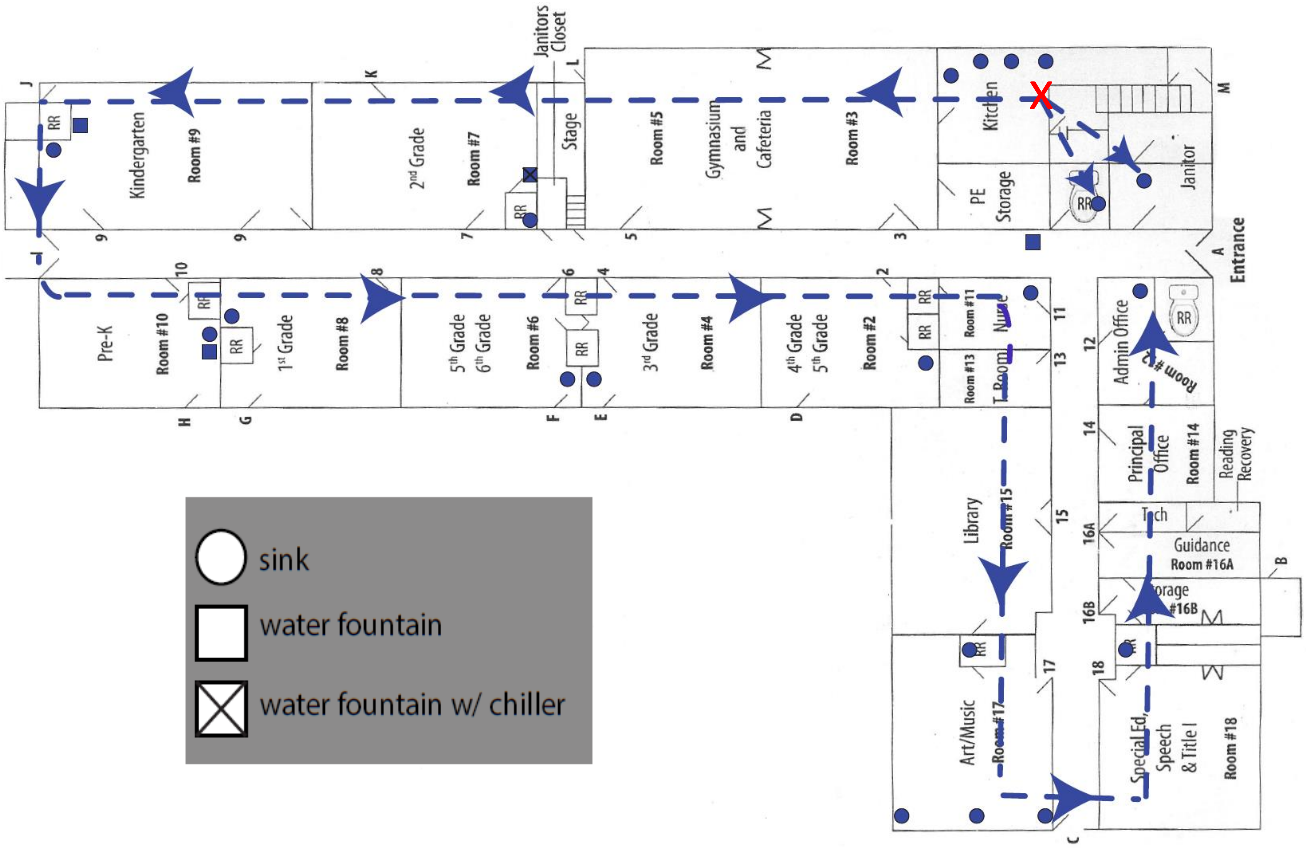

Figure 1. Bridport Central School floor plan showing water flow paths and water outlet (sample) locations. The location of water input to the school is in the marked with an X. Marker shapes indicate fixture type. The sample-naming scheme associated with outlets is provided in (**Appendix B**). The floor plan with outlet locations labeled by Outlet ID is provided in **Appendix C**.

Sample Collection

Water was sampled on a Saturday morning (January 13, 2017) during the regular school year and prior to any use for the day.[3] Water should ideally sit stagnant in the pipes and fixtures for least 8 h, but no more than 12 h before collection.[4] Water samples were collected in certified clean HDPE Nalgene bottles (250 mL).[5] 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 the BCS. The sample naming scheme and BCS floor plan showing outlet locations labeled by outlet ID are provided in **Appendix B** and **C**, respectively.

