

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

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August 17, 2018

SUMMARY

Lead in drinking water was determined for all water outlets ($n = 122$) at Middlebury Union High School (MUHS) 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) samples were collected for all outlets, acidified ($\text{pH} < 2$), 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 collected only for outlets that produced FD samples that exceeded the EPA action level and were used to determine the likely source of any lead in the water.

Most outlets (79%) produced FD samples that exceeded the American Academy of Pediatrics (AAP) recommended safety level for school water fountains (2-41 ppb), with 12 of these outlets also exceeding the 15-ppb EPA action level. EPA exceedances included 1 food preparation sink (26 ppb), 8 classroom/office sinks (16-41 ppb), and 3 bathroom sinks (15-20 ppb). A total of 84 outlets (69%) exceeded the AAP safety level but not the EPA action level (2-14 ppb); these included 3 water fountains, 8 kitchen sinks/sprayers, 35 classroom/office sinks, 36 bathroom sinks, and 2 utility sinks. 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, nearly 40% of the FL samples 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 MUHS for reducing lead to acceptable levels.

We categorized the 3 water fountains and 9 kitchen or food preparation sinks/sprayers that exceeded the AAP or EPA levels as *highest priority* for remediation due to their intended use for direct consumption or for food preparation. *Highest priority* was placed on remediating 11 classroom/office and bathroom sinks that exceeded the EPA action level due to their potential use for consumption. Remaining bathroom and classroom/office sinks that exceeded the AAP but not the EPA action level were considered a *high priority* for remediation. The utility sinks were considered a *low priority* for remediation, because they are contained within a custodial closet and not likely to be used for consumption.

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 MUHS 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 ($<5 \mu\text{g-Pb/dL-blood}$), 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 $\sim 35\text{-}50\%$ [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 $1 \mu\text{g/L}$ (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]. The U.S. Government Accountability Office recently took the U.S. Environmental Protection Agency to task for not better protecting children from lead exposure via school drinking water [11].

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 [12]. 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 [13]. This results in water being tested for lead in only $\sim 8\text{-}11\%$ of schools nationwide [14] and fewer than half of school districts ever having tested for lead in any of their schools [11]. 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” [15]. 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 $\leq 0.25\%$ lead and the wetted surfaces of solder and flux contain a weighted average of $\leq 0.2\%$ 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 [15]. 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 $5 \mu\text{g/dL}$ 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 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 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

Middlebury Union High School (MUHS) is on the Town of Middlebury municipal water supply and, therefore, federal law does not require it to test for lead. MUHS has 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 MUHS.

METHODS

Site Description

Middlebury Union High School (MUHS) is located in the town of Middlebury, VT and serves ~650 from Middlebury and surrounding towns. MUHS is part of the Addison Central School District, which oversees public schools in the area. MUHS was built prior to 1986, with renovations and additions made more recently [19]. 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 ($n = 122$), even if not intended for that purpose, were mapped by location and type. Outlets at MUHS included sinks (conventional and floor/utility), kitchen sprayers, water fountains, bottle fillers, and an ice machine (**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.

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.

Prior to commencing sampling, ACSD Superintendent Dr. Peter Burrows agreed to share information about the water testing with the school community (**Appendix A**).



Figure 1. Middlebury Union High School floor plan showing water flow paths and water outlet (sample) locations. Marker shapes indicate fixture type. The location of water input to the school (Boiler Room) is marked with an X. Samples were collected in order from upstream to downstream within and between flow paths. The three main flows stemming from the water source are red (RD), blue (BL) and green (GR); branches off these primary paths are shown in yellow (YW), and for the upper floors, pink (PK), turquoise (TQ), and purple (PU); these color/path indications are included in the sample naming scheme (**Appendix B**). Floor plans with outlet locations labeled by Outlet ID are provided in **Appendix C**.

Sample Collection

Water was sampled on two Saturday mornings (March 18 and April 22, 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. Confirmatory FD and FL samples were collected on the second sampling date only for outlets for which the first FD sample exceeded the EPA action level. The sample naming scheme and MUHS 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 <i>subsequently having been flushed for 30 seconds</i> . Provides information on Pb in the drinking from all sources <i>excluding</i> 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 HNO₃) for preservation. After 16 h or more, total suspended solids was verified to be <1% by weight 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.⁶ Any sample that exceeded 15 ppb was analyzed a second time (in triplicate) to confirm the exceedance. 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.⁷ 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

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 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%). ~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.

⁷ The limit of detection (LOD) varied by analytical technique: LOD_{GFAAS} = 0.5 ppb; LOD_{ICP} = 0.1 ppb.

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 122 outlets was sampled, including collecting FD samples for each outlet and FL samples for outlet that produced FD samples that exceeded the EPA action level. 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**. Most outlets (79%) exceeded the American Academy of Pediatrics (AAP) recommended safety level for school water fountains (2-41 ppb), with 14 of these outlets also meeting/exceeding 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.

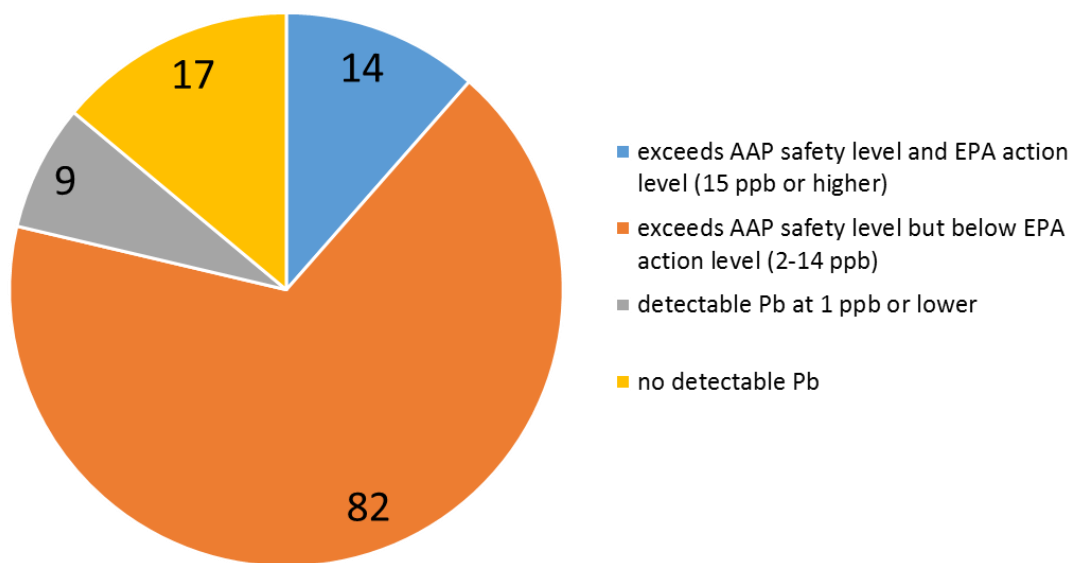


Figure 2. Summary of lead levels in Middlebury Union High School FD samples (total outlets = 122), by lead concentration category. Numbers represent the number of outlets.

The 14 outlets that produced FD samples that met/exceeded the administrative EPA action level of 15 ppb were a food preparation sink (26 ppb); ten classroom or office sinks (15-41 ppb), and three bathroom sinks (15-20 ppb). Locations and lead levels in these 13 outlets are shown in **Figure 3**. The food preparation sink is located at the “pizza kiosk” within the cafeteria; although intended primarily for hand-washing its location within an area expressly used for food preparation increases the likelihood and potential frequency of its use for consumption or food preparation. For this reason, we consider the pizza kiosk sink as a *highest priority* outlet for remedial action. The classroom/office and bathroom sinks are potentially used for consumption, even if the locations of some sinks should deter students from drinking from them (i.e., in the chemistry classroom), and are categorized as a *high priority* for remediation. Priority outlets for remediation are summarized and appropriate remedial actions are discussed in the *Summary & Recommendations* section below.

