# Seattle Public Schools Drinking Water Quality Improvement Program

## Phase 2 Report
## Remediation Plan, Status, and Recommendations

July 2007

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R.2 Lead Release from End-Use Plumbing Components in Seattle Public Schools. Presentation to NSF International, November 2005

R.3 Challenge and Approach for Mitigating Iron-Related Water Quality Problems in Seattle Public Schools. Presentation at AWWA Water Quality Technology Conference, November 2005.

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R.5 Lead Release from End-Use Plumbing Components in Seattle Public Schools. Presentation at AWWA Annual Conference, June 2006.

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R.11 Occurrence and Mitigation of Arsenic in Drinking Water Taps in Public School Buildings. AWWA Research Symposium. March 2007.

# Abbreviated Summary

Beginning in late 2003 the Seattle Public Schools (SPS) began a comprehensive effort to test the drinking water quality in sources in all of its buildings and take appropriate remediation measures. This effort included testing in each of nearly 100 separate schools and buildings, public notification of results, and remediation activities in the schools.

Seattle Public Schools developed a comprehensive School Board Policy and Procedure for water quality (the "Water Policy"), which was adopted on December 1, 2004. As of March, 2007, testing and remediation has been completed in virtually all of the Seattle Public School District's 98 schools; students and parents were informed of the results; and the schools were returned to service. In accomplishing this effort, SPS, HDR, and other consultants have instituted the strongest water quality testing and remediation program in the nation. This program includes development of procedures for testing and public reporting of results, development of specifications and identification of extremely low lead components, and research into such areas as filter performance, lead rebound rates, testing variability, and lead intake and health impacts.

This report documents those efforts and sets forth procedures to be used by SPS in maintaining the high water quality results achieved. The authors believe this report can also serve as a model and provide important information for other school districts throughout the country.

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# 1.0 Introduction and Program Guide

The overall purpose of the Water Policy (Attachment A) and the resulting Drinking Water Quality Improvement Program is to take the necessary steps to improve the drinking water quality in SPS facilities such that the staff, students, and parents have confidence that they will have access to water that is safe and aesthetically appealing. The Board Adopted Policy includes requirements for water quality and access, remediation, long term testing, and reporting of results. Both health and aesthetic issues are being addressed. The Drinking Water Quality Improvement Program includes five major steps:

Step 1. Determine the initial water quality conditions at each school,

Step 2. Develop overall strategies for remediation (the "General Water Quality Remediation Plan"),

Step 3. Identify options and develop specific remediation plans for each school

Step 4. Implement remediation plans (ongoing) in schools, and

Step 5. Monitor water quality (ongoing) in all schools.

Initial water quality testing (Step 1) was conducted at all schools during March 2004 – June 2004 and results are documented in the report, "Results of Water Quality Testing in Schools and Associated Facilities," prepared by EES, August 2004. Work was begun in spring 2004 to identify feasible remediation options, and several were tested in the field. Based on initial water quality testing results and circumstances at each school, remediation plans were developed and specific activities varied from school to school with some schools requiring minimal work to achieve the Water Policy criteria while others required full piping replacement.

This report provides a summary of the Drinking Water Quality Improvement Program including the purpose of the Program, discussion of water quality and access issues, and SPS drinking water policy requirements. In addition, this report documents the General Water Quality Remediation Plan (Plan) and the status and results to date of the Program. This report includes discussion of the major elements of the overall strategies (Step 2) and specific activities used to remediate water quality concerns at schools (Step 3). Implementation of the Plan (Step 4) and water quality monitoring (Step 5) are ongoing to assure compliance with the School Board's water quality and access requirements.

This report consists of the following major sections:

- Section 1 provides an overview of the SPS Water Policy, the steps of the Drinking Water Quality Improvement Program, and discussion regarding how the General Water Quality Remediation Plan fits into the Improvement Program.
- Section 2 describes the purpose and requirements of the Drinking Water Quality Improvement Program.
- Section 3 summarizes the considerations used in developing the General Water Quality Remediation Plan and identifies the contaminants of concern, their sources in SPS buildings, and feasible options for remediation of water quality problems.
- Section 4 provides a description of the General Water Quality Remediation Plan including remediation priorities and activities and specific remediation options to address each contaminant of concern.
- Section 5 describes the status and results of remediation activities as of April 3, 2007.

- Section 6 describes ongoing contaminant control and monitoring including the recurring Drinking Water Quality Monitoring Plan, requirements for communications and status reports for water quality, and guidelines for coordination with Seattle Public Utilities and state and city/county health departments.
- Section 7 provides recommendations for next steps for the Drinking Water Quality Improvement Program

Attachments included with this report provide detailed, specific information that was used to develop the Plan, including results from special studies that were conducted to address specific water quality issues and provide guidance for ongoing activities to maintain and improve water quality in schools. Also attached are records of outreach in the form of presentations and papers associated with the SPS Drinking Water Quality Improvement Program.

# 2.0 Drinking Water Quality Improvement Program

## 2.1 Purpose

The overall purpose of the Drinking Water Quality Improvement Program is to develop a comprehensive Remediation Plan to improve drinking water quality in Seattle Public Schools (SPS) facilities such that the staff, students, and parents have access to plentiful supplies of water that are safe and aesthetically appealing. Both health and aesthetic issues are addressed.

## 2.2 Drinking Water Quality Issues

### 2.2.1 Health and Safety Issues

Health and safety water quality issues include lead, cadmium, arsenic, copper, and bacteria levels. The most pressing health-related issue was lead, which originates primarily from brass-containing drinking fountains and sink faucets or end-use plumbing components and also from lead solder in connective copper piping. Other lead sources that potentially release lead to a lesser extent include impurities in galvanized steel piping, and possibly from meters and valves. Cadmium was generally less of a concern than lead at most drinking water sources, but impurities in galvanized steel pipes and brass fixtures can contribute to elevated cadmium levels. Copper was less of a health concern than lead, but can be a health issue at high levels in water. The presence of arsenic has been detected at a limited number of fountains and sinks and is attributable to a particular corrosion phenomenon that can occur when iron piping is in direct contact with brass or copper components or piping. The presence of non-pathogenic (non-harmful) bacteria at drinking water sources in schools can be encountered within buildings that have heavily-scaled pipes and/or where the water is not adequately flushed through the piping on a regular basis. Pathogenic (harmful) bacteria are highly unusual in public water systems and could result if an external contamination event occurs, such as a cross-connection to non-potable water.

### 2.2.2 Aesthetic Issues

Discolored water was the primary aesthetic problem at many of the schools. Orange-colored water is a common problem in many older Seattle-area buildings as a result of iron release from older galvanized steel and cast iron pipe. The release of iron particles from pipes results in turbid (unclear) and/or colored water and often stains fixtures, but poses no health concerns. However, higher levels of iron, turbidity, and color can be indicative of deteriorating pipes. SPS is not unique as many older buildings in Seattle have these same issues.

## 2.3 Access to Drinking Water

SPS' goal is that drinking water should be not only safe and appealing, but that it also be available where needed. Prior to the adoption of the SPS Water Policy, there were no established standards or guidelines available to assure a safe, appealing and plentiful supply of drinking water in SPS. The Water Policy established specific requirements for access to drinking water, as described below. Attachment B contains the definition of accessibility criteria that is used throughout this report.

Most elementary schools have fountains or sinks in each classroom, whereas most secondary schools do not. All schools have fountains in hallways, gyms and other locations. Based on the differing needs of elementary and secondary students, particularly the need for elementary teachers to oversee the activities of their students and avoid repeated trips down the hall to the drinking fountain, criteria were developed for specific types of schools.

Generally, in elementary schools there are fountains and/or sinks that are used as drinking water sources in most “teaching spaces” which includes classrooms, libraries, gyms, and nurse stations. Working fountains generally are not required in elementary school hallways (except at doorways leading in from the main playground areas), nor are they required in isolated locations such as school offices, teacher lunchrooms, and workrooms. Secondary schools require working fountains in hallways and gyms: these fountains must be located in each general area (e.g., a wing or floor) of the school, and there must be at least one fountain per each 100 students. Fountains or sink faucets located in nurse stations and kitchen sink faucets that are used for food preparation are also considered drinking water sources. Classroom sinks in secondary schools, such as sinks found in classrooms used for science, art, or home economics, are not considered drinking water sources.

Consideration was given to restroom sinks as potential sources of drinking water. However, the primary purpose of restroom sinks is for sanitation (i.e., hand washing) and not as drinking water sources. Therefore, restroom sinks are not subject to the drinking water policy. Signs are required to be posted in all restrooms that read “Do Not Drink Restroom Water”.

## 2.4 SPS Drinking Water Policy Requirements

To address the water quality and accessibility issues, the School Board Adopted Policy E10.00 and Procedure E10.01 for Drinking Water Quality and Access were adopted on December 1, 2004. The full policy is contained in Attachment A. The policy establishes requirements for the following: 1) drinking water quality; 2) accessibility to drinking water sources; 3) remediation of piping and components to achieve the water quality and accessibility criteria; 4) long-term periodic testing to demonstrate compliance with the policy; and 5) reporting of results. Table 2-1 summarizes the water quality and access portions of the policy.