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

[4] Some outlets are used infrequently and had likely been sitting for longer than 8-12 h. We considered this to be in keeping with the goals of the EPA guidance in that our samples are representative of what a student might encounter at that particular outlet on a given day.

[5] 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)

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. 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, 1 ppb); as <1 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 voluntary standards: the administrative (not health-based) EPA action level for lead of 15-ppb and the American Academy of Pediatrics health-based safety standard for school water fountains of 1 ppb. The AAP recommendation is based on the fact that children use water fountains for direct consumption; in this report, we extend this recommendation other outlet types that might also be readily used for direct consumption by children, including bottle filling stations, classroom sinks, kitchen sinks/sprayers, and bathroom sinks.

RESULTS & DISCUSSION

Lead Level Summary

Water from 24 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 C**. Summary results for FD samples are shown in **Figure 2**. All outlets produced FD samples with detectable lead, but in most cases (79%), the lead was at 1 ppb or lower and, therefore, meets the AAP recommended safety level. The remaining five outlets produced FD samples at 2 ppb or higher (range 2-18 ppb), exceeding the AAP recommendation, of which two also exceeded the 15-ppb EPA action level (**Figure 3**). 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.

[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.

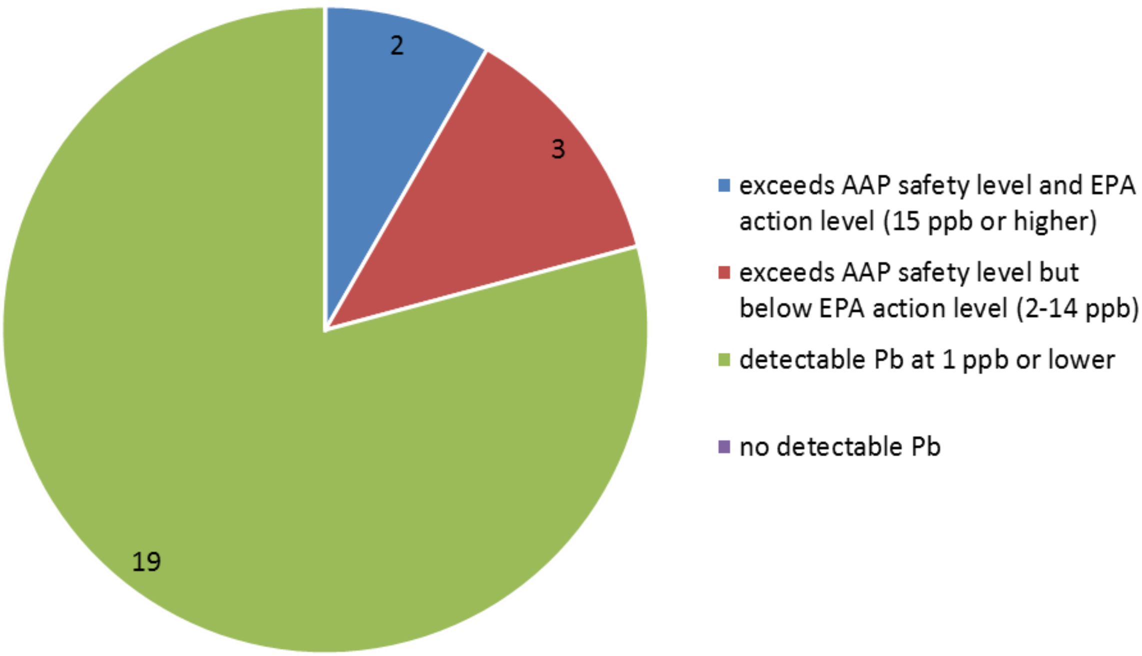

Figure 2. Summary of lead levels in Bridport Central School FD samples. Numbers represent the number of outlets producing FD samples in each lead concentration category. All FD samples had detectable lead.

