Lead Levels in Drinking Water at Mary Hogan Elementary School, Middlebury, VT

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SUMMARY
Lead in drinking water was determined for all water outlets (n = 101) at Mary Hogan Elementary School (MHES) 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 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.

More than half of the outlets (54%) exceeded the American Academy of Pediatrics (AAP) recommended safety level for school water fountains (2-71 ppb), of which three also exceeded the 15-ppb EPA action level. Six water fountains, 4 kitchen sinks, and 39 classroom or office sinks exceeded the AAP recommended safety level (2-10 ppb), while two utility sinks and the health office shower exceeded the EPA action level (18-71 ppb). FL samples suggest that the predominant source of lead is the fixtures or their immediate connections, rather than incoming water or pipes within the school. Nevertheless, 14 outlets delivered water that exceeded the AAP recommendation *even after flushing*, which suggests that some more distal pipes or connections may contain lead and also contribute to lead levels in water and that flushing prior to use is not a generally effective approach at MHES for reducing lead to acceptable levels.

We categorized the six water fountains and four kitchen sinks that exceeded the AAP recommendation as *highest priority* for remediation due to their likely use for direct consumption or for food preparation. *High priority* was placed on remediating the shower and remaining bathroom and classroom sinks that exceeded the AAP or EPA action level, but which are less likely and/or less frequently used for consumption. Utility sinks were generally considered a *low priority* for remediation, depending on their location and potential for use for consumption (e.g., within a custodial closet vs. in the kitchen (considered a *high priority*)).

Recommended permanent remedial actions include replacing fixtures with “lead-free” fixtures/solder, with follow-up testing to verify remediation efficacy, or removing the outlets entirely. Additionally, we recommend that MHES 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]

Mary Hogan Elementary School (MHES) is on the Town of Middlebury municipal water supply and, therefore, federal law does not require it to test for lead. Under Vermont state law, MHES does test water for lead in early education (preschool) classrooms [18]. MHES has also voluntarily tested select drinking water outlets within the school in the past [19]. The current study represents the first-time lead levels have been tested in water from all outlets at MHES.

METHODS

Site Description

Mary Hogan Elementary School is located in the town of Middlebury, VT and serves ~430 pre-kindergarten through 6th grade students each year, making it the largest elementary school in Addison County [20]. MHES is part of the Addison Central School District, which oversees public schools in the area. The original building was constructed in 1956, with the C wing extended (year unknown) and the E-Wing added in 2000 (**Figure 1**). We worked with Director of Facilities, Bruce MacIntire, 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 = 101), even if not intended for that purpose, were mapped by location and type. Outlets at MHES included sinks (conventional and floor/utility), water fountains, bottle fillers, and showers (**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 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 EPA's 3Ts, and includes questions regarding pipe and fixture type and composition, building age, and dates of renovation, among other information.

Sample Collection

Water was sampled on a Saturday morning (September 30, 2017 or January 13, 2018) 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.[6] 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 MHES. The sample naming scheme and MHES floor plan showing outlet locations labeled by outlet ID are provided in **Appendix B** and **C**, respectively.

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 graphite furnace atomic absorption spectrophotometry and/or inductively coupled plasma mass spectrometry, manufacturer-recommended conditions, and conventional quality control and quality assurance methods.[7] 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.[8] A health-based prioritization of

[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)

[6] A-Wing and E-Wing West FL samples were collected by flushing out the water for 30 seconds, turning the outlet off, and then turning the outlet back on for collection. All other FL samples from the other wings were collected by flushing the water for 30 seconds and immediately collecting the sample without turning off the outlet.

[7] Reliability was ensured by use of a 5-point calibration; analysis of field and calibration blank samples; analysis in triplicate (±10%); Pb recovery for a National Institutes of Standards and Technology certified reference material (±10%). More than 10% of samples were independently analyzed by two analytical techniques (GFAAS and ICPMS) (±10%) and typically within <1 ppb; averages of independent analyses are reported.

[8] The limit of detection (LOD) varied by analytical technique: LOD_{GFAAS} = 0.5 ppb; LOD_{ICP} = 0.1 ppb.

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.