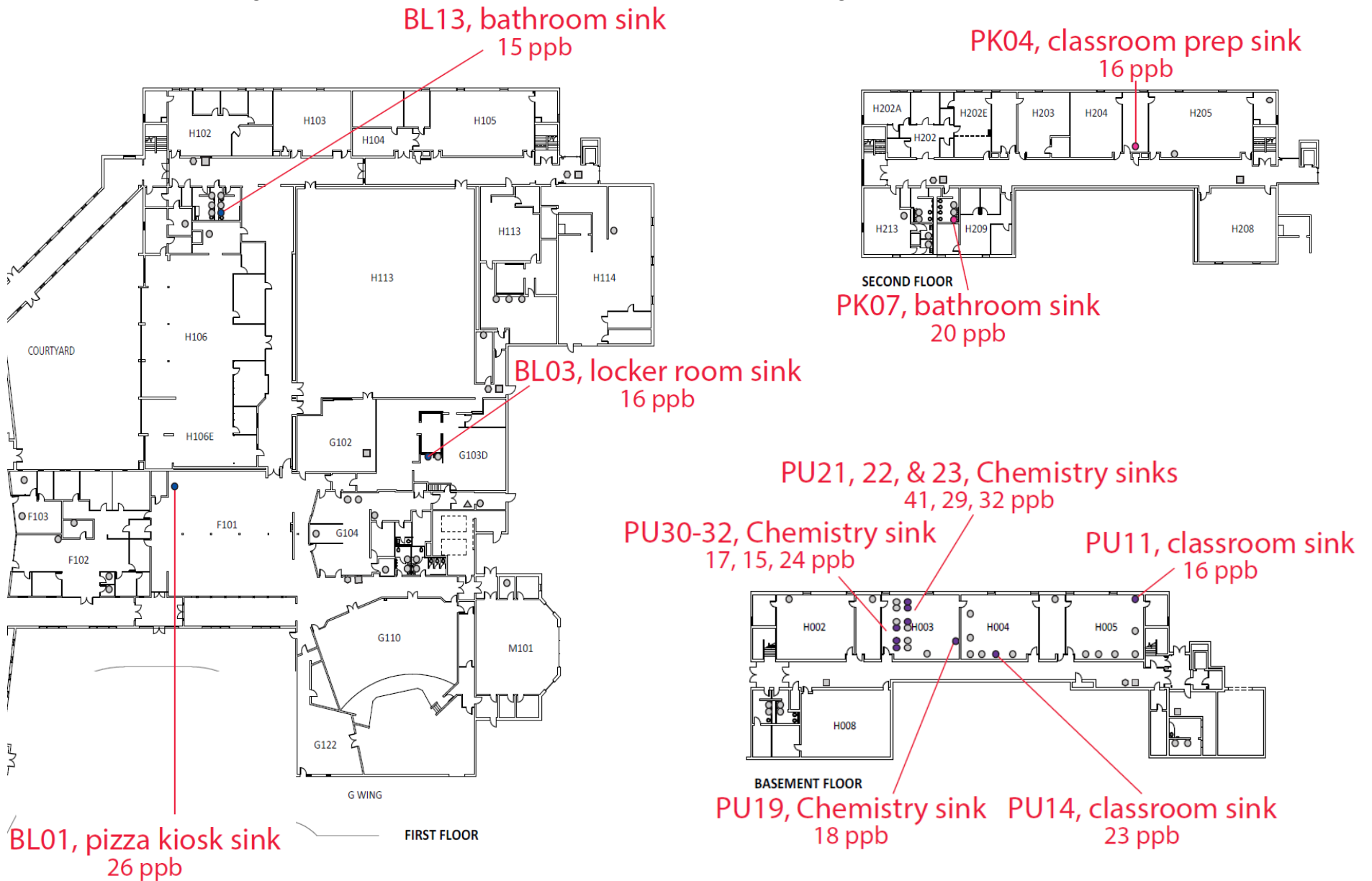


Figure 3. Floor plan sections showing Middlebury Union High School locations and lead levels for outlets that met/exceeded the EPA action level of 15 ppb.

A total of 82 outlets (67%) produced FD lead levels that were below the EPA action level, but exceeded the AAP recommendation. These outlets included 3 water fountains (6, 9 and 12 ppb), 8 kitchen sinks/sprayers (2-7 ppb, includes sinks in cooking classrooms); 33 classroom/office sinks (2-12 ppb), 36 bathroom sinks (2-13 ppb), and 2 utility sinks (4 and 5 ppb); their lead levels and locations are listed and shown in **Table 2** and **Figure 4**, respectively.

The potential health risk posed by these outlets depends on the nature of their use for direct consumption. Of the 22 water fountains and bottle filling stations in MUHS, three water fountains produced FD samples that exceeded the AAP safety level (6-12 ppb), and are classified as a *highest priority* for remediation. Likewise, the eight kitchen sink/sprayers are considered as a *highest priority*, given their use for direct consumption or food preparation. The classroom/office and bathroom sinks are convenient for use for consumption, including students filling water bottles and staff making coffee, and are therefore classified as a *high priority* for remediation. The two 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.

Table 2. Middlebury Union High School outlets by location type and lead concentration that exceeded the American Academy of Pediatrics recommended safety level of 1 ppb but not the EPA action level.

Outlet category (number)	Outlet ID (water lead concentration, ppb)	
Water fountain (3)	12 ppb: PU35	
	9 ppb: BL02	
	6 ppb: TQ01	
Kitchen sink/sprayer (8)	7 ppb: RD09, RD07	
	5 ppb: RD11	
	4 ppb: RD08	
	3 ppb: YW08 ^a	
	2 ppb: YW03, YW05, YW06 ⁸	
Classroom/office sink (33)	12 ppb: PU24	6 ppb: PU07, PU08, PU29, RD27
	11 ppb: PU12, PU27, PU33	5 ppb: YW09
	10 ppb: PU25, PU26, PU34	4 ppb: BL19, PK10, PU10, PU13, PU15, RD28
	9 ppb: RD30	3 ppb: BL05, PU20, RD14, YW02
	8 ppb: BL20, PU16, PU28, RD29	2 ppb: PU06, PU09, RD15, RD16
	7 ppb: PU17, PU18	
Bathroom sink (36)	13 ppb: BL04, RD20	5 ppb: RD22, RD34
	10 ppb: RD33	4 ppb: BL11, BL11.5, BL14, RD01, RD02, RD04
	9 ppb: BL16	3 ppb: BL07, BL15, PK06, PK09, PK12, RD03, RD17, RD23, RD25, RD36
	8 ppb: BL06	
	7 ppb: RD21	2 ppb: BL12, PK05, PK11, PU01, PU36, PU37, PU38, PU39, RD12, RD13, RD26
	6 ppb: PU02	
Utility sink in custodial closet (2)	5 ppb: TQ03	
	4 ppb: TQ02	

⁸ YW03, 05, 06, and 08 are located in a classroom used for cooking instruction. For the purposes of prioritizing remediation, these sinks are classified as kitchen sinks.