**Table 2-1. Summary of the SPS Policy for Drinking Water Quality and Access Criteria**

| Drinking Water Quality Criteria |
|---|
| Health and Safety:<br>• Lead: not greater than 10 ppb[1]<br>• Cadmium: not greater than 5 ppb<br>• Copper: not greater than 1.3 ppm[2,3]<br>• Coliform bacteria – absent in any sample (representative locations only)<br><br>Aesthetic Criteria:<br>• Iron: not greater than 0.3 ppm in no more than 50% of drinking water sources; no source shall exceed 0.5 ppm[3] |
| **Accessibility Criteria** |
| Elementary Schools:<br>• Fountains in all classrooms, gyms, and libraries. Must be in service and meet health and safety criteria.<br><br>Secondary Schools:<br>• Adequate number of fountains dispersed throughout the school. |

Expressions for concentrations of contaminants are:

[1]ppb (parts per billion)

[2]ppm (parts per million)

[3]Initial test results above the threshold will be confirmed and the lower result used to determine compliance

In 2006 the SPS District conducted sampling for arsenic at all drinking water sources. Over 99% of the results were below the recommended threshold of 10 ppb, which is based on the EPA Maximum Contaminant Level for arsenic in drinking water. This testing was not part of the SPS policy and no further testing for arsenic is planned.

# 3.0 Remediation Plan Development

This section summarizes the considerations used to develop the General Water Quality Remediation Plan, including the sources of drinking water contaminants in SPS facilities, feasible remediation options, and the planned renovations and future uses of school buildings.

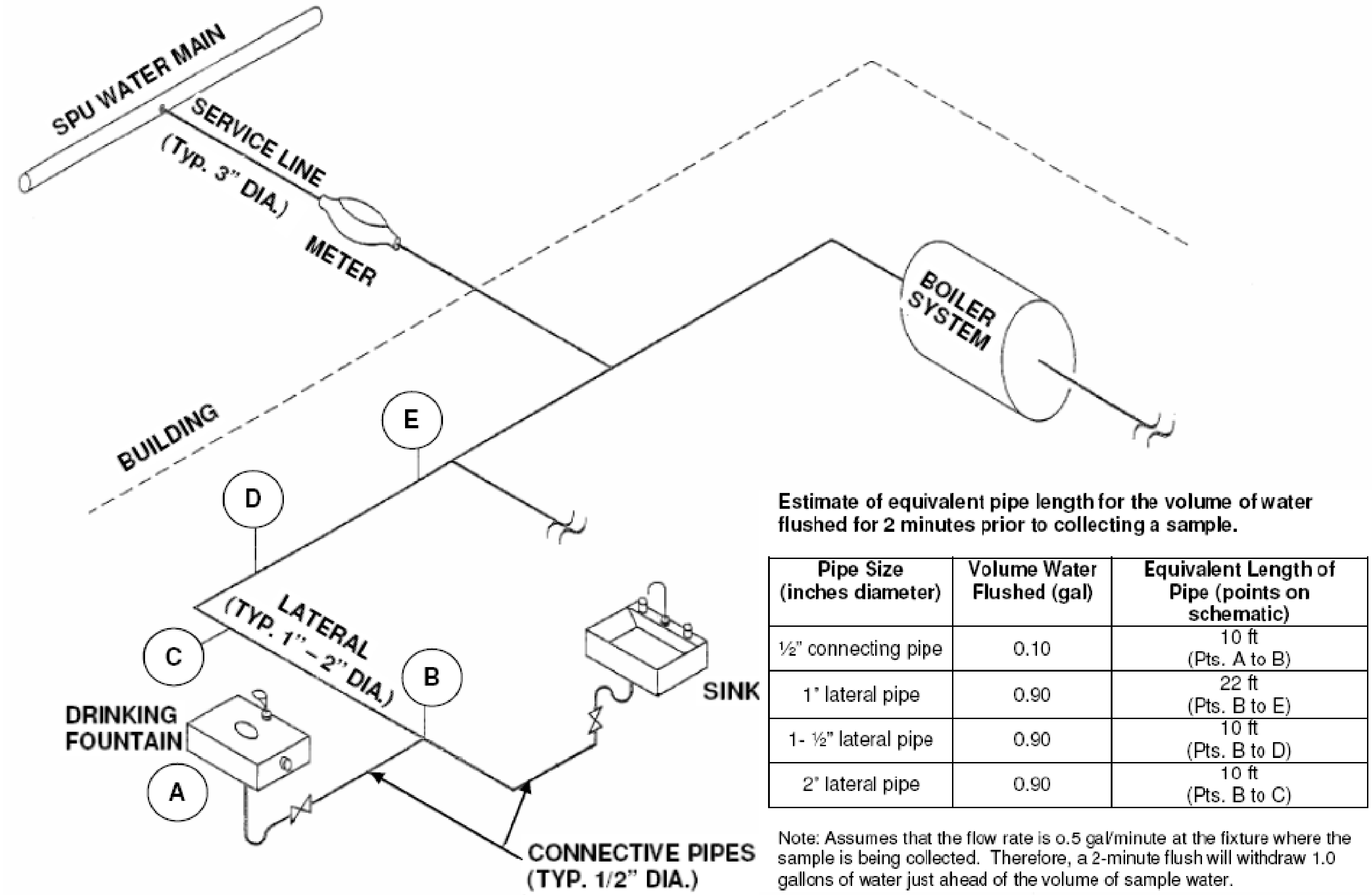
## 3.1 Contaminant Sources

The source of a water quality contaminant is the major consideration for developing appropriate remediation plans. This section summarizes the likely sources for each contaminant of concern and the implications for remediation to address the contaminants within school buildings. The likely sources of the contaminants are based on the results of the water quality testing program and information from analogous systems and the literature.

Figure 3-1 is a schematic showing the typical components of a school building plumbing system that is used to help illustrate the various contaminant sources. Table 3-1 is a summary of the contaminant sources as they relate to the different types of water quality samples.

**Table 3-1. Summary of Sources of Water Contaminants of Concern in Schools**

| Contaminant Sources | Types of Water Samples to Determine Contaminant Source (250 mL) | | |
|---|---|---|---|
| | First Draw | 30-sec Flush | 2-min Flush |
| *Lead Sources:* | | | |
| Brass faucets and components | ✓ | | |
| Older lead-bearing solder on copper pipes | ✓ | ✓ | |
| Galvanized steel pipes | | ✓ | ✓ |
| *Cadmium Sources:* | | | |
| Older brass faucets and components (possibly) | ✓ | | |
| Galvanized steel pipes | | ✓ | |
| *Copper Sources:* | | | |
| Brass faucets and components | ✓ | | |
| Copper pipe | | ✓ | |
| *Iron Sources:* | | | |
| Older galvanized steel pipes with exposed steel | | | ✓ **(at taps)** |
| Cast iron or old galvanized steel service pipes | | | ✓ **(at building service entry)** |
| *Bacteria Sources:* | | | |
| TBD | | | |




**Estimate of equivalent pipe length for the volume of water flushed for 2 minutes prior to collecting a sample.**

| Pipe Size (inches diameter) | Volume Water Flushed (gal) | Equivalent Length of Pipe (points on schematic) |
|---|---|---|
| ½" connecting pipe | 0.10 | 10 ft (Pts. A to B) |
| 1" lateral pipe | 0.90 | 22 ft (Pts. B to E) |
| 1- ½" lateral pipe | 0.90 | 10 ft (Pts. B to D) |
| 2" lateral pipe | 0.90 | 10 ft (Pts. B to C) |

Note: Assumes that the flow rate is 0.5 gal/minute at the fixture where the sample is being collected. Therefore, a 2-minute flush will withdraw 1.0 gallons of water just ahead of the volume of sample water.

**Figure 3-1. Typical School Building Plumbing Schematic**

### 3.1.1 Lead Sources

Brass bubblers, faucet components and associated end-use plumbing components were identified as the components that released the greatest amount of lead to the water supply. These components are typically made from brass alloys which can contain up to 8% lead. It is common to have elevated lead levels in water that has stood in contact with lead-bearing brass components for one hour or more. The findings of the initial testing program performed in 2004 support this conclusion in that the lead levels in first draw samples were in most cases higher than in flushed samples. The findings from laboratory testing of end-use plumbing components (Attachment D); from special lead testing at Decatur (AE II) School (Attachment E); and the Lead Variability Evaluation (Attachment F) also support the conclusion that end-use plumbing components were the primary sources of lead in school drinking water.

Lead-tin solder can be a source of lead in any building that has copper pipe installed prior to about 1980 in Seattle. Lead from solder can appear in both first draw and flushed samples collected from a drinking water source. Newer copper piping is joined with tin-antimony solders and hence is not a major source of lead. New or refurbished schools that have newer copper piping had low lead levels in flushed samples.