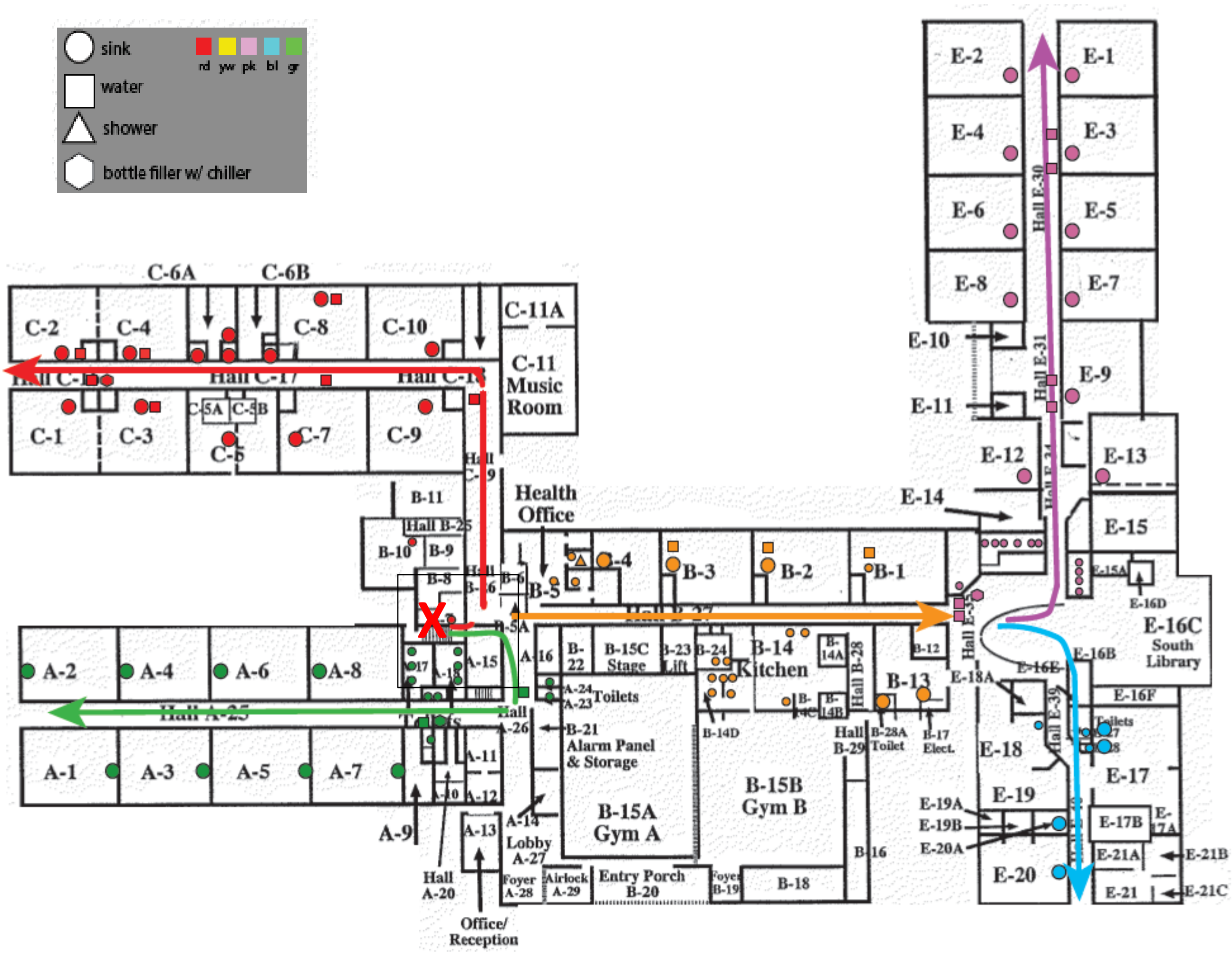

Figure 1. Mary Hogan Elementary School floor plan showing water flow paths and water outlet (sample) locations. The location of water input to the school is marked with an X. The three main flows stemming from the water entry point are red (RD), green (GC), and yellow (YW), with branches off the yellow path shown in pink (PK) and blue (BL); these color/path indications are included in the sample naming scheme (**Appendix B**). Marker shapes indicate fixture type. Floor plans with outlet locations labeled by Outlet ID are provided in **Appendix C**.

RESULTS & DISCUSSION

Lead Level Summary

Water from 101 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**. More than half of the outlets (54%) exceeded the American Academy of Pediatrics (AAP) recommended safety level for school water fountains (2-71 ppb), of which three also exceeded the 15-ppb EPA action level. 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.

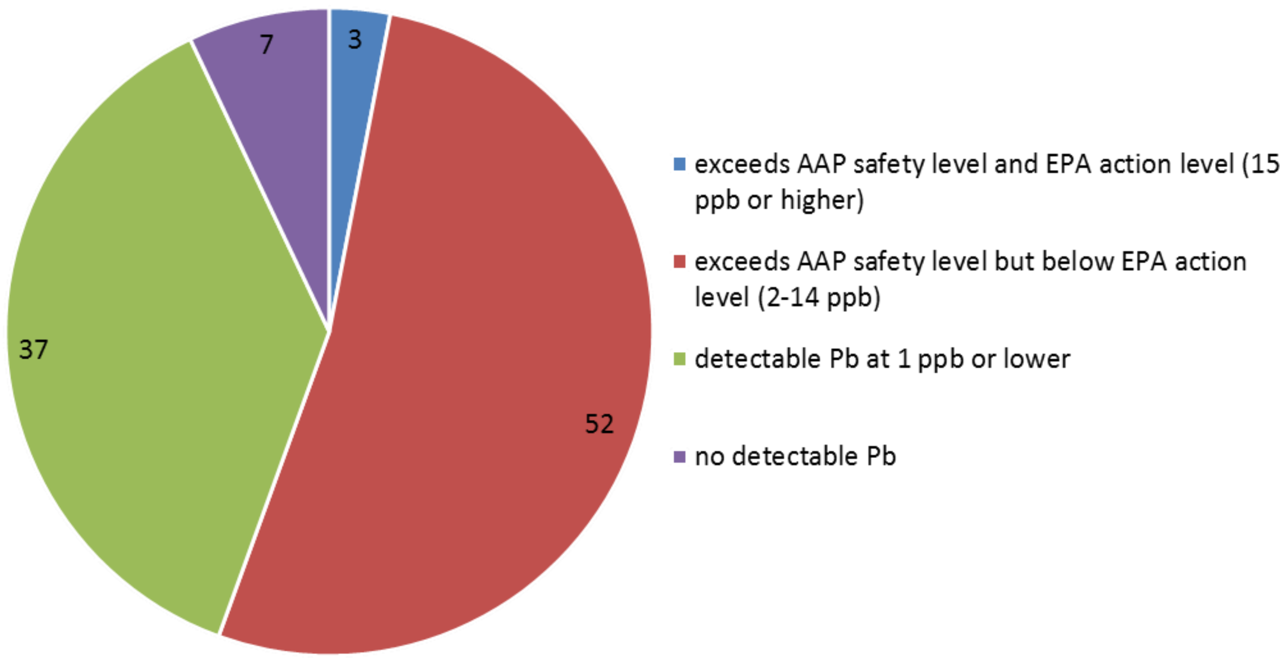

Figure 2. Summary of lead levels in Mary Hogan Elementary School FD samples (total outlets = 101), by lead concentration category. Numbers represent the number of outlets.