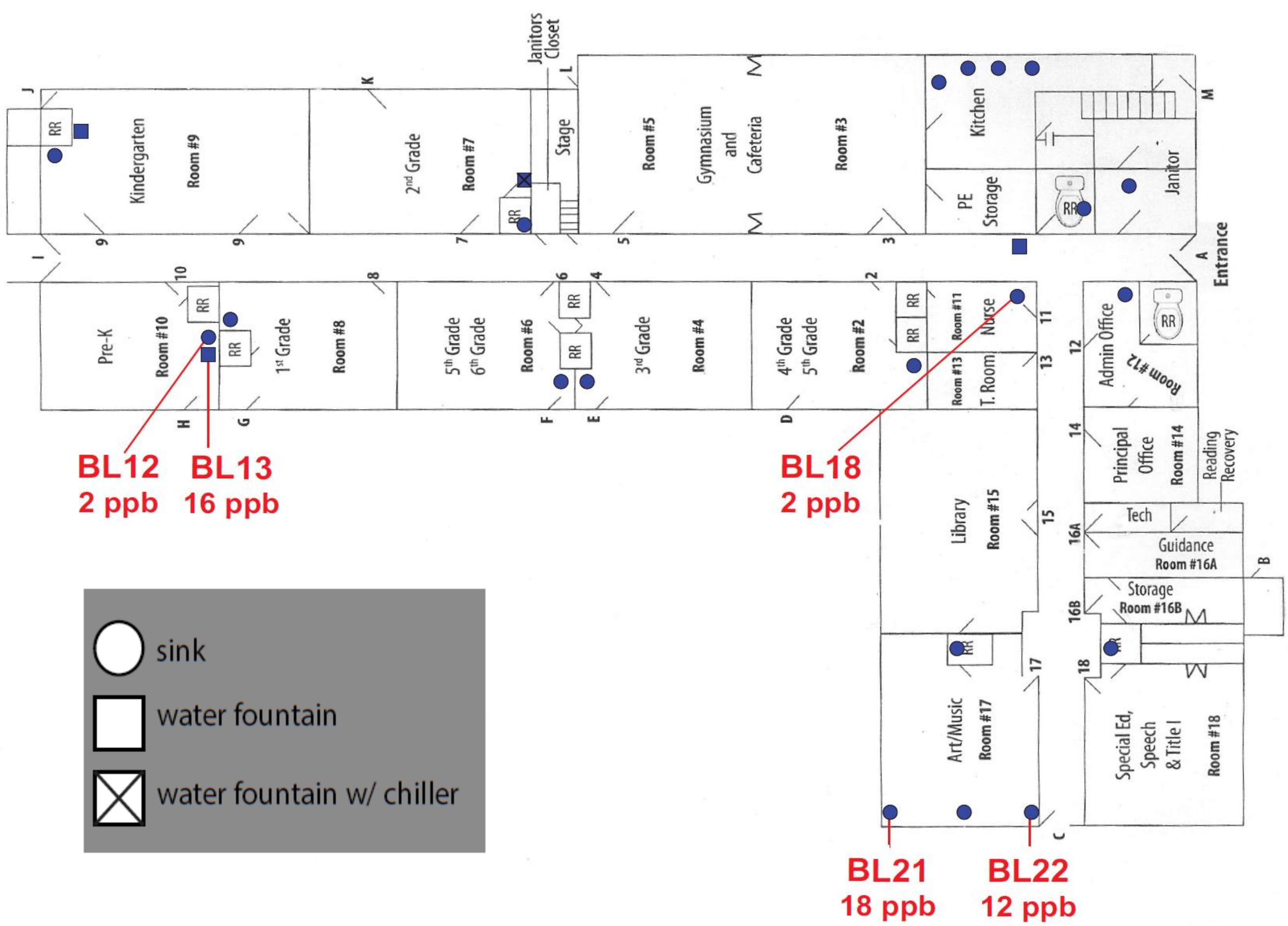

Figure 3. Floor plan showing locations and lead levels for Bridport Central School outlets that exceeded the EPA action level of 15-ppb or the American Academy of Pediatrics recommended safety level of 1 ppb.

The two outlets that produced FD samples that exceed the administrative EPA action level of 15 ppb were the classroom water fountain (16 ppb, BL13, Room 10) and a classroom sink (18 ppb, BL21, Room 17). Both of these outlets are considered as *highest priority* outlets for remedial action.