Some older galvanized steel pipes can be sources of lead, which is attributed to lead impurities in the zinc coatings. Also, it is possible that lead originating in other parts of a building piping system can attach and accumulate onto iron corrosion scales on the interior of older steel and iron pipes.

### 3.1.2 Cadmium Sources

Cadmium often occurs naturally with zinc and zinc alloys. Brass alloys and galvanized coatings of steel pipes usually contain zinc. Consequently, both brass components and galvanized steel pipe can be sources of cadmium. Initial testing results (EES, 2004) showed that cadmium could occur in both first draw and flushed samples at taps in buildings with predominantly galvanized steel piping, which supports the likelihood that some older galvanized steel pipe could have been a significant source of cadmium.

The initial testing results also showed that cadmium levels in buildings with predominantly copper plumbing were below analytical detection limits (less than 1 ppb); thereby further implicating galvanized steel as the more probable source of cadmium.

### 3.1.3 Copper Sources

Copper pipes and brass components are the primary sources of copper in drinking water. New copper pipe and brass will almost always leach copper at higher rates initially, and then relatively lower rates with continued exposure to water due to the formation of inhibiting corrosion scales.

### 3.1.4 Iron Sources

Older galvanized steel pipe is the major source of iron at taps in buildings. As the galvanized (zinc) layer on these pipes is depleted, the steel is exposed and develops iron oxide scales. These scales can release iron, both in particulate and dissolved form. Older cast iron or galvanized steel service pipes can also be a source of iron in school buildings.

### 3.1.5 Arsenic Sources

The presence of arsenic above analytical detection levels at taps in school buildings is infrequent. In spring 2006, arsenic was detected at some drinking water sources in Seattle Public Schools. Results of a follow-up investigation in summer 2006 indicated that arsenic was released to the water supply from corrosion scales at those taps where elevated levels of arsenic were found. The source of arsenic was not specifically identified; however it is probable that the original sources of arsenic are the old galvanized steel coatings which can contain arsenic as an impurity. Destructive testing of components recovered from some of the affected sites indicated the occurrence of arsenic in galvanic corrosion scales associated with direct connections of brass components or copper and galvanized steel pipe with no dielectric unions. Attachment M describes the arsenic investigations and testing results in SPS.

### 3.1.6 Bacteria Sources

Almost any interior piping surface in contact with potable water can support the growth of bacteria. Non-pathogenic (not harmful to human health) bacteria are most often found in so-called “biofilms” on pipe surfaces. Corrosion scales on the interior of iron or steel pipes can be expected to support higher levels of bacteria and biofilms. Two types of non-pathogenic bacteria are typically found on iron corrosion scales: (1) heterotrophic bacteria, which require organic carbon as their carbon and energy source, and (2) iron bacteria which are generally interpreted to be those that utilize iron as an energy source and inorganic carbon as their carbon source and are categorized as autotrophs. There is no evidence that these heterotrophic or autotrophic bacteria alone directly relate to health risks either from epidemiological studies or from correlation with occurrence of waterborne pathogens.

Pathogenic (harmful) bacteria may enter building piping systems either via a cross-connection to non-potable water or through some other external entry pathway. However, there is no evidence that pathogenic bacteria can or will grow to harmful levels on iron corrosion scales (Camper, 2004).

*Legionella* spp., in contrast, are bacteria that are found naturally in water systems and can be found in biofilms, but are most likely to grow in hot water systems. There is no research to show that iron surfaces are more likely to support the growth of these organisms than any other materials found in distribution systems or plumbing, although there is some evidence that new copper may lower the counts of these bacteria (Camper, 2004).

Based on the results of the initial testing in 2004, no pathogenic bacteria were found at any of the schools tested.

## 3.2 Remediation Options

### 3.2.1 Identification of Possible Remediation Options

A total of twelve (12) remediation options were identified for controlling the release of contaminants (lead, cadmium, copper, iron and bacteria) into the drinking water supply in SPS. These remediation options are shown in Table 3-2.

Of the twelve options, six were eliminated because they were considered either not feasible and/or not technically viable for achieving the necessary level of water quality improvements. Table 3-2 provides a summary and evaluation of each option based on its likelihood of success, management considerations, and its major advantages and disadvantages. The furthest right column on Table 3-2 indicates if an option was recommended for further consideration or eliminated from the list of remediation options.

**Table 3-2. Remediation Options**

| Option | Contaminants Mitigated | Likelihood of Success | Management Considerations | Major Advantages /Drawbacks | Recommended for Further Consideration |
|---|---|---|---|---|---|
| Flushing Only (w/o any other remediation) | Primarily lead | Low | Excessive burden on custodial staff; overtime labor likely required. Poor control for ensuring flushing is always performed. | Not feasible to perform on a regular basis. Limited effectiveness for any contaminant unless done frequently. | No |
| Point-of-Entry (POE) Chemical Treatment for building piping | Specific based on type of treatment | Low | Treatment types not common to all schools. O&M burden for Facilities staff. Requires certification as a public water supplier. | Best available treatment system may still not result in achieving water quality goals at all places. SPS would become responsible for quality of supplied water. | No |
| Point-of-Entry (POE) filter for service pipe | All except cadmium | Low | Requires periodic filter replacement. O&M burden for Facilities staff. | Iron is major contaminant associated with service pipes. POE filters clog easily with iron. Does not address building piping. | No |
| Magnesium Anodes | Unknown | Very Low/ None | Not evaluated. | Technically unfeasible for mitigating water quality concerns in building piping systems. Has not been successfully applied for controlling any contaminant within buildings. | No |
| Bottled Water | All | High | Well-established mechanisms for obtaining bottled water exist. | Provides high quality water easily. Providing enough sources limits access to water in elementary schools. Normally considered an interim solution. | Yes |

| Option | Contaminants Mitigated | Likelihood of Success | Management Considerations | Major Advantages /Drawbacks | Recommended for Further Consideration |
|---|---|---|---|---|---|
| Remove specific fountains from service | All | High | Little if any follow-up maintenance required. | Option to retain existing fixture, remove it, or replace it in the future. Limited by accessibility criteria. | Yes |
| Remove specific fountains and connective piping | Mainly lead, cadmium and iron in some cases | High | Little if any follow-up maintenance required. | Removes primary sources of lead; also cadmium and iron in some cases. | Yes |
| Replace building plumbing | All | High | Major replacement work limited to summer only. Six schools per year is likely achievable. | Removes primary sources of iron and cadmium, if present. Typical life of new plumbing is 50 years. | Yes |
| Replace service line | Iron, possibly lead in isolated cases | Moderate | Work can be completed over holiday breaks. | Can help reduce iron levels if service line is significant source of iron. | Yes |
| Epoxy lining of building plumbing | All | High | May carry out lining work while school is in session, depending upon piping configuration. Is being used by other local school districts. | Can provide similar effective performance as pipe replacement if existing pipes are structurally adequate. Expected life of linings is not well known. | No |
| Granular Media Point-of-Use (POU) Filters | All | Moderate-High | Required frequent filter replacement, projected at 1 to 3 times per year. | High iron levels plug filters. Lower water pressure in building can limit useful life. Not NSF certified for cadmium. | Yes |
| RO Point-of-Use Filters | All | High | Requires frequent maintenance. Size and complexity of units will significantly limit number of sources that can be treated. Costs are high. | Very high treatment performance. RO filter rejection rates are high, resulting in large quantities of wastewater and increased costs for water usage. | No |

### 3.2.2 Eliminated Remediation Options

The six remediation options that were not considered feasible, and the main reasons they were determined to be not feasible, are described below.

#### 3.2.2.1 Flushing

The most common source of lead in Seattle Public Schools was determined to be brass plumbing components that contain lead. Water that has stood in contact with such components overnight or for longer periods can exhibit elevated lead levels. Therefore, flushing of drinking water sources after idle periods will often reduce lead levels at a source. However, flushing is not likely to work on a daily basis for long periods because it requires custodial staff or others to consistently perform the flushing operation. Also, additional lead testing performed as part of the SPS Drinking Water Quality Improvement Program showed that lead levels can increase to significant levels after only 1–2 hours following flushing. Therefore, flushing alone, without any other remediation measures, was not considered a viable option for consistent lead reduction in SPS.

#### 3.2.2.2 Point-of-Entry Chemical Treatment

Point-of-Entry (POE) chemical addition is sometimes used to help improve the water quality conditions within buildings. Chemicals can be added that help control the corrosion of metal pipes and components. Some corrosion control chemicals can be effective for reducing the leaching of lead and copper from pipes and components. However, this option was considered unfeasible because a chemical treatment system would need to be added to many SPS buildings. Chemical feed systems require a significant amount of operation and maintenance effort and cost, most often under the supervision of trained operators. Additionally, by implementing POE treatment, SPS would be considered a water system under state drinking water regulations and thus would be subject to regulatory requirements associated with being a water system.