The three outlets that produced FD samples that exceed the administrative EPA action level of 15 ppb were a shower in the health office (71 ppb, YW03); a utility (floor) sink in the kitchen (25 ppb, YW20); and a utility sink in a utility closet (18 ppb, YW09) (**Figure 3**). While the health office shower is not intended for direct consumption and is used infrequently, it delivered water at nearly five times the EPA action level and children are the likely users of the shower, increasing the potential for lead exposure. Similarly, although utility sinks are not intended for direct consumption, the location of the YW20 within the kitchen opens up the possibility, for example, of using it to fill larger water coolers that might be challenging to fill and lift out of a conventional sink, and therefore increases the potential for lead exposure. For these reasons, we consider both the shower and kitchen utility sink as *high priority* outlets for remedial action. In contrast, the utility sink located within a custodial closet (YW09) that exceeded the EPA limit is considered as only a *moderate priority*. Priority outlets for remediation are summarized and appropriate remedial actions are discussed in the *Summary & Recommendations* section below.

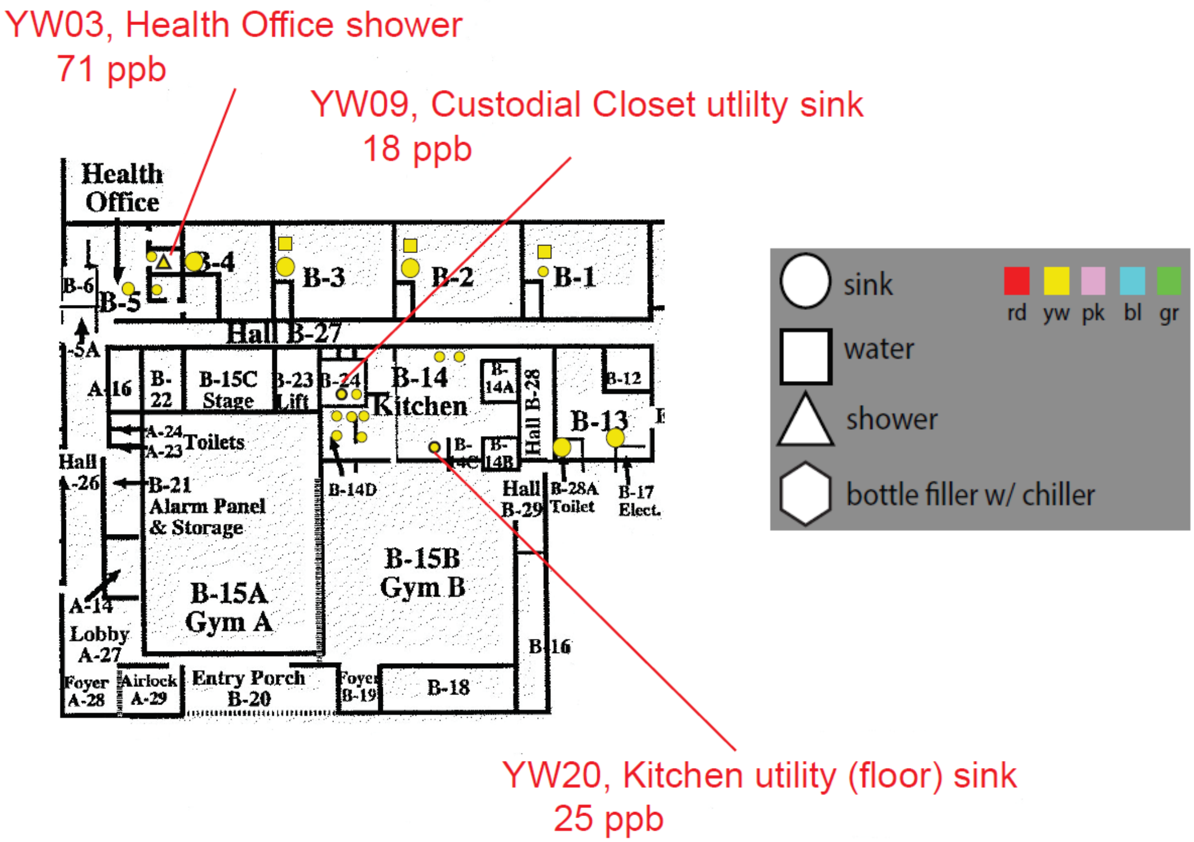

Figure 3. Floor plan showing all Mary Hogan Elementary School outlets that met/exceeded the EPA action level of 15 ppb.

Just over half of the outlets (51%, 52 outlets) produced FD lead levels that were below the EPA action level, but exceeded the AAP recommendation. These outlets produced FD samples ranging from 2 to 10 ppb. All outlets that exceeded either the EPA action level or the AAP safety level are shown in **Figure 4**.

The potential health risk posed by these outlets depends on their use for direct consumption. Of the 20 water fountains and bottle filling stations in MHES, six water fountains produced FD samples that exceeded the AAP safety level, ranging from 2 to 6 ppb, and are classified as a *highest priority* for remediation (**Figure 5**). Additionally, 28 classroom/office sinks, 4 kitchen sinks/sprayers, and 11 bathroom sinks produced FD samples that exceeded the AAP recommendation (**Table 2**). Although MHES children and staff are advised against drinking from sinks [21], these outlets are available and often convenient for use by children and staff; we did not note any signage instructing against their use for direct consumption. Further, there is anecdotal evidence suggesting that MHES school children consume water from classroom sinks at least some of the time.[9] For these reasons, we include these 43 outlets as a *high priority* for remediation. The three utility sinks located in custodial closets that exceeded the AAP recommendation but were below the EPA action level are considered as a *low priority* concern because they are highly unlikely to be used for consumption.