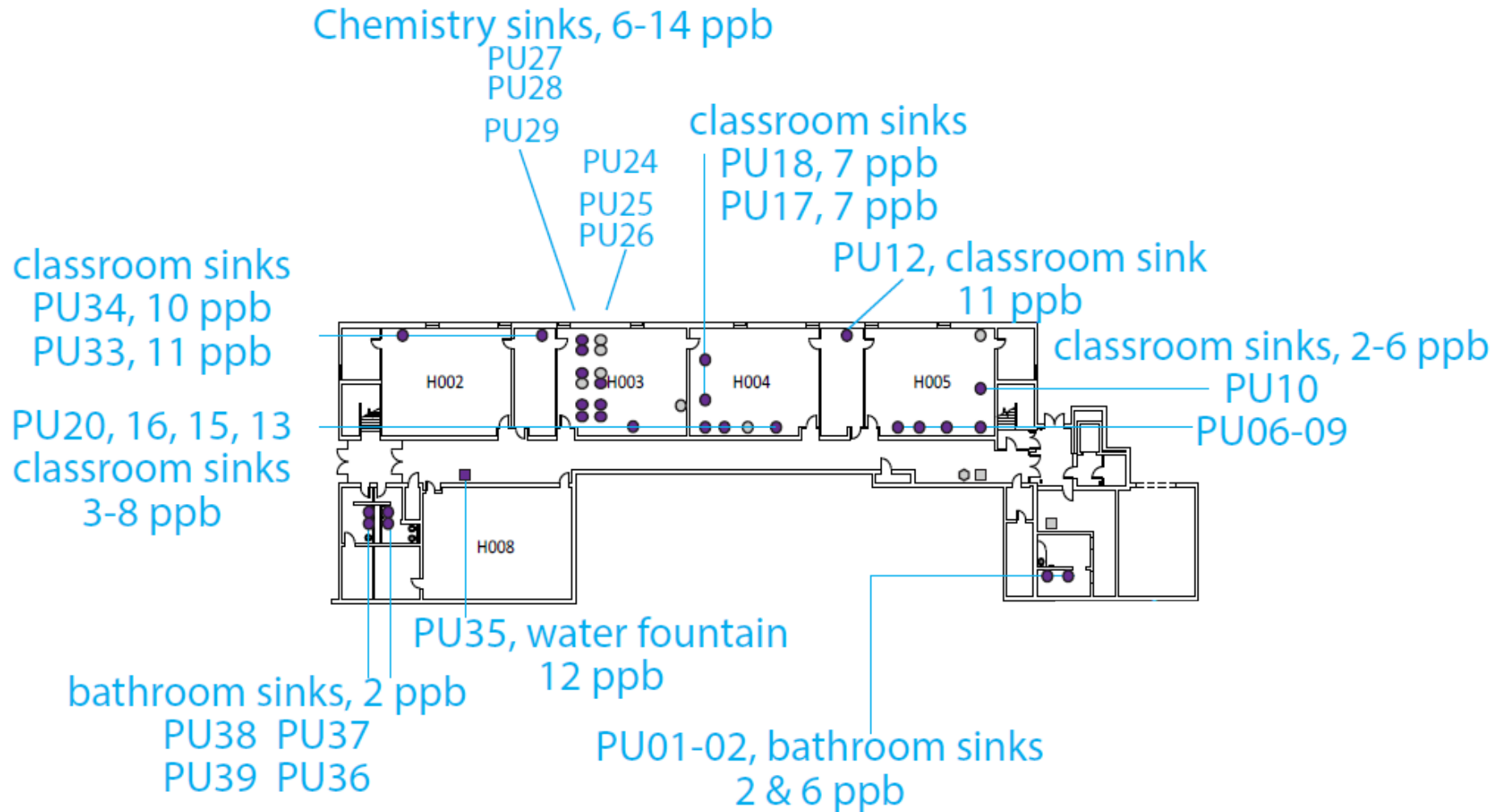
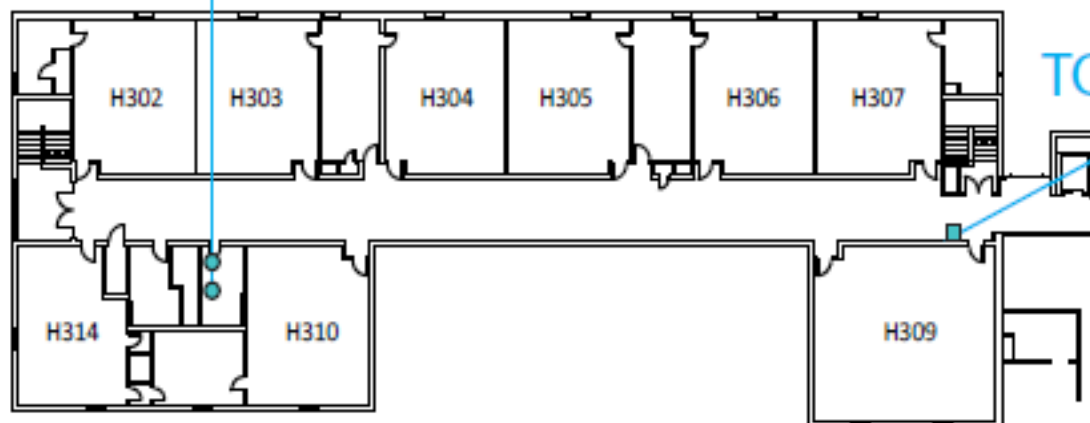


Figure 4 (continued on next page). Floor plan showing location of all Middlebury Union High School outlets that exceeded the American Academy of Pediatrics recommended safety level of 1 ppb (but not the EPA action level).

utility sinks, 4-5 ppb

TQ02

TQ03



TQ01, water fountain
6 ppb

THIRD FLOOR

Figure 4 (continued on next page). Floor plan showing location of all Middlebury Union High School outlets that exceeded the American Academy of Pediatrics recommended safety level of 1 ppb (but not the EPA action level).