Three sinks produced FD lead levels (2-12 ppb) that were below the EPA action level, but exceeded the AAP recommendation: the sink in the health office (2 ppb, BL18) and two classroom sinks (12 ppb, BL22, Room 17; 2 ppb, BL12, Room 10). Although BCS children and staff are advised against drinking from sinks [20], these outlets are available and convenient for use by children and staff; we did not note any signage instructing against their use for direct consumption. For these reasons, we include these three outlets as a *high priority* for remediation. 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 lower lead levels as compared to their associated FD sample, which suggests 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. All but one FL sample were either non-detect for lead or lead was present only at trace levels (e.g., <1 ppb), which suggests that flushing may serve as an effective temporary measure for four of the five priority outlets. The BL13 outlet (classroom water fountain), which produced one of the FD EPA exceedances, produced water at 3 ppb, exceeding the AAP recommendation, even after the 30-second flush.

SUMMARY & RECOMMENDATIONS

All 24 outlets produced FD samples with detectable lead. Most (79%) of those with detectable lead were at trace levels or lower (i.e., <1 ppb) and are not considered to be a safety concern. Two FD samples exceeded the EPA action level, including a classroom water fountain and a classroom sink, while three sinks exceeded the health-based AAP recommended safety level. A summary of outlets prioritized for remediation is shown in **Table 2** and their locations in **Figure 3**, with priority level indicated based on lead levels and the likelihood and frequency of direct consumption.

Table 2. Summary of Bridport Central School outlets that exceeded the EPA action level or 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.

Priority level	Concern	Rationale	Outlet ID	Outlet type & location	First Draw (ppb)	Flush (ppb)
Highest	Exceeds EPA action level	Likely & frequent use for direct consumption	BL13	classroom water fountain, Room 10	16	3
		Potential use for direct consumption	BL21	classroom sink, Room 17	18	1
High	Exceeds AAP recommended safety level	Potential use for direct consumption	BL22	classroom sink, Room 17	12	<1
			BL12	classroom sink, Room 10	2	n.d.
			BL18	health office sink, Room 11	2	n.d.

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 BCS pursue the following *permanent* remediation approach for priority outlets:

1) replace existing outlet fixtures with "lead-free" fixtures/solder or remove the outlets entirely
2) if replaced, verify remediation efficacy via follow-up lead testing following replacement

Until priority outlets are permanently remediated, we suggest that BCS pursue the following *temporary* approaches:

1) disconnect water supply to the priority water fountain (BL13)
2) disconnect water supply to priority sinks in locations where water is not needed for non-consumption uses
3) for priority sinks in locations where water *is* needed for non-consumption uses,
    a. establish school-wide policies for water consumption from outlets by outlet type (e.g., "only drink from water fountains and bottle fillers,"), rather than location-specific policies
    b. complement school-wide policy with age-appropriate signage at each priority outlet instructing against consumption and with educational outreach regarding the policy and its rationale

Finally, we recommend that BCS 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 E**.

ACKNOWLEDGEMENTS

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Appendix A – Communication with BCS Community Prior to Sampling

The following letter was drafted for BCS to share with the school community prior to commencing sampling.

Dear Parents,

This winter, Bridport Central School will partner with students and faculty researchers from Middlebury College to test all the sources of drinking water at Bridport Central for lead. Bridport Central is pursuing this testing, because Middlebury College is incorporating this testing into one of its courses, and the drinking water testing will be conducted at no cost to the school.

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 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.

How will samples be taken? Student researchers will follow standard EPA methods and guidelines to take the samples from any taps supplying water that may be consumed including drinking fountains and bathroom, kitchen, and classroom sinks. Samples will be analyzed at Middlebury College. Some duplicate samples will also be sent to a certified commercial laboratory for analysis.

How long will it take to get the results? Laboratory results should be available within 2-4 weeks after samples are collected. The results will be reviewed by the school to determine if any follow-up actions are needed, although none are anticipated based on the previous testing. Results will be shared with parents, faculty, and staff within two weeks after the results are received by the school.

What will happen if there is lead in the drinking water at the school? Fixtures that show lead levels at or above the action level of 15 parts per billion (ppb) will require follow-up sampling to pinpoint the source of the lead (pipes or fixtures). If lead levels are at or above 15 ppb, the school is committed to fixing the problem using a combination of easy fixes including:

- Routine practices (clean debris from screens, flush holding tanks, place signage).
- Permanent measures (install filtration systems, replace piping, replace water fixtures).