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

[9] Anecdotes provided by current and recently former MHES students.

(e.g., solder), rather than incoming water or pipes within the school. One sample, RD11, a sink located in classroom C-5A was the only notable exception, for which the FD and FL samples had water lead levels of 3 and 7 ppb, respectively. This relatively small increase in an isolated sample is likely due to the flushing action serving to flake off lead-containing particles (scale) from within the pipe (e.g., [22]). Although FL samples contained substantially lower lead levels than their associated FD samples, 14 outlets delivered water that exceeded the AAP recommendation even after flushing; this may indicate that pipes or more distal connections are contributing lead to the samples. For this reason, we do not recommend flushing prior to use for consumption as an effective temporary measure for reducing lead to acceptable levels.

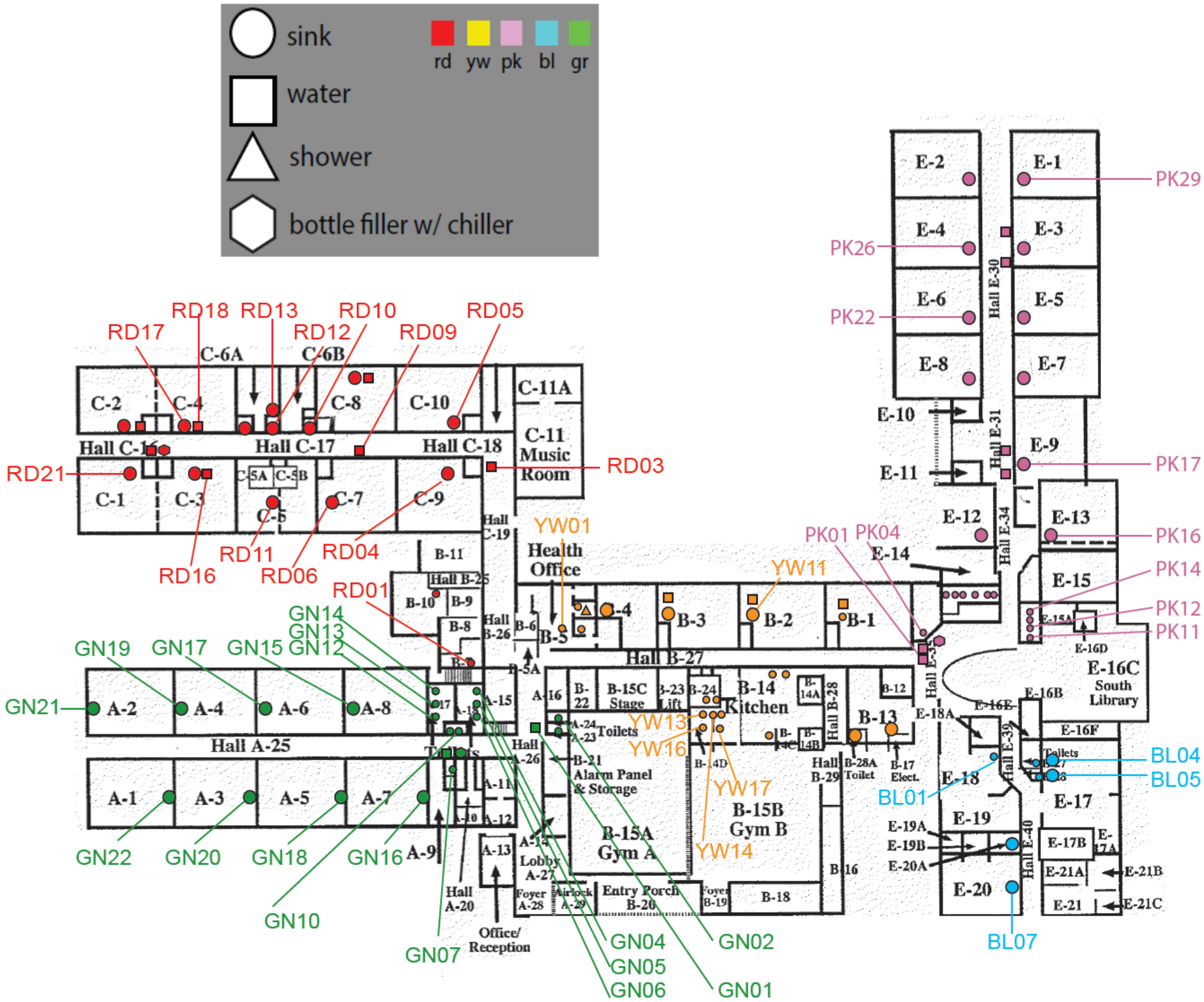

Figure 4. Floor plan showing location of all Mary Hogan Elementary School outlets that exceeded the American Academy of Pediatrics recommended safety level of 1 ppb. FD lead levels for each outlet are provided in **Figure 5** for water fountains and in **Table 2** for sinks.