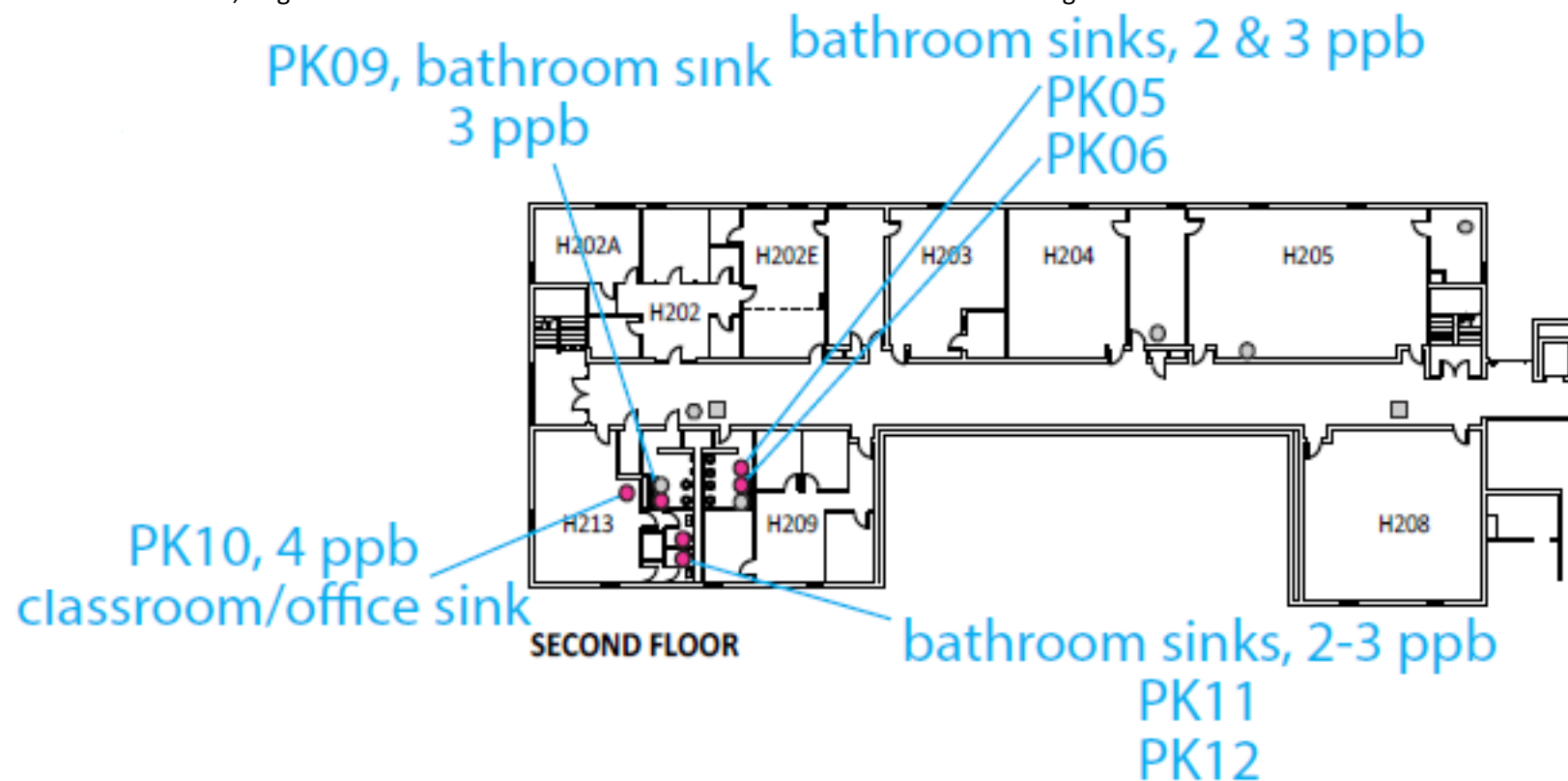


Figure 4 (continued on next page). Floor plan showing location of all Middlebury Union High School outlets that exceeded the American Academy of Pediatrics recommended safety level of 1 ppb (but not the EPA action level).

Lead Levels in MUHS Drinking Water

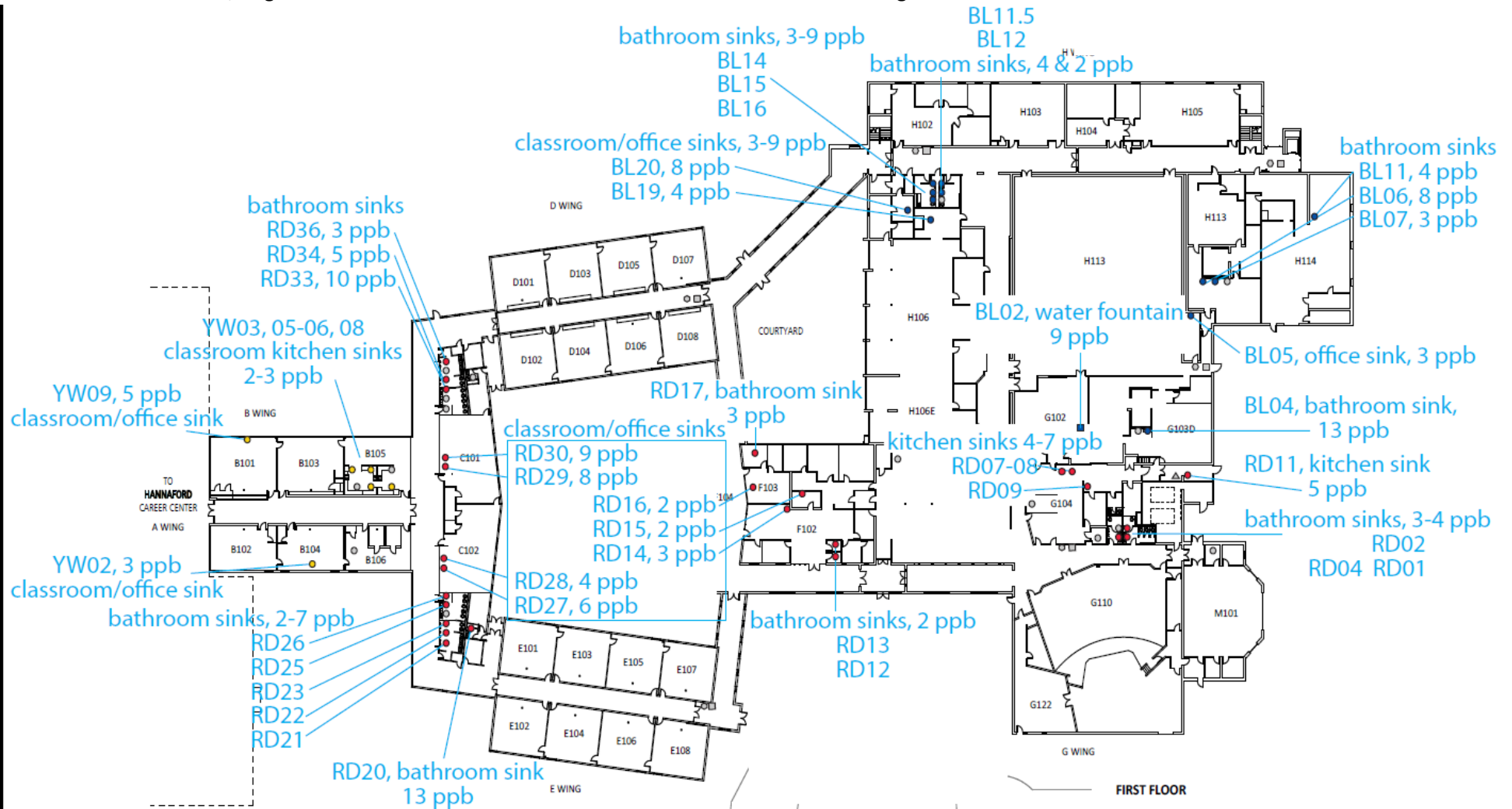


Figure 4 continued. Floor plan showing location of all Middlebury Union High School outlets that exceeded the American Academy of Pediatrics recommended safety level of 1 ppb (but not the EPA action level).

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. Although FL samples contained substantially lower lead levels than their associated FD samples, nearly 40% of outlets for which FL were collected still exceeded the AAP recommendation even after 30 seconds of flushing; this suggests that pipes or more distal connections may be 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.

SUMMARY & RECOMMENDATIONS

Most of the 122 outlets (n=96, 79%) produced FD samples that exceeded the AAP recommended safety level of 1-ppb, with 13 of these also exceeding the EPA action level. EPA exceedances were observed for a food preparation sink, 9 classroom/office sinks, and 3 bathroom sinks. AAP exceedances were observed for water fountains; kitchen sinks/sprayers; and classroom/office, bathroom, and utility sinks. A summary of outlets prioritized for remediation is shown in **Table 3**.

Table 3. Summary of Middlebury Union High 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. * indicates samples were not collected.