#### 3.2.2.3 Point-of-Entry Filters

Commercially-available POE filters are capable of removing an array of contaminants from water. However, using a POE filter at the entry point to a SPS building would not remove contaminants whose source is the piping and/or components within the building. Therefore, POE filters would not be able to mitigate the primary sources of lead, cadmium, copper, and iron in school buildings. Also, POE filters need to have relatively large flow-rate capacities to treat all water entering a school building, which could require the use of filter units that would be physically too large to install easily in mechanical rooms of some SPS buildings.

#### 3.2.2.4 Magnesium Anodes

Corrosion is the process by which the metal components of plumbing systems are oxidized. Oxidation is the first step leading to the solubilization of the metal, and ultimately its release into the water flowing through the plumbing system. During development of the remediation plan, it was suggested that it is technically possible to provide corrosion protection to individual school plumbing systems by installing sacrificial magnesium anode systems that would prevent internal corrosion and metal release. The use of anode systems for protection of internal plumbing surfaces in drinking water systems is not a new idea or a new technology; the concept dates back to at least the 1930s. However, there is absolutely no case history for the use of magnesium anodes to protect the interior of school or residential plumbing systems. There are no examples of successful installations that can be referenced. There is nothing in the literature that would suggest that this "new" application of old cathodic protection principles is appropriate for small-diameter piping systems.

#### 3.2.2.5 Reverse Osmosis Point-of Use Filters

Reverse Osmosis (RO) Point-of-Use (POU) filters can remove most contaminants of concern. RO POU filter units are commercially available in configurations that can be installed under a sink counter or in a stand-alone cabinet. As part of this option, the old component would also be replaced with a new component and immediate connective piping that does not contribute elevated levels of contaminants. However, there are significant constraints associated with installation, access, limited volumes and water rejection (waste) rates that need to be considered. In particular, the size and access requirements for maintenance of these units would limit the number of locations where they could be installed in a school, thereby making this option unfeasible except for isolated locations in secondary schools.

#### 3.2.2.6 Epoxy Lining of Building Piping

This option can provide a similar level of performance as pipe replacement in that it provides an effective barrier against the release of iron and other contaminants from older metal pipes, provided that the existing pipes are structurally adequate. As part of this option, all old components would also be replaced with new components that do not contribute elevated levels of contaminants. This option could be applicable in schools that have significant water quality problems associated with the main building piping system, such as excessive iron or cadmium levels at numerous sources. Epoxy lining systems are NSF approved and have been successfully applied by other school districts. From a technical standpoint, this option appears to be feasible for controlling the release of contaminants from pipes into water. However, the expected life of epoxy lining systems has not been fully demonstrated for smaller diameter piping systems and some questions remain as to the overall service life, performance, and costs of epoxy lining in relation to those for piping replacement, which are known. There were also some concerns about the potential for leaching of synthetic organic compounds but the available information on epoxy linings did not support this conclusion. This option was not considered further.

### 3.2.3 Selected Possible Remediation Options

The remediation options that are technically and operationally feasible for school applications are listed below. For each option, the major reason it has been retained as a feasible option and where it can be applied are summarized. The options are not in order of preference, as different options are more or less appropriate for a given school depending upon the type and extent of water quality problems. Also, for some schools, it may be appropriate to implement more than one option for addressing specific water quality concerns.

#### 3.2.3.1 Bottled Water

The use of bottled water was successfully implemented by the District as an interim remediation measure. This option can be applied to any school with water quality concerns at any number of places throughout a school. A review of regulatory considerations and guidelines for bottled water are included as Attachment K.

#### 3.2.3.2 Remove Specific Sources from Service

The removal of specific sources from service was determined to be a feasible option and it was successfully implemented by SPS. This option was exercised in areas where the accessibility criteria for adequate supply of safe, clean drinking water could be met because of other nearby drinking water sources.

#### 3.2.3.3 Replace Components and Connective Piping at Specific Sources

This option provides for the removal of a component and/or the immediate connective piping to a component that contributes to elevated lead, copper, or cadmium levels in water at that source, and replacement with plumbing components that do not contribute these contaminants above established standards. Components and plumbing materials with very low lead content (or zero lead added during the manufacturing of the alloy) are commercially available, as well as end-use plumbing components made of polymeric materials. As part of the development of this Remediation Plan, SPS considered potential risks associated with leaching of organic contaminants from plastic piping materials (Attachment L). SPS has shown that the replacement of components and connective piping can be highly successful based on water quality results collected at sites where this option has been implemented. SPS should continue to identify available metal alloy plumbing components with less than 0.2% lead for future applications.

This option requires the pre-conditioning of metal components before installation, as it has been observed that low lead (or non-leaded) components can leach lead during initial usage. Pre-conditioning is necessary to consistently meet the SPS goal for no more than 10 ppb of lead in the initial standing sample. Attachment Q.3 provides a description of pre-conditioning procedures. This option is applicable in schools that do not have significant water quality problems associated with the main building piping system.

#### 3.2.3.4 Replace All Building Piping and Components

This option provides for the removal of virtually all potential sources of lead, cadmium, and iron from a building water supply system. Per current building codes, the replacement piping material is copper. New copper pipes can sometimes result in elevated copper levels when the pipes are first exposed to water, but this does not create elevated copper concerns in water supplied by Seattle Public Utilities except under some highly unusual circumstances such as improper electrical grounding to copper pipes. As part of this option, all old components are replaced with new components that do not contribute elevated levels of contaminants. This option is applicable in schools that have significant water quality problems associated with the main building piping system, such as excessive iron or cadmium levels at numerous sources. It may also be applied to portions of schools, such as selected wings.

#### 3.2.3.5 Replace Service Line

Old galvanized steel or cast iron service lines can contribute to elevated iron levels in buildings. Replacement of the old service line with new pipe material can reduce the release of iron and other metals into the building's water supply. This option can be implemented either by itself if the service line is the only known source of iron to a school, or in conjunction with other remediation measures.

#### 3.2.3.6 Granular Media Point-of-Use Filters

Point-of-Use (POU) filters that are certified by NSF Standard 61 for lead removal have been shown to be effective for removing metals (lead, cadmium, copper, and iron) contaminants, as well as color and turbidity, based on special studies performed as part of this project (see Attachment J). POU filters require periodic replacement of the internal cartridge. As part of this option, old POU filter components are replaced with new components and associated end-use plumbing components. Filters are applicable for removing metals (lead, cadmium, copper, iron) even if used in buildings with higher iron levels, but the service life of the filter cartridge can be shortened because of plugging from iron particulates. The filter cartridge service life may also be constrained if available water pressure at the source is not sufficient to overcome the head loss buildup as the filter cartridge is filled with particulate matter. This option is not preferred for long term usage (more than a few years) as it requires scheduled maintenance consisting of regular replacement of the filter cartridges. SPS has decided not to install additional filters except where no other solution is cost effective and to phase out filters where opportunities present themselves.

## 3.3 Planned Renovations and Future Uses of Facilities

A number of schools were candidates for work as part of two SPS capital improvement programs, the Building Excellence Program and the Buildings, Technology and Athletics Program. Some of the projects under these programs involved complete replacement of all piping. Piping replacement work in selected schools started in the summer of 2004 and is expected to continue each summer for at least the next decade.

# 4.0 Remediation Plan Description

This section describes the major elements of the Remediation Plan, which includes the following:

- Administration, funding, and management for water quality improvements
- Overall remediation approach
- Remediation approach for contaminants of concern

## 4.1 Administration, Funding, and Management for Water Quality Improvements

### 4.1.1 Administration and Funding

Funding for the testing and remediation program was provided from various capital funds, primarily the Building, Technology and Athletics (BTA) levies. As such, the program was administered by the District's capital department, as part of the ongoing BTA II levy program. Major remediation efforts were managed by the BTA Program Manager utilizing outside contractors. Smaller efforts (replacement of individual sources, etc) were managed by the District's Maintenance Department.

### 4.1.2 Drinking Water Quality Program Coordinator

SPS created a new position for a Drinking Water Quality Program Coordinator in FY 2007. This person will be responsible for managing and carrying-out all necessary activities associated with the program.

## 4.2 Overall Remediation Approach

To better organize and implement the necessary water quality remediation activities, the relative magnitude and types of water quality problems were identified for each school, and the schools were then placed into three groups for remediation, as described in Table 4-1.