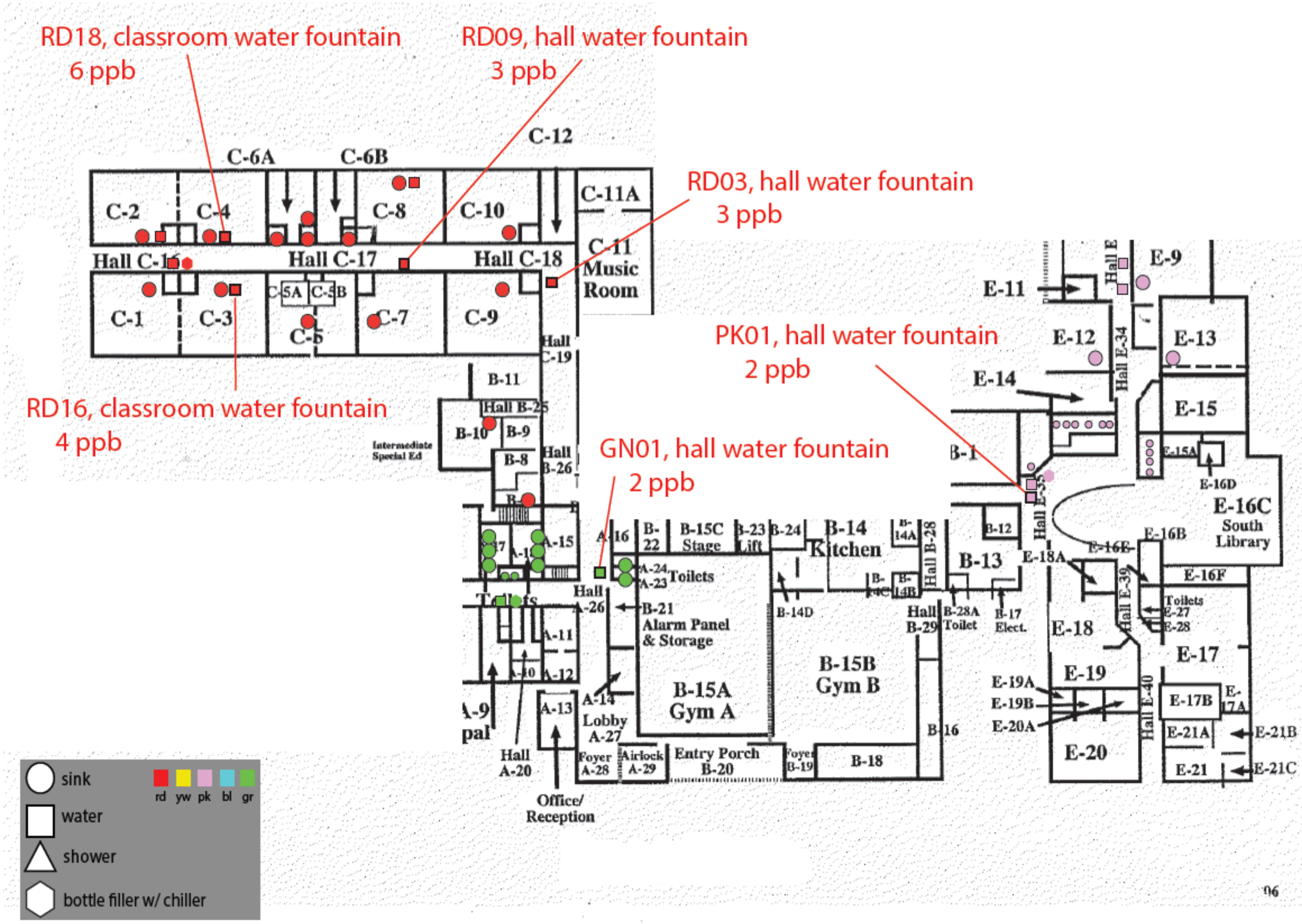

Figure 5. Floor plan showing location and lead concentration of Mary Hogan Elementary School water fountains that exceeded the American Academy of Pediatrics recommended safety level of 1 ppb.

Table 2. Mary Hogan Elementary School sinks by location type and lead concentration that exceeded the American Academy of Pediatrics recommended safety level of 1 ppb.

Outlet category (number)	Outlet ID (water lead concentration, ppb)
Kitchen sink/sprayer (4)	7 ppb: YW14 3 ppb: YW16, YW17 2 ppb: YW13
Classroom/office sink (28)	10 ppb: BL07, PK16 8 ppb: GN21 4 ppb: YW01 3 ppb: BL04, GN15, GN16, GN18, GN19, GN20, PK22, RD01, RD11 2 ppb: BL05, GN07, GN17, GN22, PK17, PK26, PK29, RD04, RD05, RD06, RD13, RD17, RD21, YW11, YW21
Bathroom sink (11)	6 ppb: GN13, PK14 5 ppb: GN12, GN14 4 ppb: RD10 3 ppb: GN05, PK11 2 ppb: GN02, GN04, GN06, PK12
Utility sink in custodial closet (3)	10 ppb: GN10 4 ppb: RD10 2 ppb: PK04

SUMMARY & RECOMMENDATIONS

Most of the 101 outlets (91%) produced FD samples with detectable lead. Roughly a quarter of those with detectable lead were at trace levels (i.e., <1 ppb) and are not considered to be a safety concern. Three samples exceeded the EPA 15-ppb action level, while 6 water fountains and 46 sinks/sprayers exceeded the health-based AAP 1-ppb safety recommendation for school water fountains. A summary of outlets prioritized for remediation is shown in **Table 3**.

Table 3. Summary of Mary Hogan Elementary School outlets that exceeded either 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	Exceedance level	Concern	Outlet ID	Outlet type & location	First Draw (ppb)	Flush (ppb)
Highest	Exceeds AAP recommended safety level	Likely & frequent use for direct consumption or food preparation	RD18	Water fountain; C-4 classroom	6	2
			RD16	Water fountain; C-3 classroom	4	<1
			RD09	Water fountain; hallway outside C-7	3	<1
			RD03	Water fountain; hallway near music room	3	1
			GN01	Water fountain; hallway near gym	2	2
			PK01	Water fountain; near library	2	2
			YW14	Kitchen sink, B-14	7	<1
			YW16	Kitchen sink, B-14	3	<1
			YW17	Kitchen sink, B-14	3	<1
			YW13	Kitchen sink, B-14	2	n.d.
High	Exceeds EPA action level	Not intended for direction consumption, but nearly 5x EPA action level	YW03	Shower; health office	71	5
		Potential use for direct consumption; nearly 2x the EPA action level	YW20	Utility sink in kitchen	25	2
	Exceeds AAP recommended safety level	Potential frequent use for direction consumption	The 39 bathroom, office, and classroom sinks shown in **Table 2**			
Moderate	Exceeds EPA action level	Unlikely for use for direction consumption	YW09	Utility sink in custodial closet	18	3
Low	Exceeds AAP recommended safety level	Unlike for use for direction consumption	GN10	Utility sinks in custodial closets	10	<1
			RD10		4	1
			PK04		2	1

Results suggest that the predominant source of the lead in the FD samples is likely the outlet fixtures or immediate connections (e.g., solder), rather than incoming water or pipes within the school. Nevertheless, 14 outlets delivered water that exceeded the AAP recommendation even after flushing, which may indicate that pipes or more distal connections are also contributing lead to the samples.