Priority level	Exceedance level	Concern	Outlet ID	Outlet type & location	First Draw (ppb) ⁹	Flush (ppb) ¹⁰
Highest	Exceeds EPA action level	Intended for direct consumption or food preparation	BL01	Food preparation sink, F101 pizza kiosk	26 (03/18/17) 18 (04/22/17)	8
			PU21	Classroom sink, H003 chemistry	41 (03/18/17) 8 (04/22/17)	<1
			PU23	Classroom sink, H003 chemistry	32 (03/18/17) 13 (04/22/17)	2
			PU22	Classroom sink, H003 chemistry	29 (03/18/17) 6 (04/22/17)	<1
		Potential frequent use for direct consumption	PU32	Classroom sink, H003 chemistry	12 (03/18/17) 24 (04/22/17)	1
			PU14	Classroom sink, H004	23(03/18/17) 21 (04/22/17)	<1
			PK07	Bathroom sink, 2 nd floor	20 (03/18/17) 18 (04/22/17)	9
			PU19	Classroom sink, H003 chemistry	18 (03/18/17) 13 (04/22/17)	2
			PU30	Classroom sink, H003 chemistry	17 (03/18/17) 18 (04/22/17)	1
			PU11	Classroom sink, H005	16 (03/18/17) 12 (04/22/17)	1

⁹ Dates provided if FD samples were collected on both sample collection dates

¹⁰ FL samples were only collected (second sampling date) if the FD sample exceeded the EPA action level

Highest (cont.)	Exceeds EPA action level (cont.)	Potential frequent use for direct consumption (cont.)	PK04	Classroom/office sink, 2 nd floor	16 (03/18/17) 18 (04/22/17)	2
			BL03	Bathroom sink, locker room	16 (03/18/17) 9 (04/22/17)	2
			BL13	Bathroom sink, 1 st floor	15(03/18/17) 15 (04/22/17)	2
			PU31	Classroom sink, H003 chemistry	14 (03/18/17) 15 (04/22/17)	<1
	Exceeds AAP recommended safety level	Intended for direct consumption or food preparation	PU35	Water fountain, basement hallway	12	*
			BL02	Water fountain, G102 weight room	9	*
			TQ01	Water fountain, 3 rd floor hallway	6	*
			RD09	Kitchen sink/sprayer, kitchen	7	*
			RD07	Kitchen sink/sprayer, kitchen	7	*
			RD11	Kitchen sink/sprayer, kitchen	5	*
			RD08	Kitchen sink/, kitchen sprayer	4	*
			YW08	Kitchen sink/sprayer, B105 instructional kitchen	3	*
			YW03	Kitchen sink/sprayer, B105 instructional kitchen	2	*
			YW05	Kitchen sink/sprayer, B105 instructional kitchen	2	*
			YW06	Kitchen sink/sprayer, B105 instructional kitchen	2	*
			The 33 classroom/office sinks listed in Table 2, ranging 2-12 ppb The 36 bathroom sinks listed in Table 2, ranging 2-13 ppb			
High	Exceeds AAP recommended safety level	Potential frequent use for direct consumption				
Low	Exceeds AAP recommended safety level	Unlikely use for direct consumption	TQ03	Utility sink, 3 rd floor utility closet	5	*
			TQ02	Utility sink, 3 rd floor utility closet	4	*

Results suggest that the predominant source of the lead in the FD samples is likely the outlet fixtures or immediate connections (e.g., solder). Nevertheless, nearly 40% of the FL samples exceeded the AAP recommendation *even after flushing*, which suggests that pipes or more distal connections may also be contributing lead to the samples.

We recommend that MUHS 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/sprayers in locations where water is not needed for non-consumption uses
- 3) For priority sinks/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 MUHS 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

The authors are grateful to Mr. Bruce MacIntire, ACS D Director of Facilities, for providing access to and technical and historical information about MUHS, and for assisting in communicating with the school community about the project. We would like to thank Dr. Peter Burrows, ACS D Superintendent for his support of the work. Finally, we gratefully acknowledge the assistance of Jody Smith, Senior Instrument Technician at Middlebury College, for instrument support, maintenance, and student training. This project was funded by the Dept. of Chemistry and Biochemistry and the Senior Work Fund at Middlebury College.

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Appendix A – Draft Letter to the MUHS Community Prior to Sampling

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

Dear Parents,

This spring, MUHS will partner with students and faculty researchers from Middlebury College to test all of the sources of drinking water at the school for lead. At present, there are no laws that require schools that are on town water to test their drinking water for lead. There is also no indication that Pb levels are high at MUHS. MUHS is pursuing this testing, because we are committed to ensuring that the water provided in our school is safe to drink. The drinking water testing will be conducted at no cost to the school.

Why is it important to test for lead? 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 by leaching 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 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. 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? Taps 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 versus fixtures). If lead levels are at or above 15 ppb, the school is committed to fixing the problem. Common fixes include cleaning debris from screens, flushing holding tanks and pipes, providing bottled water, installing filtration systems, and replacing fixtures or pipes.

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>

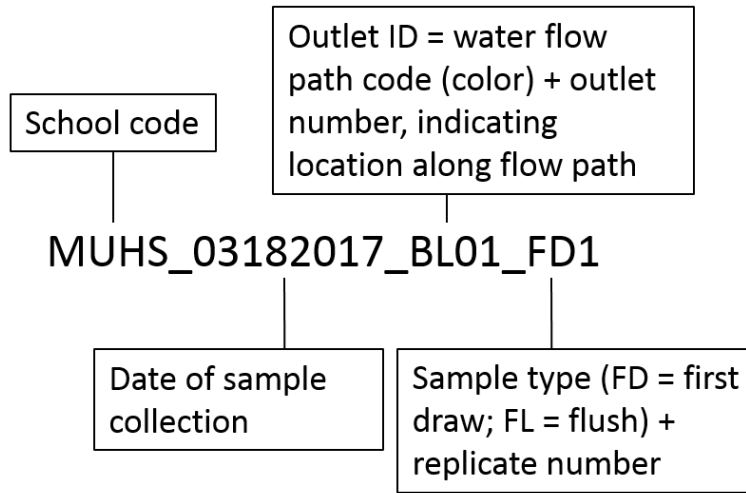
To request a drinking water test kit:

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

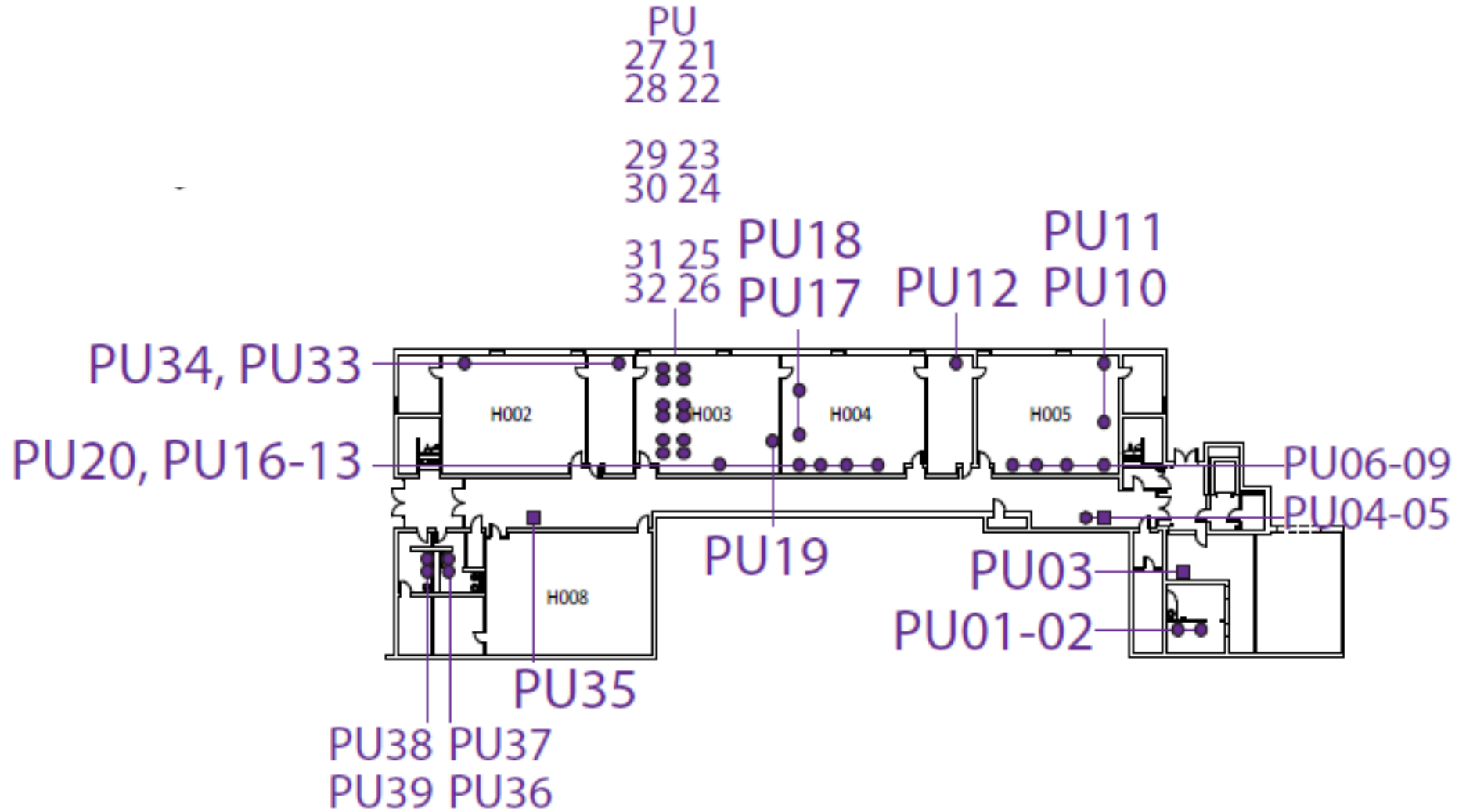
Sincerely,
Dr. Peter Burrows
Superintendent ACSD