**Table 4-1. Classification of Schools into Remediation Groups**

| Remediation Group | Description | Remediation Activities |
|---|---|---|
| 1 | These schools were either already in-service (i.e., water supplied from Seattle Public Utilities through the building piping system) prior to August 2004 or have been placed back into service after successful remediation since that time. | Additional remediation of specific sources was needed to fully conform to SPS Water Policy water quality and accessibility criteria. |
| 2 | These schools had remained on bottled water, but because they had few or no iron problems, it did not appear that major remediation would be required to address water quality problems. Following successful remediation, most of these schools were moved to Group 1. Those that were subsequently found to have more significant problems were moved to Group 3. | The necessary remediation activities at these schools were completed while school was in session with minimal disruption because major piping remediation was not required to meet all water quality criteria. |
| 3 | These were schools that had numerous sources failing the lead and/or cadmium criteria which also initially failed the iron criterion of 0.3 ppm in more than 50% of the samples collected, indicating that the piping conditions were poor and in need of repair in portions of or all of the school. | Further testing and evaluations in these schools were completed to determine if the school failed the 50% requirement for iron and where specific piping replacements would be needed within each school.<br><br>Remediation included the replacement of old galvanized steel piping in portions of or all of the school, as well as replacement of end-use plumbing and components. The level of remediation work for these schools required that the work be completed during summers only. |

As further testing was conducted and remediation work performed, schools were moved from one group to another. Virtually all schools are now on-line as of May, 2007.

## 4.3 Remediation Approach for Contaminants of Concern

This section provides summary descriptions of the remediation approaches and methods that were used to address contaminants that exceeded the SPS criteria for water quality from March 2004 through April 2007. Specific actions that were taken during the Drinking Water Quality Improvement Program to address lead, cadmium, copper, iron, and biological contamination are described below.

### 4.3.1 Remediation for Lead

#### 4.3.1.1 Criteria for Remediation

Per the Water Policy, if the lead concentration exceeded 10 ppb in a 250-mL sample (either first draw or flushed) from any drinking water source (bubbler or sink faucet) that was needed to meet the accessibility criteria, it was remediated as described below.

Drinking water sources that did not meet the lead criterion, but are not needed to meet the accessibility criteria, were shut off, disabled, or removed.

#### 4.3.1.2 Applicable Remediation Methods and Actions

The primary objective for remediation of lead is to remove any and all sources of lead in end-use plumbing at individual sources and in building piping systems when and where they are identified.

If lead exceeded the 10 ppb criterion in the first draw sample, but not in the flushed sample, results indicated that the bubbler/faucet and/or the associated end-use plumbing components were the probable sources of lead. Replacement of the bubbler/faucet and the end-use plumbing was the most appropriate remediation method. If the source was not needed to meet the accessibility criteria of the Water Policy, it was removed from service.

If lead exceeded the 10 ppb criterion in the flushed sample (or in both the first draw and flushed samples), results indicated that in addition to the bubbler/faucet or end-use plumbing, there may have been lead sources farther back in the building piping system. For buildings that had more than three sources with higher lead levels in flushed samples, remediation in addition to replacement of end-use plumbing components was considered, such as replacement of portions of the building plumbing.

#### 4.3.1.3 Post-Remediation Verification Testing and Actions

Following remediation of a drinking water source for lead, verification testing was performed. This consisted of conducting a two-minute flush of the fixture the day prior to sampling, followed by the collection of samples on the following morning not more than 18 hours after flushing. Two 250-mL samples were collected, the first captured the first draw water from the source and the second was collected after 30 seconds of flushing. Refer to the detailed sampling protocol in Attachment Q.5. Samples were analyzed by a certified commercial laboratory.

If the post-remediation testing results were less than or equal to the 10 ppb lead criterion, and all other required water quality parameters were met, the source was then identified as one that could be released to service.

If the post-remediation testing results were greater than the 10 ppb lead criterion, the source was temporarily disabled, and follow-up actions were taken to bring the source into compliance as follows:

1. Verified that the bubbler/faucet and end-use plumbing met SPS standards;
2. Checked for any unusual plumbing conditions or external sources of contamination;
3. Performed additional flushing to further condition the bubbler/faucet, followed by re-testing; and

4. If the three preceding actions did not correct the problem, and the source was needed to meet the accessibility criteria, the next step was to provide a bottled water station at the source.

### 4.3.2 Remediation for Cadmium

#### 4.3.2.1 Criteria for Remediation

Per the Water Policy, if the cadmium concentration exceeded 5 ppb in a 250-mL sample (first draw or flushed) from any drinking water source (bubbler or faucet) needed to meet the accessibility criteria; it was remediated as described below.

#### 4.3.2.2 Applicable Remediation Methods and Actions

If cadmium exceeded the 5 ppb criterion in the first draw sample, but not the flushed sample, this indicated that the fixture and/or the immediate connective piping to the fixture were the probable sources of cadmium. Replacement of the bubbler/faucet and the end-use plumbing was the most appropriate remediation method. Drinking water sources that did not meet the cadmium criterion and were not needed to meet the accessibility criteria, were shut-off, disabled, or removed.

If cadmium exceeded the 5 ppb criterion in both the first draw and flushed samples or the flushed sample only, this indicated that, in addition to the bubbler/faucet or end-use plumbing, there may have been cadmium sources farther back in the building piping system. Further investigation was made to determine the appropriate action.

#### 4.3.2.3 Post-Remediation Verification Testing and Actions

The same procedures that were followed for lead, as described above in Section 4.3.1 were followed for cadmium.

### 4.3.3 Remediation for Copper

#### 4.3.3.1 Criteria for Remediation

Per the Water Policy, if the copper concentration exceeded 1.3 ppm in a 250-mL sample (first draw or flushed) from any drinking water source (bubbler or faucet) needed to meet the accessibility criteria, it was remediated using one of the applicable methods described below.

#### 4.3.3.2 Applicable Remediation Methods and Actions

Based on the Phase 1 data, as well as data from Seattle Public Utilities, copper levels exceeding the 1.3 ppm criterion are unusual for buildings served with Seattle water, even with new copper pipe, as discussed in more detail in section 3.2.3.4.

If copper exceeded the 1.3 ppm criterion in the first draw sample, but not the flushed sample, this indicated that the end-use components and/or the immediate connective piping to the fixture was the probable source of copper. Replacement of the bubbler/faucet and the end-use plumbing was the most appropriate remediation method. Drinking water sources that did not meet the copper criterion and were not needed to meet the accessibility criteria, were shut-off, disabled, or removed.

If copper exceeded the 1.3 ppm criterion in both the first draw and flushed samples or the flushed sample only, this indicated that, in addition to the bubbler/faucet or end-use plumbing, the source of the elevated copper was farther back in the building piping system and further investigation was performed, as described below.

#### 4.3.3.3 Post-Remediation Verification Testing and Actions

Following remediation of a drinking water source for copper, verification testing was performed. This consisted of conducting a two-minute flush of the fixture the day prior to sampling, followed by the collection of samples on the following morning not more than 18 hours after flushing. Two 250 mL samples were collected; the first to capture the first draw water from the fixture, and the second was collected after 30 seconds of flushing through the fixture.

If the post-remediation testing results were less than the 1.3 ppm copper criterion, and all other required water quality parameters were met, the source was then identified as one that could be released to service.

If the testing results were greater than the 1.3 ppm copper criterion in either the first draw or flushed sample, further investigate was done as described below:

The following conditions may contribute or cause an elevated copper level in water:

- Electrical grounding directly to copper pipe
- Newly installed copper piping to the source

If improper electrical grounding was verified, necessary corrections were made to remove the grounding connection.

If new copper tubing was found, but no other potential problems were noted, it was assumed that copper levels would gradually decrease with time as corrosion films formed (passivation) and limited the dissolution of copper. Therefore, if the initial copper level was between 1.3 ppm and 1.5 ppm, the appropriate course of action was to temporarily take the source out-of-service and allow the copper to “age” for 2 to 4 weeks before re-sampling. If the re-sample results were below 1.3 ppm, the fixture was returned to service and no physical work was needed for remediation. If the source had a copper level greater than 1.5 ppm and the fixture had to be returned to service quickly, the copper tubing to the fixture was replaced with an alternative piping material such as PVC.

### 4.3.4 Remediation for Iron

#### 4.3.4.1 Criteria for Remediation

For a drinking water source that is governed by the accessibility criteria (described in the Water Policy), remediation of iron is required if:

1. A 250-ml sample (collected after two minutes of flushing) exceeds 0.5 ppm iron
2. More than 50% of 250-ml samples (collected after two minutes of flushing) contain less than 0.3 ppm iron

It should be noted that these iron criteria were based on confirmation sampling results; i.e., if an initial sample failed the criteria, a second sample was taken. The lower of the two results was then used to determine whether and to what extent remediation was necessary. This confirmation step lengthened the testing program, but recognized that iron was an aesthetic concern, not a health issue.

Although not specifically identified as an iron criterion in SPS Water Policy, it was recommended that if the iron concentration in water at a building service entrance was greater than 0.3 ppm in a confirming two-minute flushed sample, this indicated that the condition of the iron or steel service pipe had deteriorated and replacement of the service line should be considered.

Drinking fountains that did not meet the iron criterion, but were not needed to meet the accessibility criteria, were shut off, disabled, or removed. A summary of the testing and remediation approach for iron in drinking water is contained in the appendix as Attachment I.