We recommend that MHES 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 the following *temporary* approaches:

1) Disconnect water supply to priority water fountains
2) Disconnect water supply to priority sinks/showers/sprayers in locations where water is not needed for non-consumption uses
3) For priority sinks/showers/sprayers 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," or "do not drink from sinks"), 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 MHES 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 – Draft Letter to the MHES Community Prior to Sampling

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

Dear Parents,

This winter, Mary Hogan Elementary will partner with students and faculty researchers from Middlebury College to test all the sources of drinking water at Mary Hogan Elementary for lead. Mary Hogan Elementary 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

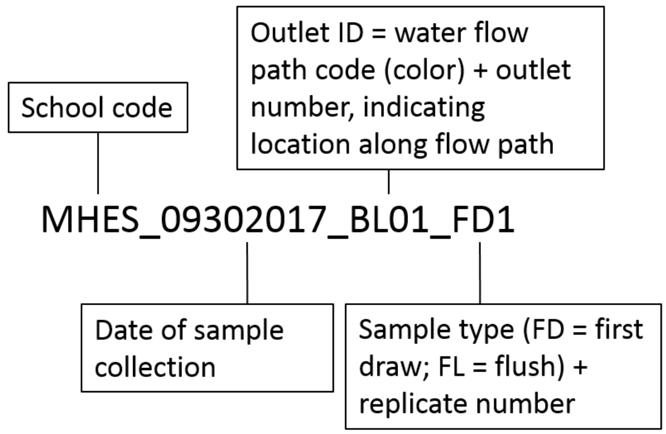
To request a drinking water test kit:

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

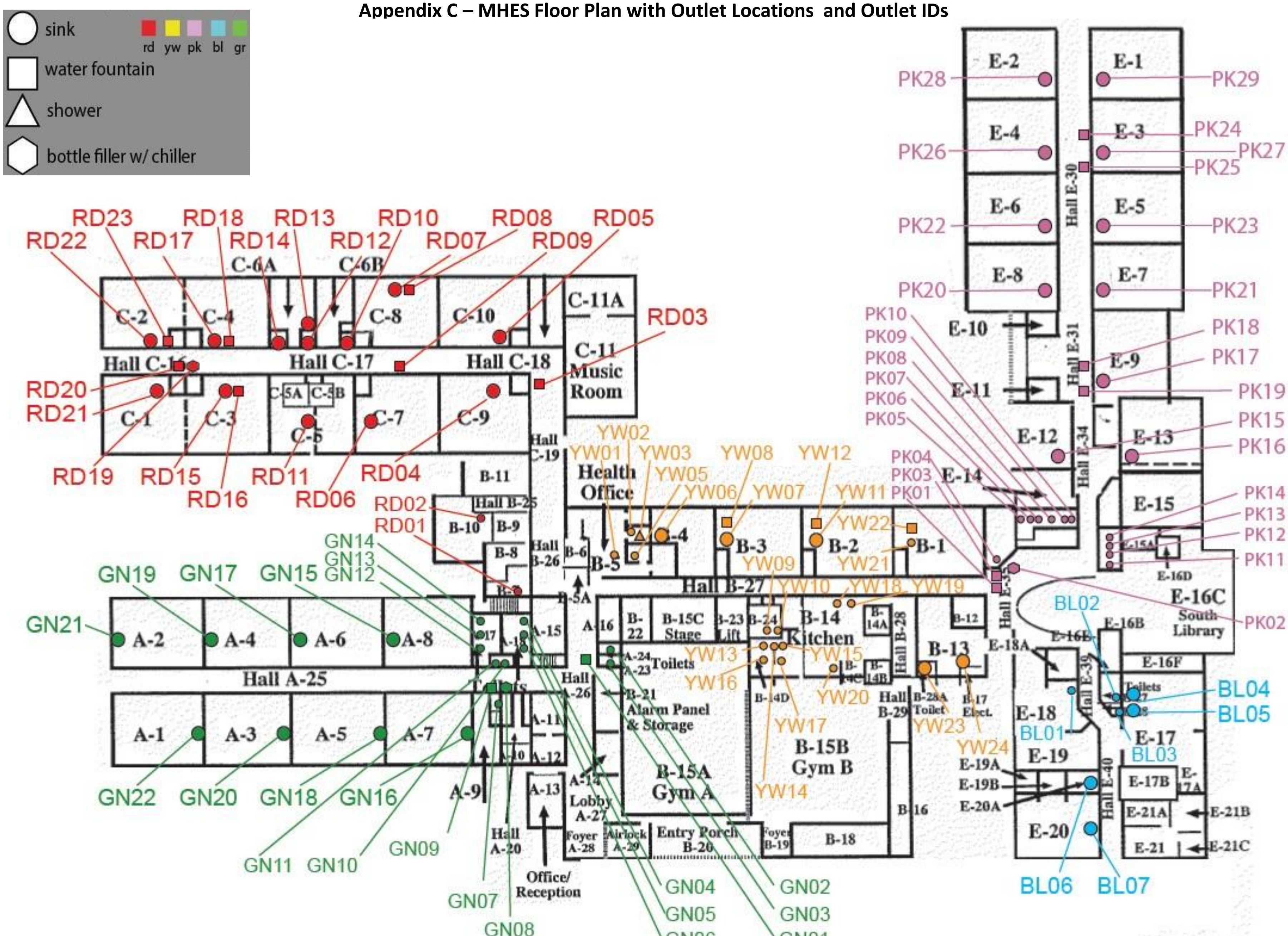
Sincerely,
Dr. Peter Burrows
Superintendent ACSD