Appendix B - Sample Naming Scheme

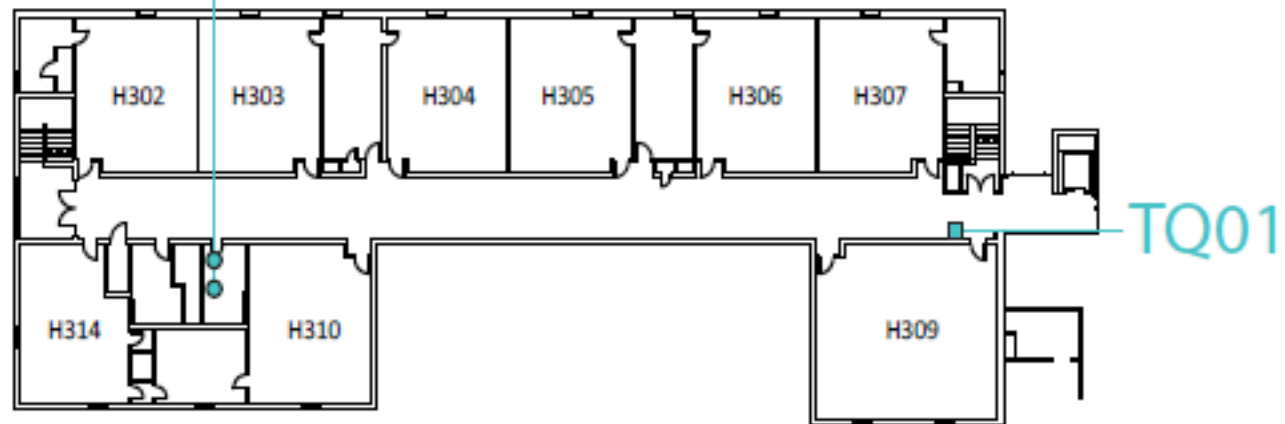
Samples collected at MUHS were assigned unique sample IDs as presented below. The IDs are composed of the school code, sampling date, flow path identification, outlet ID, and the type of sample.