Where can I get more information?
For more information regarding the testing project or sampling results:

- Call Bruce MacIntire at 802-382-1500

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

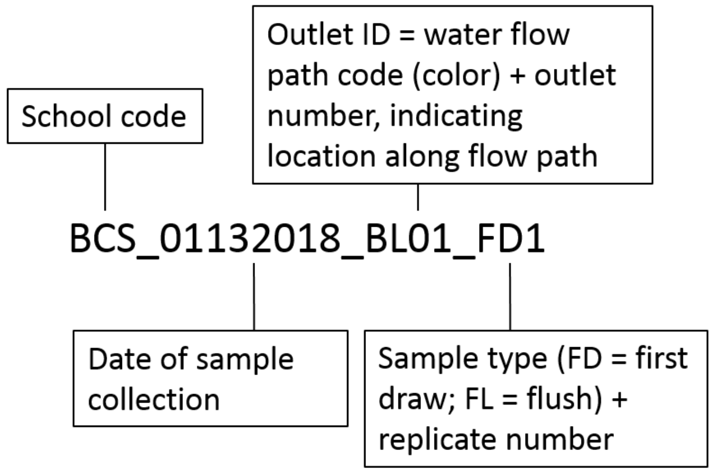
To request a drinking water test kit:

- Call the Health Department Laboratory at 802-338-4736 or 800-660-9997

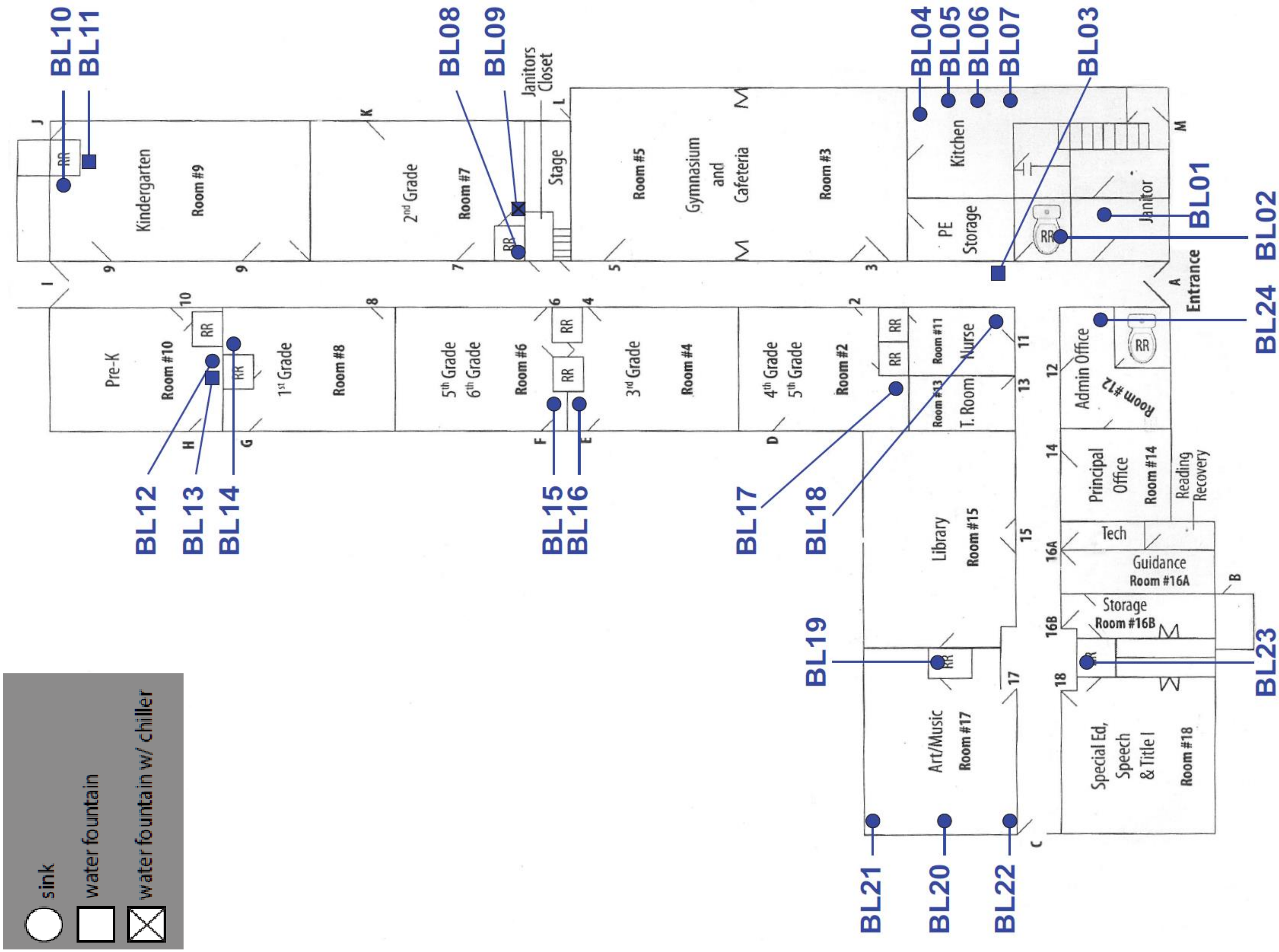
Sincerely,
Dr. Peter Burrows
Superintendent ACSD