#### 4.3.4.2 Applicable Remediation Methods and Actions

There were three sets of applicable methods for iron remediation, depending upon which criterion for iron is exceeded.

1. ***Remediation of individual sources exceeding 0.5 ppm iron in a confirmed flushed sample.*** For these sources, the following investigations and remediation actions were performed:
   - If the source was not needed to meet the accessibility criteria, and the school staff agreed that the source was not needed, the source was disabled or removed.
   - If the source was needed to meet the accessibility criteria, coordination with the school staff determined which of the following actions was most appropriate: 1) keep the source in-service and post a sign above the source indicating that iron levels may exceed the Water Policy criterion (0.5 ppm), or 2) temporarily disable the source and provide a bottled water station.
2. ***Remediation for schools with more than 50% of confirmed flushed samples greater than 0.3 ppm.*** In this case, the following remediation actions were performed:
   - If the sources that were over 0.3 ppm for confirmed flushed samples were within a particular area of the school, replace the piping in the area of the building that supplies these sources. For any sources that exceeded 0.5 ppm for confirmed flushed samples, the actions described above were performed.
   - If the sources that were over 0.3 ppm for confirmed flushed samples were numerous and found throughout the school, a full piping replacement at the school was planned.
3. ***Remediation for iron greater than 0.3 ppm in flushed samples from the service pipe.***
   - First, it was confirmed that the water sample taken at the service entrance was representative of water from the service line. If the initial sample showed iron greater than 0.3 ppm, a second sample was taken to confirm that iron was a problem.
   - If the results of the representative service pipe sample still had iron greater than 0.3 ppm, the service line was replaced with copper or cement-mortar lined ductile iron pipe.

#### 4.3.4.3 Post-Remediation Verification Testing and Actions

Following remediation, verification testing was performed. This consisted of conducting a two-minute flush of the fixture the day prior to sampling, followed by the collection of samples on the following day. One 250-mL sample was collected after two minutes of flushing through the source. (Refer to the detailed sampling protocol in Attachment Q.5.) If the sample results exceeded the iron criteria, appropriate remediation actions were taken to bring the source into compliance as described above.

Following replacement of a service pipe, verification testing was performed. This consisted of collecting a sample at the most suitable tap in the service entry to the building. The sample was collected first thing in the morning prior to the start of the school day (if school is in session) after flushing for two minutes.

Samples were analyzed by a certified commercial laboratory.

### 4.3.5 Remediation for Preventing Arsenic Contamination

Because arsenic testing is not regularly done this section is not part of SPS procedures. This section is included for historical purposes only.

#### 4.3.5.1 Criteria for Remediation

If the arsenic concentration exceeds 10 ppb in a 250-mL sample (first draw or flushed) from any drinking water source (bubbler or faucet) needed to meet the accessibility criteria, the remediation approach is as described below.

#### 4.3.5.2 Applicable Remediation Methods and Actions

Check the connective piping to the source for any dissimilar metals (steel to brass or copper) that are in direct contact without a dielectric union. If such a condition is found, make appropriate changes to the piping and components to remove the steel to brass/copper points of contact.

If the dissimilar metals piping condition is not found or cannot be determined, testing conducted in summer 2006 has shown that keeping the source in regular service so that water is flushed through it on a fairly frequent basis is a highly effective mitigation method. However, sources that have exhibited elevated arsenic levels should not be allowed to stand stagnant for more than 5 days to preclude the buildup of arsenic in the stagnant water. Therefore, flushing of such sources shall be done after school breaks of 5 days or longer.

### 4.3.6 Remediation for Preventing Biological Contamination

#### 4.3.6.1 Criteria for Remediation

If an initial bacteriological sample was found to be positive for total coliform (TC), follow-up sampling was done, as described below. All samples that were found positive for TC were then analyzed for fecal coliform. The analytical method for fecal coliform also detects pathogenic bacteria including *E. coli*. Remediation for biological contamination was performed within a building or that portion of a building that had had a confirmed positive TC result, i.e., when a positive TC occurred in one of the follow-up samples taken at the building.

#### 4.3.6.2 Applicable Remediation Methods and Actions

When an initial positive TC sample was found, the following actions were performed:

- Follow-up coliform samples were collected from the source with the initial positive TC sample, at two or more other adjacent sources, and at the service entrance.
- If any of the follow-up samples were positive for TC, the entire school was placed on bottled water within one day of the confirmation and Public Health Seattle-King County (PHSKC) was contacted to help determine the most appropriate mitigation strategy.
- Within one working day school staff and parents were notified of the positive TC confirmation and what actions were being taken.

- A thorough flushing of the entire wing or area of the building where the positive TC sample or samples occurred was performed. Flushing was conducted when school was not in session. The duration of flushing was at least 20 minutes.
- At the earliest practicable time, a complete cross-connection inspection of the entire building piping system was performed. If any potential cross-connection conditions were found, appropriate corrections were made to remove the condition.
- After flushing, a second set of follow-up coliform samples from the same sources as before were collected. If none were positive for TC, no further action was taken.

If any sample (initial or repeat) was also positive for fecal coliform, this observation indicated that there was or had been a source of fecal contamination. In this case, the entire school was placed on bottled water immediately and PHSKC was contacted to help determine the most appropriate mitigation strategy.

#### 4.3.6.3 Cross-Connection Control

SPS has an ongoing cross-connection control program (CCCP) for all facilities. The CCCP is a preventative maintenance program for the purpose of precluding the possibility of microbial and other types of contamination from entering building piping systems. The guidelines for the CCCP are described in Attachment Q.8

# 5.0 Overview of Remediation Activities and Summary of Remediation Results

This section provides an overview of the general sequence of the water quality remediation activities that have been implemented since summer 2004 and the status of these activities as of April, 2007. The chronological sequence of the major remediation activities that have been undertaken is shown in Table 5-1.

**Table 5-1. Summary and Sequence of the Major Remediation Activities**

| Major Remediation Activity | Approximate Start Date | Approximate Completion Date | Notes |
|---|---|---|---|
| All schools and related facilities (except the 15 schools built since 1997) taken off Seattle water and supplied with bottled water. | December 2003 | January 2004 | Schools remained on bottled water until all necessary remediation was completed. |
| Initial (Phase 1) water quality testing at all schools and facilities. | March 2004 | July 2004 | Phase 1 testing results served as baseline from which to identify the necessary and additional remediation actions. |
| Schools with most pressing water quality concerns were identified, had complete piping replacement, and are returned to normal water service. Lead trigger level used was 20 ppb. | April 2004 | August 2004 | Four schools had complete pipe replacements. Two then passed all criteria and were returned to service; 2 did not and required further remediation. |
| Schools with fewest water quality problems were identified, individual problem sources remediated, and returned to normal water service. Lead trigger level used was 20 ppb. | June 2004 | August 2004 | This activity returned 22 schools to normal water service by start of the 2004/05 school year. |
| Carried out additional testing for cadmium, copper, and iron at all sources not previously tested for these metals in those schools that had not been returned to service in August 2004. | September 2004 | March 2005 | Additional testing was done at about 56 schools. |
| Identified the schools with the worst overall water quality for extensive piping remediation in summer 2005. | November 2004 | August 2005 | Six schools had complete or partial piping replacement during summer 2005. Four schools passed all criteria and were returned to service; 2 did not and required further remediation. |

| Major Remediation Activity | Approximate Start Date | Approximate Completion Date | Notes |
|---|---|---|---|
| After the School Board established the lead criterion of 10 ppb, identified and remediated those sources in 39 on-line schools that had lead levels greater than 10 but less than 20 ppb. | December 2004 | March 2005 | Over 150 individual sources in these schools were identified, remediated, re-tested, and returned to service. |
| Conducted detailed laboratory investigations of new end-use plumbing components and filters to improve materials selection and remediation actions for controlling lead. | July 2005 | October 2005 | Overall purpose of the investigations was to determine why many sources with all new plumbing components would still fail the lead criterion. |
| Carried out remediation of individual sources that had failed one or more water quality criterion in schools still not in normal water service. As sources were successfully fixed, these schools were returned to service. | July 2005 | March 2006 | During this period, 49 more schools were successfully remediated and returned to normal water service, if six or fewer locations require bottled water. |
| Conducted special study of lead level variability. | December 2005 | February 2006 | Tested 12 representative sources for 8 days to determine probable variability in measured lead levels. |
| Carried out comprehensive testing program for arsenic in all schools. | April 2006 | July 2006 | SPS chose to have comprehensive arsenic testing done after some elevated levels of arsenic were found in water samples collected in early 2006. Methods and Results are described in Attachment M. |
| Special evaluations to determine the possible sources of arsenic and the most effective remediation approach for arsenic. | June 2006 | August 2006 | Evaluations were done of plumbing component materials and the effect of stagnant water on arsenic levels. |
| Continued to carry out remediation of individual sources that had failed one or more water quality criterion in schools still not in normal water service. As sources were successfully fixed, these schools were returned to service. | August 2006 | April 2007 | Almost all schools were returned to regular water service as individual sources are remediated. |

To document the effectiveness of the Plan, the initial (Phase 1) water quality testing results from 2004 are compared to current water quality results that were measured after remediation was completed in virtually all of the 98 schools and other facilities. The schools that are currently on-line may have up to 6 individual sources that are awaiting remediation. Until remediation is completed, the sources in these schools will remain disabled.