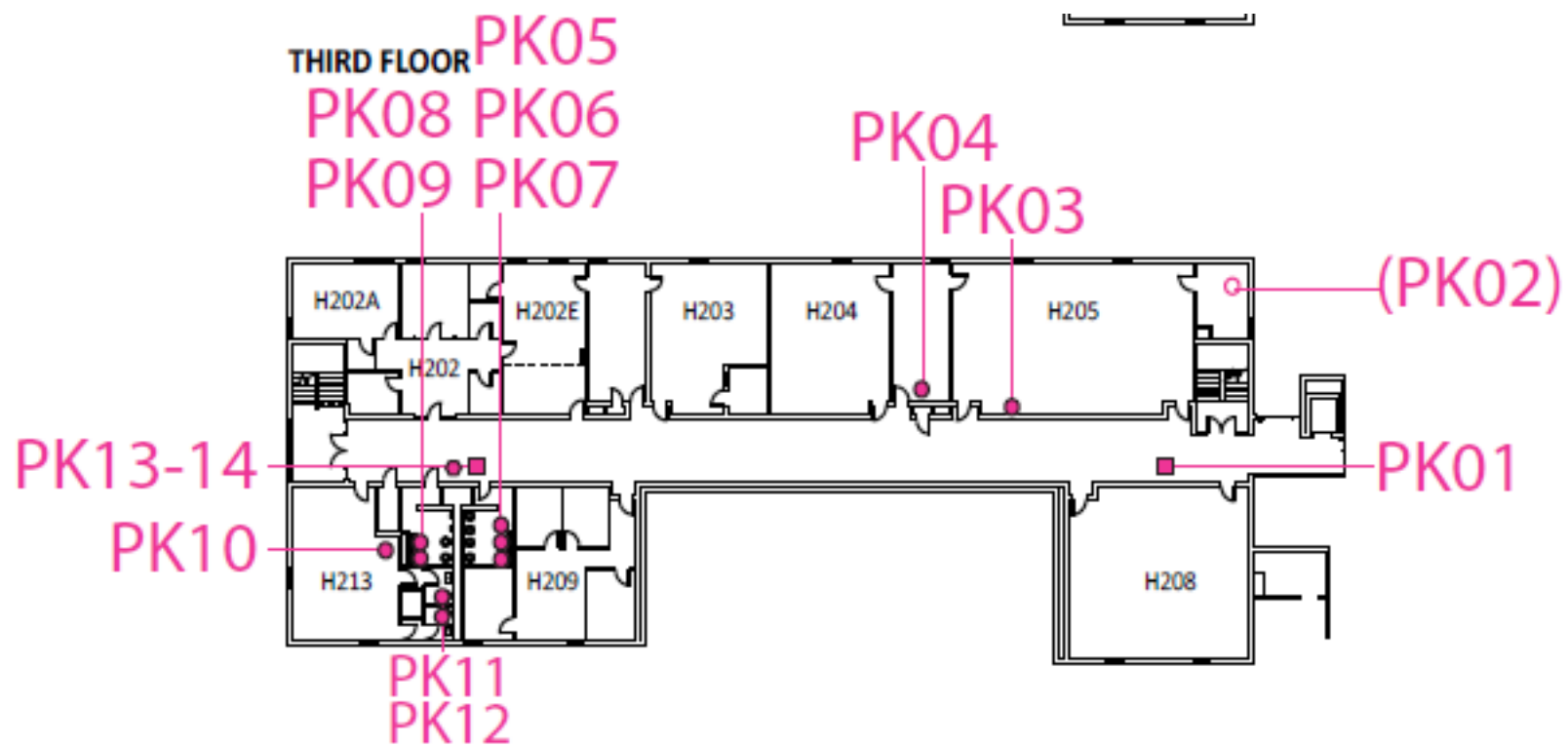


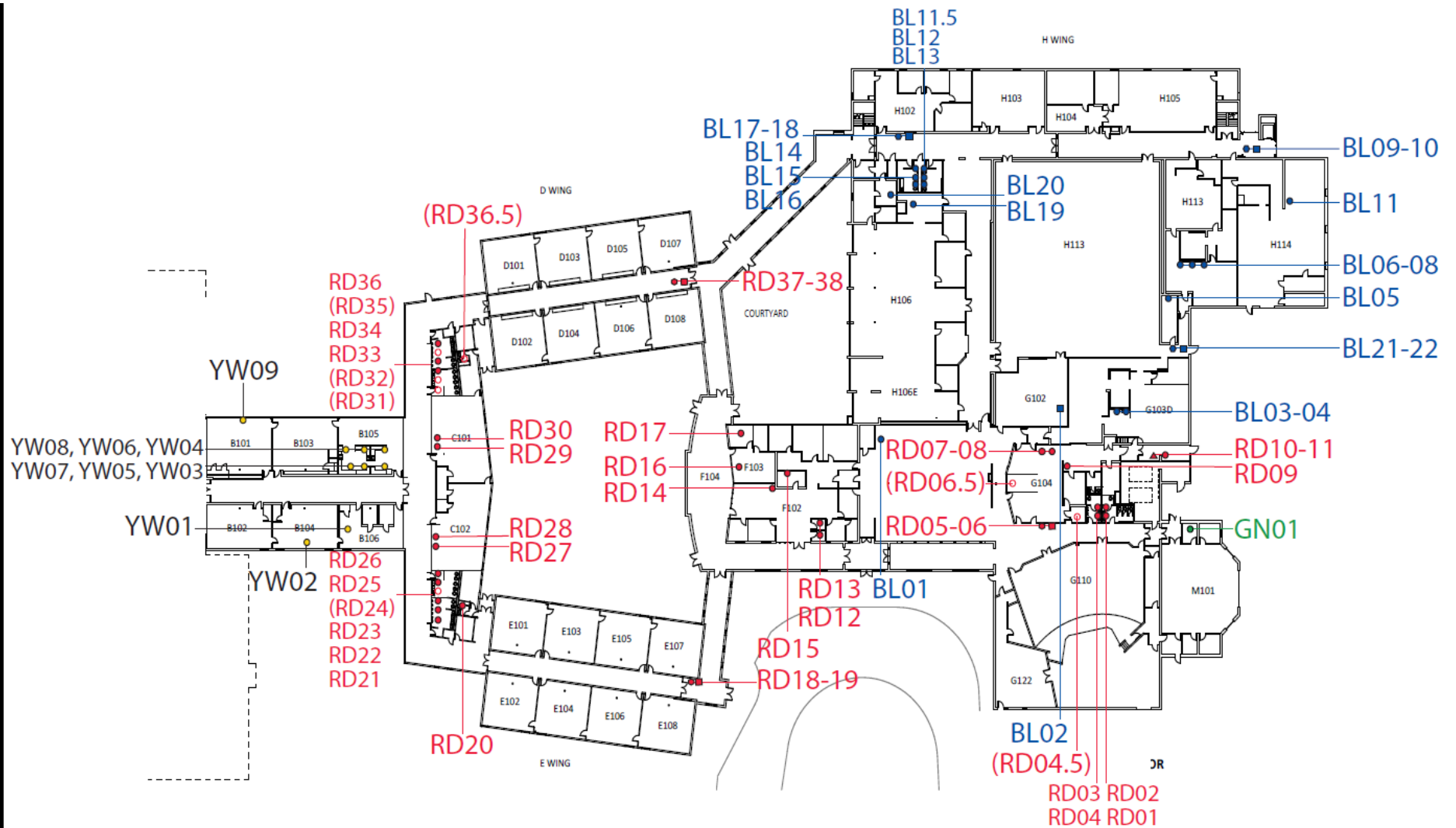
Appendix C – MUHS Floor Plan with Outlet Locations and Outlet IDs



TQ02
TQ03







Appendix D – Complete Lead Concentration Results for MUHS

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., $\mu\text{g-Pb/L-water}$) 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; * indicates samples were not collected. 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**. When multiple first draw samples were collected, the outlet was categorized using data from the first collection date.

School	Outlet ID	Outlet Type	Outlet Description/Location	First Draw Lead Conc (ppb)	Flush Lead Conc (ppb)
MUHS	BL01	kitchen sink/sprayer	F101 pizza kiosk sink	26 and 18	8
MUHS	BL02	water fountain or bottle filler	G102 weight room water fountain	9	*
MUHS	BL03	bathroom sink	1st floor bathroom sink	16 and 9	2
MUHS	BL04	bathroom sink	1st floor sink	13 and 9	2
MUHS	BL05	classroom/office sink	athletic trainer's office sink	3	*
MUHS	BL06	bathroom sink	locker room sink	8	2
MUHS	BL07	bathroom sink	locker room sink	3	*
MUHS	BL08	bathroom sink	locker room sink	<1	*
MUHS	BL09	water fountain or bottle filler	1st floor bottle filler	n.d.	*
MUHS	BL10	water fountain or bottle filler	1st floor water fountain	n.d.	*
MUHS	BL11	bathroom sink	locker room sink	4	*
MUHS	BL11.5	bathroom sink	1st floor bathroom sink	4	*
MUHS	BL12	bathroom sink	1st floor bathroom sink	2	*
MUHS	BL13	bathroom sink	1st floor bathroom sink	15 and 15	2
MUHS	BL14	bathroom sink	1st floor bathroom sink	4	*
MUHS	BL15	bathroom sink	1st floor bathroom sink	3	*
MUHS	BL16	bathroom sink	1st floor bathroom sink	9	*
MUHS	BL17	water fountain or bottle filler	1st floor bottle filler	n.d.	*
MUHS	BL18	water fountain or bottle filler	1st floor water fountain	n.d.	*
MUHS	BL19	classroom/office sink	1st floor classroom/office sink	4	*
MUHS	BL20	classroom/office sink	1st floor classroom/office sink	8	*
MUHS	BL21	water fountain or bottle filler	1st floor bottle filler	n.d.	n.d.
MUHS	BL22	water fountain or bottle filler	1st floor water fountain	n.d.	n.d.
MUHS	GR01	bathroom sink	sink off of band room	<1	*
MUHS	PK01	water fountain or bottle filler	2nd floor water fountain	1	*
MUHS	PK02	classroom/office sink	n/a	*	*
MUHS	PK03	classroom/office sink	H205 classroom sink	1	*
MUHS	PK04	classroom/office sink	2nd floor classroom/office sink	16 and 18	2
MUHS	PK05	bathroom sink	2nd floor bathroom sink	2	*
MUHS	PK06	bathroom sink	2nd floor bathroom sink	3	*
MUHS	PK07	bathroom sink	2nd floor bathroom sink	20 and 18	9