Appendix B - Sample Naming Scheme

Samples collected at BCS 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 C – BCS Floor plan showing Outlet Locations and Outlet IDs



Appendix D – Complete Lead Concentration Results for BCS

Samples were collected as described in the Methods; sample names are as described and located in **Appendix B** and **C**, 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, 1 ppb); as <1 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). Samples that exceed the EPA action level are shown in red and those that exceed the AAP (but not the EPA) recommendation are shown in blue.

School	Outlet ID	Outlet Type	Outlet Description/Location	First Draw Lead Conc (ppb)	Flush Lead Conc (ppb)
BCS	BL19	bathroom sink	Room 15/17 bathroom sink	1	<1
BCS	BL02	bathroom sink	bathroom sink	<1	n.d.
BCS	BL08	bathroom sink	Room 7 bathroom sink	<1	<1
BCS	BL23	bathroom sink	Room 16B/18 bathroom sink	<1	n.d.
BCS	BL12	classroom or office sink	Room 10 classroom sink	2	<1
BCS	BL18	classroom or office sink	Room 11, health office sink	2	<1
BCS	BL22	classroom or office sink	Room 17 classroom sink	12	<1
BCS	BL21	classroom or office sink	Room 17 classroom sink	18	1
BCS	BL10	classroom or office sink	Room 9 classroom sink	<1	n.d.
BCS	BL14	classroom or office sink	Room 8 classroom sink	<1	<1
BCS	BL15	classroom or office sink	Room 6 classroom sink	<1	n.d.
BCS	BL16	classroom or office sink	Room 4 classroom sink	<1	n.d.
BCS	BL17	classroom or office sink	Room 2 classroom sink	<1	n.d.
BCS	BL20	classroom or office sink	Room 17 classroom sink	<1	1
BCS	BL24	classroom or office sink	Room 12 administrative office sink	<1	n.d.
BCS	BL04	kitchen sink/sprayer	kitchen sink	1	<1
BCS	BL05	kitchen sink/sprayer	kitchen sink	1	n.d.
BCS	BL06	kitchen sink/sprayer	kitchen sink	<1	n.d.
BCS	BL07	kitchen sink/sprayer	kitchen sink	<1	n.d.
BCS	BL01	utility sink	utility sink in custodial closet	<1	n.d.
BCS	BL13	water fountain or bottle filler	Room 10 water fountain	16	3
BCS	BL03	water fountain or bottle filler	hallway water fountain	<1	<1
BCS	BL09	water fountain or bottle filler	Room 7 water fountain	<1	1
BCS	BL11	water fountain or bottle filler	Room 9 water fountain	<1	<1

Appendix E – Sample Letter to the BCS Community Regarding Study Results

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

Dear Parents,
As we shared this past spring, Bridport Central School (BCS) partnered with students and faculty researchers from Middlebury College to test all the sources of drinking water at BCS for lead, including water from water fountains and sinks -- a total of 24 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?
Most outlets at the school (79%) met the American Academy of Pediatrics (AAP) recommended safety level of 1 ppb for lead in school drinking water. One water fountain (16 ppb) and one sink (18 ppb) exceeded the EPA action level and were considered a *highest priority* for remediation. An additional three classroom or office sinks exceeded the AAP recommendation but not the EPA action level (2-12 ppb) and were considered a *high 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 older fixtures and those with demonstrated exceedances – especially those used for consumption – with newer Pb-free fixtures and Pb-free solder – or remove the outlets entirely
(2) Verify remediation efficacy via follow-up lead testing following 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