Results are broken out by contaminant (lead, cadmium, copper, iron, and arsenic) and discussed in the subsections below. Follow-up monitoring of other parameters that were measured as part of Phase 1 testing (pH, turbidity, color, total coliform, and zinc) was not done after remediation measures – these parameters were measured in Phase 1 only to gain a better understanding of the overall water quality conditions.

## 5.1 Lead Remediation Results

A summary of lead test results in first draw and 30-second flushed samples for all drinking water sources at all on-line schools is given in Table 5-2 and Table 5-3. Results of initial Phase I testing prior to remediation efforts and Phase II testing post-remediation are presented for testing up until April 3, 2007. Those schools that were still on bottled water are not included in the remediation results because: 1) more extensive remediation efforts are planned, or 2) no remediation is planned due to possible closure or renovation. Results of initial (Phase 1) testing for lead at schools and related facilities also are shown in Tables 5-2 and 5-3.

Figure 5-1 and Figure 5-2 show how the percentage of "passing" sources with lead levels less than 10 ppb has increased in Phase II, after remediation, for both first-draw and flushed samples. The percentage of sources with lead levels greater than 10ppb has decreased in Phase II for both first-draw and flushed samples.

Table 5-2. Summary of Lead Remediation Results – First Draw Samples

| Testing Phase | Total No. of Sources Tested | % Sources Passing (0-10 ppb) | Number of Sources in Concentration Range of | | |
|---|---|---|---|---|---|
| | | | 0 - 10 ppb | >10 - 20 ppb | >20 ppb |
| Initial – Phase 1 (until June 1, 2004) | 3185 | 67.3% | 2144 | 417 | 624 |
| Phase II (June 2, 2004 - April 3, 2007) | 2050 | 85.3% | 1749 | 150 | 151 |

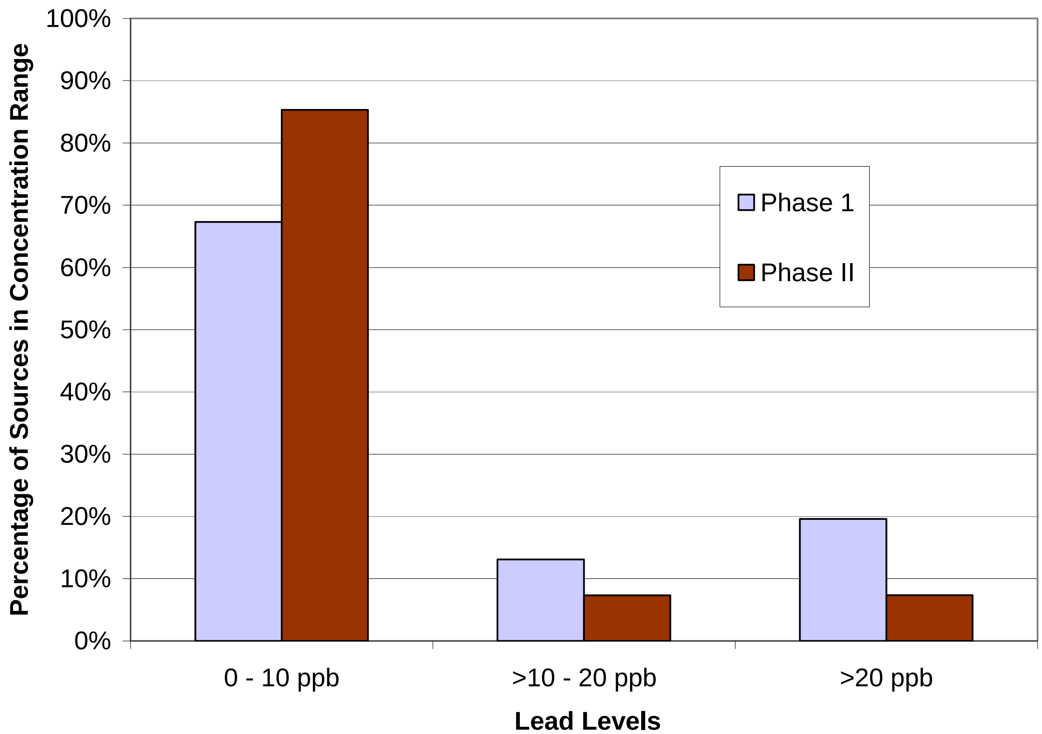



**Figure 5-1. First-Draw Lead Results: Percentage of Sources in a Given Lead Concentration Range for Phase I and Phase II (post-remediation)**

Drinking water sources that had lead levels greater than 10 ppb are disabled, or otherwise posted where appropriate.

**Table 5-3. Summary of Lead Remediation Results – 30 Second Flushed**

| Testing Phase | Total No. of Sources Tested | % Sources Passing (0-10 ppb) | Number of Sources in Concentration Range of | | |
|---|---|---|---|---|---|
| | | | 0 - 10 ppb | >10 - 20 ppb | >20 ppb |
| Initial – Phase 1 (until June 1, 2004) | 3221 | 93.6% | 3014 | 114 | 93 |
| Phase II (June 2, 2004 - April 3, 2007) | 2048 | 97.1% | 1988 | 35 | 25 |

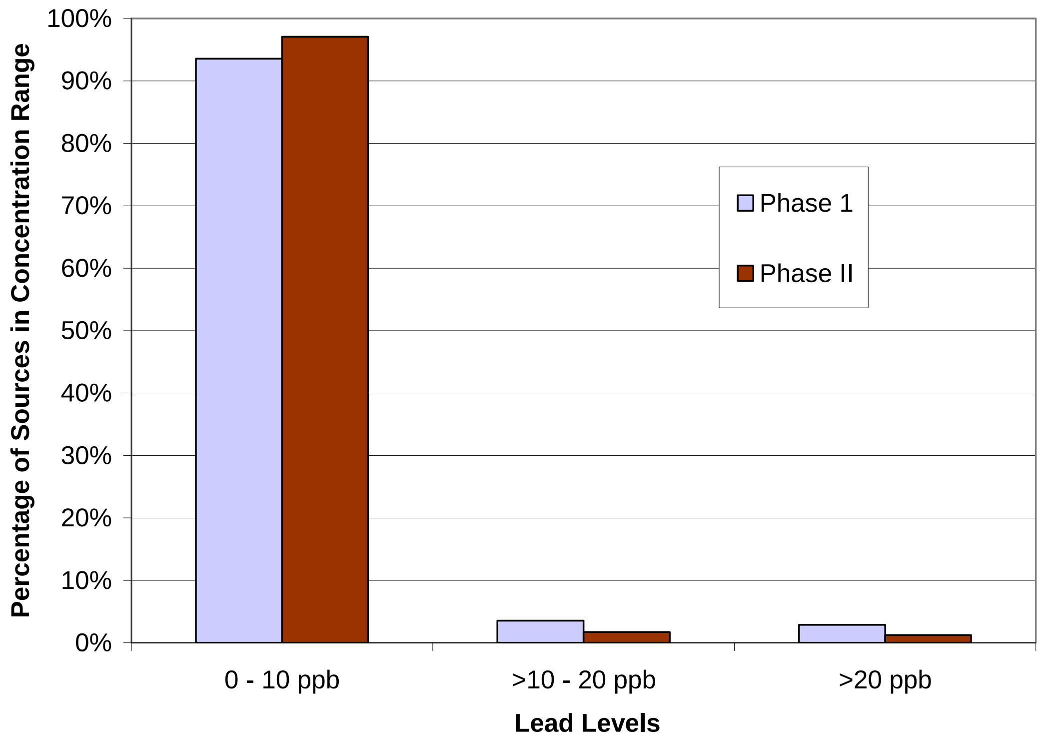



**Figure 5-2. 30-Second Flushed Lead Results: Percentage of Sources in a Given Lead Concentration Range for Phase I and Phase II (post-remediation)**

Drinking water sources that had lead levels greater than 10 ppb are disabled, or otherwise posted where appropriate.

Remediation of the sources that are still above the 10 ppb lead limit is ongoing. These sources will remain turned off so that they cannot be used until sampling results indicate that the source water meets the SPS water quality criteria.

## 5.2 Cadmium Remediation Results

A summary of cadmium results in first draw and 30-second flushed samples for all drinking water sources at all on-line schools after remediation, for data collected through April 3, 2007, are shown in Table 5-4 and Table 5-5, respectively. Those schools that were still on bottled water are not included in the remediation results because: 1) more extensive remediation efforts are planned, or 2) no remediation is planned due to possible closure or renovation. The results of the initial (Phase 1) testing for cadmium at all schools and related facilities are also shown.