Appendix B - Sample Naming Scheme

Samples collected at MHES 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 – MHES Floor Plan with Outlet Locations and Outlet IDs



Appendix D – Complete Lead Concentration Results for MHES

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. n/a indicates outlets were not in service. Outlets/samples that meet or exceed the EPA action level are shown in **red** and those that exceed the AAP safety level but are below the EPA action level are shown in **blue**.

School	Outlet ID	Outlet Type	Outlet Description/Location	First Draw Lead Conc (ppb)	Flush Lead Conc (ppb)
MHES	BL01	classroom/office sink	E-18 classroom sink	2	1
MHES	BL02	bathroom sink	bathroom sink	<1	n.d.
MHES	BL03	bathroom sink	bathroom sink	<1	<1
MHES	BL04	classroom/office sink	E-17 classroom sink	3	<1
MHES	BL05	classroom/office sink	E-17 classroom sink	2	<1
MHES	BL06	classroom/office sink	E-20A office sink	<1	n.d.
MHES	BL07	classroom/office sink	E-20 classroom sink	10	4
MHES	GN01	water fountain or bottle filler	Hall A-26 water fountain	2	2
MHES	GN02	bathroom sink	A-24 bathroom sink	2	2
MHES	GN03	bathroom sink	A-23 bathroom sink	1	<1
MHES	GN04	bathroom sink	A-18 bathroom sink	2	n.d.
MHES	GN05	bathroom sink	A-18 bathroom sink	3	<1
MHES	GN06	bathroom sink	A-18 bathroom sink	2	<1
MHES	GN07	classroom/office sink	A-9 office sink	2	n.d.
MHES	GN08	water fountain or bottle filler	Hall A-15 bottle filler	n.d.	n.d.
MHES	GN09	water fountain or bottle filler	Hall A-25 water fountain	n.d.	n.d.
MHES	GN10	utility sink	Custodial closet utility sink	10	<1
MHES	GN11	utility sink	Custodial closet utility sink	*	*
MHES	GN12	bathroom sink	A-17 bathroom sink	5	1
MHES	GN13	bathroom sink	A-17 bathroom sink	6	1
MHES	GN14	bathroom sink	A-17 bathroom sink	5	1
MHES	GN15	classroom/office sink	A-8 classroom sink	3	<1
MHES	GN16	classroom/office sink	A-7 classroom sink	3	n.d.
MHES	GN17	classroom/office sink	A-6 classroom sink	2	<1
MHES	GN18	classroom/office sink	A-5 classroom sink	3	n.d.
MHES	GN19	classroom/office sink	A-4 classroom sink	3	<1
MHES	GN20	classroom/office sink	A-3 classroom sink	3	n.d.
MHES	GN21	classroom/office sink	A-2 classroom sink	8	1
MHES	GN22	classroom/office sink	A-1 classroom sink	2	<1
MHES	PK01	water fountain or bottle filler	Hall E-35 water fountain	2	2
MHES	PK02	water fountain or bottle filler	Hall E-35 bottle filler	n.d.	n.d.
MHES	PK03	water fountain or bottle filler	Hall E-35 water fountain	n.d.	n.d.
MHES	PK04	utility sink	Custodial closet utility sink	2	1
MHES	PK05	bathroom sink	bathroom sink	<1	<1
MHES	PK06	bathroom sink	bathroom sink	<1	n.d.
School	Outlet ID	Outlet Type	Outlet Description/Location	First Draw Lead Conc (ppb)	Flush Lead Conc (ppb)