MUHS	PK08	bathroom sink	2nd floor bathroom sink	1	*
MUHS	PK09	bathroom sink	2nd floor bathroom sink	3	*
MUHS	PK10	classroom/office sink	H213 classroom/office sink	4	*
MUHS	PK11	bathroom sink	2nd floor bathroom sink	2	*
MUHS	PK12	bathroom sink	2nd floor bathroom sink	3	*
MUHS	PK13	water fountain or bottle filler	2nd floor bottle filler	n.d.	*
MUHS	PK14	water fountain or bottle filler	2nd floor water fountain	n.d.	*
MUHS	PU01	bathroom sink	basement bathroom sink	2	*
MUHS	PU02	bathroom sink	basement bathroom sink	6	*
MUHS	PU03	water fountain or bottle filler	basement water fountain	1	*
MUHS	PU04	water fountain or bottle filler	basement bottle filler	n.d.	*
MUHS	PU05	water fountain or bottle filler	basement water fountain	n.d.	*
MUHS	PU06	classroom/office sink	H005 classroom sink	2	*
MUHS	PU07	classroom/office sink	H005 classroom sink	6	*
MUHS	PU08	classroom/office sink	H005 classroom sink	6	*
MUHS	PU09	classroom/office sink	H005 classroom sink	2	*
MUHS	PU10	classroom/office sink	H005 classroom sink	4	*
MUHS	PU11	classroom/office sink	H005 classroom sink	16 and 12	1
MUHS	PU12	classroom/office sink	basement classroom/office sink	11 and 14	1
MUHS	PU13	classroom/office sink	H004 classroom sink	4	*
MUHS	PU14	classroom/office sink	H004 classroom sink	23 and 21	<1
MUHS	PU15	classroom/office sink	H004 classroom sink	4	*
MUHS	PU16	classroom/office sink	H004 classroom sink	8	*
MUHS	PU17	classroom/office sink	H004 classroom sink	7	*
MUHS	PU18	classroom/office sink	H004 classroom sink	7	*
MUHS	PU19	classroom/office sink	H003 classroom sink	18 and 13	2
MUHS	PU20	classroom/office sink	H003 classroom sink	3	*
MUHS	PU21	classroom/office sink	H003 classroom sink	41 and 8	<1
MUHS	PU22	classroom/office sink	H003 classroom sink	29 and 6	<1
MUHS	PU23	classroom/office sink	H003 classroom sink	32 and 13	2
MUHS	PU24	classroom/office sink	H003 classroom sink	12 and 14	2
MUHS	PU25	classroom/office sink	H003 classroom sink	10	*
MUHS	PU26	classroom/office sink	H003 classroom sink	10	*
MUHS	PU27	classroom/office sink	H003 classroom sink	11	*
MUHS	PU28	classroom/office sink	H003 classroom sink	8	*
MUHS	PU29	classroom/office sink	H003 classroom sink	6	*
MUHS	PU30	classroom/office sink	H003 classroom sink	17 and 18	1
MUHS	PU31	classroom/office sink	H003 classroom sink	14 and 15	<1
MUHS	PU32	classroom/office sink	H003 classroom sink	12 and 24	1
MUHS	PU33	classroom/office sink	basement classroom/office sink	11 and 11	1
MUHS	PU34	classroom/office sink	H002 classroom sink	10 and 9	1

MUHS	PU35	water fountain or bottle filler	basement water fountain	12 and 4	4
MUHS	PU36	bathroom sink	basement bathroom sink	2	*
MUHS	PU37	bathroom sink	basement bathroom sink	2	*
MUHS	PU38	bathroom sink	basement bathroom sink	2 and 2	<1
MUHS	PU39	bathroom sink	basement bathroom sink	2 and 2	<1
MUHS	RD01	bathroom sink	1st floor bathroom sink	4	*
MUHS	RD02	bathroom sink	1st floor bathroom sink	4	*
MUHS	RD03	bathroom sink	1st floor bathroom sink	3	*
MUHS	RD04	bathroom sink	1st floor bathroom sink	4	*
MUHS	RD05	water fountain or bottle filler	1st floor bottle filler	n.d.	*
MUHS	RD06	water fountain or bottle filler	1st floor water fountain	n.d.	*
MUHS	RD07	kitchen sink/sprayer	G104 kitchen sink	7	*
MUHS	RD08	kitchen sink/sprayer	G104 kitchen sink	4	*
MUHS	RD09	kitchen sink/sprayer	G104 kitchen hand wash sink	7	*
MUHS	RD10	other	G104 kitchen ice machine	n.d. and n.d.	*
MUHS	RD11	kitchen sink/sprayer	G104 kitchen sink	5	*
MUHS	RD12	bathroom sink	1st floor bathroom sink	2	*
MUHS	RD13	bathroom sink	1st floor bathroom sink	2	*
MUHS	RD14	classroom/office sink	F102 main office sink	3	*
MUHS	RD15	classroom/office sink	office sink	2	*
MUHS	RD16	classroom/office sink	F103 health office sink	2	*
MUHS	RD17	bathroom sink	health office bathroom sink	3	*
MUHS	RD18	water fountain or bottle filler	1st floor bottle filler	n.d.	*
MUHS	RD19	water fountain or bottle filler	1st floor water fountain	n.d.	*
MUHS	RD20	bathroom sink	1st floor bathroom sink	13 and 10	1
MUHS	RD21	bathroom sink	1st floor bathroom sink	7	<1
MUHS	RD22	bathroom sink	1st floor bathroom sink	5	*
MUHS	RD23	bathroom sink	1st floor bathroom sink	3	*
MUHS	RD24	bathroom sink	n/a	*	*
MUHS	RD25	bathroom sink	1st floor bathroom sink	3	*
MUHS	RD26	bathroom sink	1st floor bathroom sink	2	*
MUHS	RD27	classroom/office sink	C102 classroom sink	6	*
MUHS	RD28	classroom/office sink	C102 classroom sink	4	*
MUHS	RD29	classroom/office sink	C101 classroom sink	8	*
MUHS	RD30	classroom/office sink	C101 classroom sink	9	*
MUHS	RD31	bathroom sink	n/a	*	*
MUHS	RD32	bathroom sink	n/a	*	*
MUHS	RD33	bathroom sink	1st floor bathroom sink	10 and 4	1
MUHS	RD34	bathroom sink	1st floor bathroom sink	5	*
MUHS	RD35	bathroom sink	n/a	*	*
MUHS	RD36	bathroom sink	1st floor bathroom sink	3	*
MUHS	RD36.5	classroom/office sink	n/a	*	*

MUHS	RD37	water fountain or bottle filler	1st floor bottle filler	n.d.	*
MUHS	RD38	water fountain or bottle filler	1st floor water fountain	n.d.	*
MUHS	TQ01	water fountain or bottle filler	3rd floor water fountain	6	*
MUHS	TQ02	utility sink	3rd floor utility sink in custodial closet	4	*
MUHS	TQ03	utility sink	3rd floor utility sink in custodial closet	5	*
MUHS	YW01	classroom/office sink	B106 classroom sink	1	*
MUHS	YW02	classroom/office sink	B104 classroom sink	3	*
MUHS	YW03	kitchen sink/sprayer	B105 cooking classroom sink	2	*
MUHS	YW04	kitchen sink/sprayer	B105 cooking classroom sink	<1	*
MUHS	YW05	kitchen sink/sprayer	B105 cooking classroom sink	2	*
MUHS	YW06	kitchen sink/sprayer	B105 cooking classroom sink	2	*
MUHS	YW07	kitchen sink/sprayer	B105 cooking classroom sink	1	*
MUHS	YW08	kitchen sink/sprayer	B105 cooking classroom sink	3	*
MUHS	YW09	classroom/office sink	B101 classroom sink	5	*

Appendix E – Sample Letter to the MUHS 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 year, MUHS partnered with students and faculty researchers from Middlebury College to test all the sources of drinking water at the school for lead, including water from water fountains, bottle fillers, sinks, kitchen sprayers, and the ice machine -- a total of 122 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 (79%) produced FD samples that exceeded the American Academy of Pediatrics (AAP) recommended safety level for school water fountains (2-41 ppb), with 12 of these outlets also exceeding the 15-ppb EPA action level. EPA exceedances included 1 food preparation sink (26 ppb), 8 classroom/office sinks (16-41 ppb), and 3 bathroom sinks (15-20 ppb), all of which were considered a *highest priority* for remediation. A total of 84 outlets (69%) exceeded the AAP safety level (but not the EPA action level) (2-14 ppb); these included 3 water fountains, 8 kitchen sinks/sprayers, 35 classroom/office sinks, 36 bathroom sinks, and 2 utility sinks. Water fountains, kitchen, and food preparation sinks/sprayers that exceeded the AAP or EPA levels as *highest priority* for remediation due to their intended use for direct consumption or for food preparation. Bathroom and classroom/office sinks that exceeded the AAP but not the EPA action level were considered a *high priority* for remediation. The utility sinks were considered a *low priority* for remediation, because they are contained within a custodial closet and not likely to be used for consumption. Results suggested that the predominant source of lead is the fixtures or their immediate connections, rather than incoming water or pipes within the school. Nevertheless, nearly 40% of the FL samples 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; thus, flushing prior to use is not a generally effective approach at MUHS for reducing lead to acceptable levels.

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 802-388-4736 or 800-660-9997