MHES	PK07	bathroom sink	bathroom sink	<1	<1
MHES	PK08	bathroom sink	bathroom sink	n.d.	<1
MHES	PK09	bathroom sink	bathroom sink	<1	<1
MHES	PK10	bathroom sink	bathroom sink	<1	n.d.
MHES	PK11	bathroom sink	bathroom sink	3	2
MHES	PK12	bathroom sink	bathroom sink	2	3
MHES	PK13	bathroom sink	bathroom sink	*	*
MHES	PK14	bathroom sink	bathroom sink	6	2
MHES	PK15	classroom/office sink	E-12 classroom sink	<1	n.d.
MHES	PK16	classroom/office sink	E-13 classroom sink	10	4
MHES	PK17	classroom/office sink	E-9 classroom sink	2	n.d.
MHES	PK18	water fountain or bottle filler	Hall E-31 water fountain	<1	n.d.
MHES	PK19	water fountain or bottle filler	Hall E-31 water fountain	<1	n.d.
MHES	PK20	classroom/office sink	E-8 classroom sink	1	n.d.
MHES	PK21	classroom/office sink	E-7 classroom sink	1	n.d.
MHES	PK22	classroom/office sink	E-6 classroom sink	3	n.d.
MHES	PK23	classroom/office sink	E-5 classroom sink	1	n.d.
MHES	PK24	water fountain or bottle filler	Hall E-30 water fountain	<1	n.d.
MHES	PK25	water fountain or bottle filler	Hall E-30 water fountain	*	*
MHES	PK26	classroom/office sink	E-4 classroom sink	2	<1
MHES	PK27	classroom/office sink	E-3 classroom sink	<1	n.d.
MHES	PK28	classroom/office sink	E-2 classroom sink	1	n.d.
MHES	PK29	classroom/office sink	E-1 classroom sink	2	n.d.
MHES	RD01	classroom/office sink	B-7 office sink	3	2
MHES	RD02	classroom/office sink	B-10 office sink	<1	n.d.
MHES	RD03	water fountain or bottle filler	Hall C-19 water fountain	3	1
MHES	RD04	classroom/office sink	C-9 classroom sink	2	<1
MHES	RD05	classroom/office sink	C-10 classroom sink	2	<1
MHES	RD06	classroom/office sink	C-7 classroom sink	2	n.d.
MHES	RD07	classroom/office sink	C-8 classroom sink	1	n.d.
MHES	RD08	water fountain or bottle filler	C-8 classroom water fountain	<1	<1
MHES	RD09	water fountain or bottle filler	Hall C-17 water fountain	3	<1
MHES	RD10	utility sink	Custodial closet utility sink	4	1
MHES	RD11	classroom/office sink	C-5A classroom sink	3	7
MHES	RD12	bathroom sink	bathroom sink	2	n.d.
MHES	RD13	classroom/office sink	C-6A classroom sink	2	<1
MHES	RD14	bathroom sink	bathroom sink	1	n.d.
MHES	RD15	classroom/office sink	C-3 classroom sink	<1	n.d.
MHES	RD16	water fountain or bottle filler	C-3 classroom water fountain	3	<1
MHES	RD17	classroom/office sink	C-4 classroom sink	2	n.d.
MHES	RD18	water fountain or bottle filler	C-4 classroom water fountain	6	2
MHES	RD19	water fountain or bottle filler	Hall C-16 bottle filler	n.d.	n.d.
MHES	RD20	water fountain or bottle filler	Hall C-16 water fountain	n.d.	n.d.
MHES	RD21	classroom/office sink	C-1 classroom sink	2	n.d.
School	**Outlet ID**	**Outlet Type**	**Outlet Description/Location**	**First Draw Lead Conc (ppb)**	**Flush Lead Conc (ppb)**

MHES	RD22	classroom/office sink	C-2 classroom sink	1	n.d.
MHES	RD23	water fountain or bottle filler	C-2 classroom water fountain	n.d.	<1
MHES	YW01	classroom/office sink	B-5 health office sink	4	<1
MHES	YW02	bathroom sink	health office bathroom sink	<1	n.d.
MHES	YW03	other	health office upper shower	71	5
MHES	YW04	other	health office lower shower	*	*
MHES	YW05	bathroom sink	bathroom sink	1	n.d.
MHES	YW06	classroom/office sink	B-4 classroom sink	1	<1
MHES	YW07	classroom/office sink	B-3 classroom sink	<1	n.d.
MHES	YW08	water fountain or bottle filler	B-3 classroom water fountain	<1	n.d.
MHES	YW09	utility sink	B-24 custodial closet utility sink	18	3
MHES	YW10	utility sink	B-24 custodial closet utility sink	<1	<1
MHES	YW11	classroom/office sink	B-2 classroom sink	2	<1
MHES	YW12	water fountain or bottle filler	B-2 classroom water fountain	<1	n.d.
MHES	YW13	kitchen outlet	B-14 kitchen sink	2	n.d.
MHES	YW14	kitchen outlet	B-14 kitchen sink	7	<1
MHES	YW15	kitchen outlet	B-14 kitchen sprayer	<1	n.d.
MHES	YW16	kitchen outlet	B-14 kitchen sink	3	<1
MHES	YW17	kitchen outlet	B-14 kitchen sink	3	<1
MHES	YW18	kitchen outlet	B-14 kitchen sink	1	n.d.
MHES	YW19	kitchen outlet	B-14 kitchen sink	<1	n.d.
MHES	YW20	utility sink	B-14 kitchen utility sink	25	2
MHES	YW21	classroom/office sink	B-1 classroom sink	1	n.d.
MHES	YW22	water fountain or bottle filler	B-1 classroom water fountain	<1	n.d.
MHES	YW23	bathroom sink	B-28A bathroom sink	n.d.	<1
MHES	YW24	classroom/office sink	B-13 office sink	1	<1

Appendix E – Sample Letter to the MHES 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, Mary Hogan Elementary partnered with students and faculty researchers from Middlebury College to test all the sources of drinking water at Mary Hogan for lead, including water from water fountains, bottle fillers, sinks, showers, and kitchen sprayers -- a total of 101 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?

More than half of the outlets (54%) exceeded the American Academy of Pediatrics (AAP) recommended safety level for school water fountains (2-71 ppb), of which three also exceeded the 15-ppb EPA action level. All bottle fillers and most water fountains met the AAP recommended safety level. Six water fountains and 46 sinks exceeded the AAP level (2-10 ppb), while two utility sinks and the health office shower exceeded the EPA 15-ppb action level (18-71 ppb). Researchers categorized the six water fountains and 2 kitchen sinks that exceeded the AAP recommendation as a *highest priority* for remediation due to their known or potential use for direct consumption or use in food preparation, with (lower) priority placed on remediating the outlets that exceeded the AAP recommendation or EPA action level, but which are not likely to be used for consumption. Results suggested that the predominant source of lead is the fixtures or their immediate connections, rather than more distal pipes or the incoming water supply. Nevertheless, 14 outlets delivered water that exceeded the AAP recommendation *even after flushing*, which suggests that more distal pipes and connections may contain lead and also contribute to lead levels in water.

What comes next?

We have accepted the researchers' recommendations that we:

(1) replace older fixtures and those with demonstrated exceedances – especially those used for food preparation and consumption – with newer Pb-free fixtures and Pb-free solder – or disconnect the water supply from the outlet entirely

(2) adopt a school-wide policy (and conduct associated educational outreach) against consuming water from sinks.

[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