**Table 5-4. Summary of Cadmium Remediation Results – First Draw Samples**

| Testing Phase | Total No. of Sources Tested | Number and Percent of Sources Passing | | Number and Percent of Sources in Concentration Ranges of: >5 ppb | |
|---|---|---|---|---|---|
| | | Number | Percent | Number | Percent |
| Initial – Phase 1 (until June 1, 2004) | 2972 | 2884 | 97.0% | 88 | 3.0% |
| Phase II (June 2, 2004 - April 3, 2007) | 2852 | 2828 | 99.2% | 24 | 0.8% |

**Table 5-5. Summary of Cadmium Remediation Results – 30-second Flushed**

| Testing Phase | Total No. of Sources Tested | Number and Percent of Sources Passing | | Number and Percent of Sources in Concentration Ranges of: >5 ppb | |
|---|---|---|---|---|---|
| | | Number | Percent | Number | Percent |
| Initial – Phase 1 (until June 1, 2004) | 2894 | 2858 | 98.8% | 36 | 1.2% |
| Phase II (June 2, 2004 - April 3, 2007) | 2849 | 2843 | 99.8% | 6 | 0.2% |

Remediation of the sources that are still above the 5 ppb cadmium limit is ongoing, and these sources will remain turned off so that they cannot be used until sampling results indicate that the source water meets the SPS water quality criteria.

## 5.3 Copper Remediation Results

A summary of copper results in first draw and 30-second flushed samples for all drinking water sources at all online schools after remediation, for data collected through April 3, 2007, are shown in Table 5-6 and Table 5-7, respectively. Those schools that were still on bottled water are not included in the remediation results because: 1) more extensive remediation efforts are planned, or 2) no remediation is planned due to possible closure or renovation. Results of the initial (Phase 1) testing for copper at all schools and related facilities are also shown.

**Table 5-6. Summary of Copper Remediation Results – First Draw Samples**

| Testing Phase | Total No. of Sources Tested | Sources Passing % | Number of Sources in Concentration Range of | |
|---|---|---|---|---|
| | | | 0 - 1.3 ppm | >1.3 ppm |
| Initial – Phase 1 (until June 1, 2004) | 2435 | 98.0% | 2387 | 48 |
| Phase II (June 2, 2004 - April 3, 2007) | 2790 | 99.4% | 2772 | 18 |

**Table 5-7. Summary of Copper Remediation Results – 30 Second Flushed Samples**

| Testing Phase | Total No. of Sources Tested | Sources Passing % | Number of Sources in Concentration Range of | |
|---|---|---|---|---|
| | | | 0 - 1.3 ppm | >1.3 ppm |
| Initial – Phase 1 (until June 1, 2004) | 2240 | 99.6% | 2230 | 10 |
| Phase II (June 2, 2004 - April 3, 2007) | 3016 | 99.9% | 3014 | 2 |

Remediation of the sources that are still above the 1.3 ppm copper limit is ongoing and these sources will remain turned off so that they cannot be used until sampling results indicate that the source water meets the SPS water quality criteria.

## 5.4 Iron Remediation Results

A summary of iron results for Phase II data collected through April 3, 2007 for 2-minute flushed samples is shown in Table 5-8. The results of the initial (Phase 1) testing for iron at all schools and related facilities are also shown. Figure 5-3 shows that the percentage of “passing” sources has increased in Phase II. Sources with iron levels greater than 0.5 ppm have decreased in Phase II compared to Phase I. Those schools that were still on bottled water or are no longer occupied are not included in the remediation results because: 1) more extensive remediation efforts are planned, or 2) no remediation was planned due to possible closure or renovation.

**Table 5-8. Summary of Iron Remediation Results – 2-minute Flushed Samples**

| Testing Phase | Total No. of Sources Tested | Sources Passing | Sources Passing % | Number of Sources in Concentration Range of | |
|---|---|---|---|---|---|
| | | | | 0.5 – 1.0 ppm | >1.0 ppm |
| Initial – Phase 1 (until June 1, 2004) | 1904 | 1684 | 88.4% | 624 | 62 |
| Phase II (June 2, 2004 - April 3, 2007) | 1873 | 1746 | 93.2% | 82 | 45 |

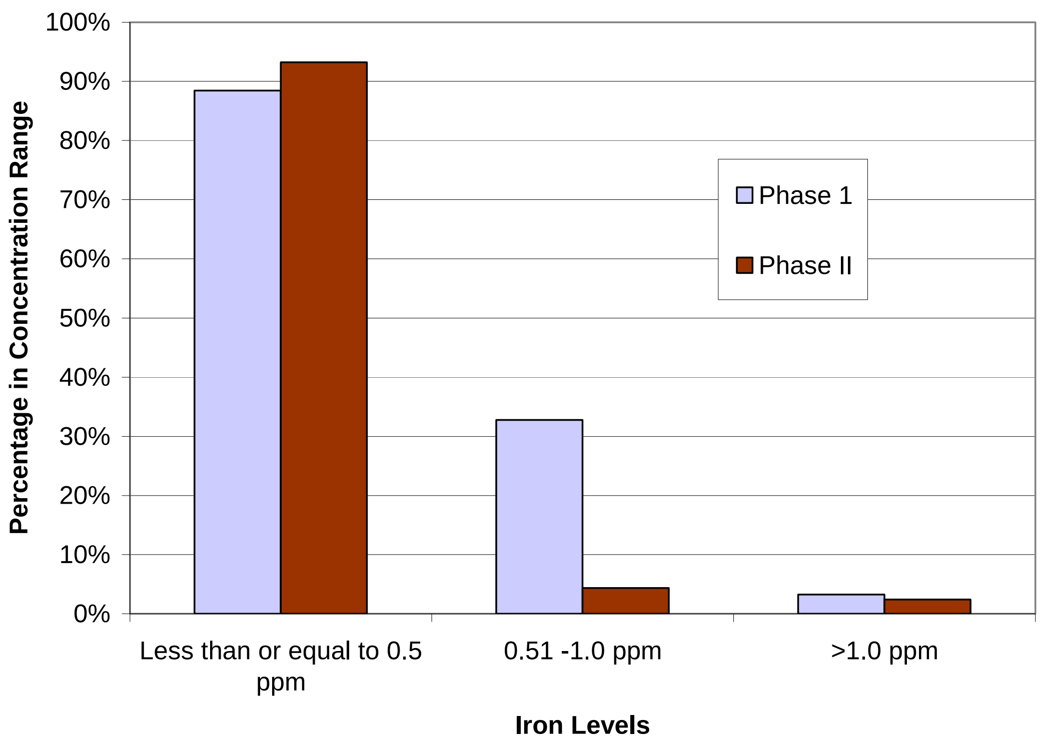



**Figure 5-3. Two-Minute Flushed Iron Results: Percentage of Sources in a Given Iron Concentration Range for Phase I and Phase II (post-remediation)**

Remediation of drinking water sources at these schools is ongoing, and until sampling results indicate that the drinking water source water meets the SPS water quality criteria, they will remain turned off so they cannot be used.

## 5.5 Arsenic Testing Results

A summary of results from the comprehensive arsenic testing program that was conducted in May and June 2006 is shown in Table 5-9. Results represent data from 93 schools that were available as of July 31, 2006. Results do not include the follow-up sampling that was performed during summer 2006 for the locations that had arsenic above 10 ppb in the May/June comprehensive sampling.

**Table 5-9. Summary of Arsenic Testing Results – First Draw or 30-Second Flush Samples**

| Total No. of Sources Tested | Number and Percent of Sources Less Than or Equal to 10 ppb | | Number and Percent of Sources in Concentration Ranges of: | | | |
|---|---|---|---|---|---|---|
| | | | 2 - 10 ppb | | >10 ppb | |
| | Number | Percent | Number | Percent | Number | Percent |
| 3526 | 3460 | 98.1% | 45 | 1.3% | 21 | 0.6% |

# 6.0 Revised Contaminant Control and Monitoring Procedures

This section describes the revised procedures for ongoing and future contaminant control and monitoring, including the following:

- Water quality data management
- Water quality monitoring plan (long-term)
- Communications and status reports
- Oversight committee
- Coordination with other agencies

## 6.1 Water Quality Data Management

Water quality monitoring data for Seattle Public Schools is stored and managed in a database. This allows easy retrieval of updated information and review of SPS drinking water source status. Water quality monitoring information is also uploaded to, and accessible through the SPS website. The procedures for updating the water quality data and the status of drinking water sources after testing and/or remediation, in the database and on the website, are described in Attachment O and P.

## 6.2 Revised Water Quality Remediation Decision Procedures

The Water Quality Remediation Decision Flowchart in Figure 6-1 shows the proposed future ongoing testing and remediation process for lead at drinking water sources. A similar procedure could be followed for copper using the applicable threshold level of 1.3 ppm.

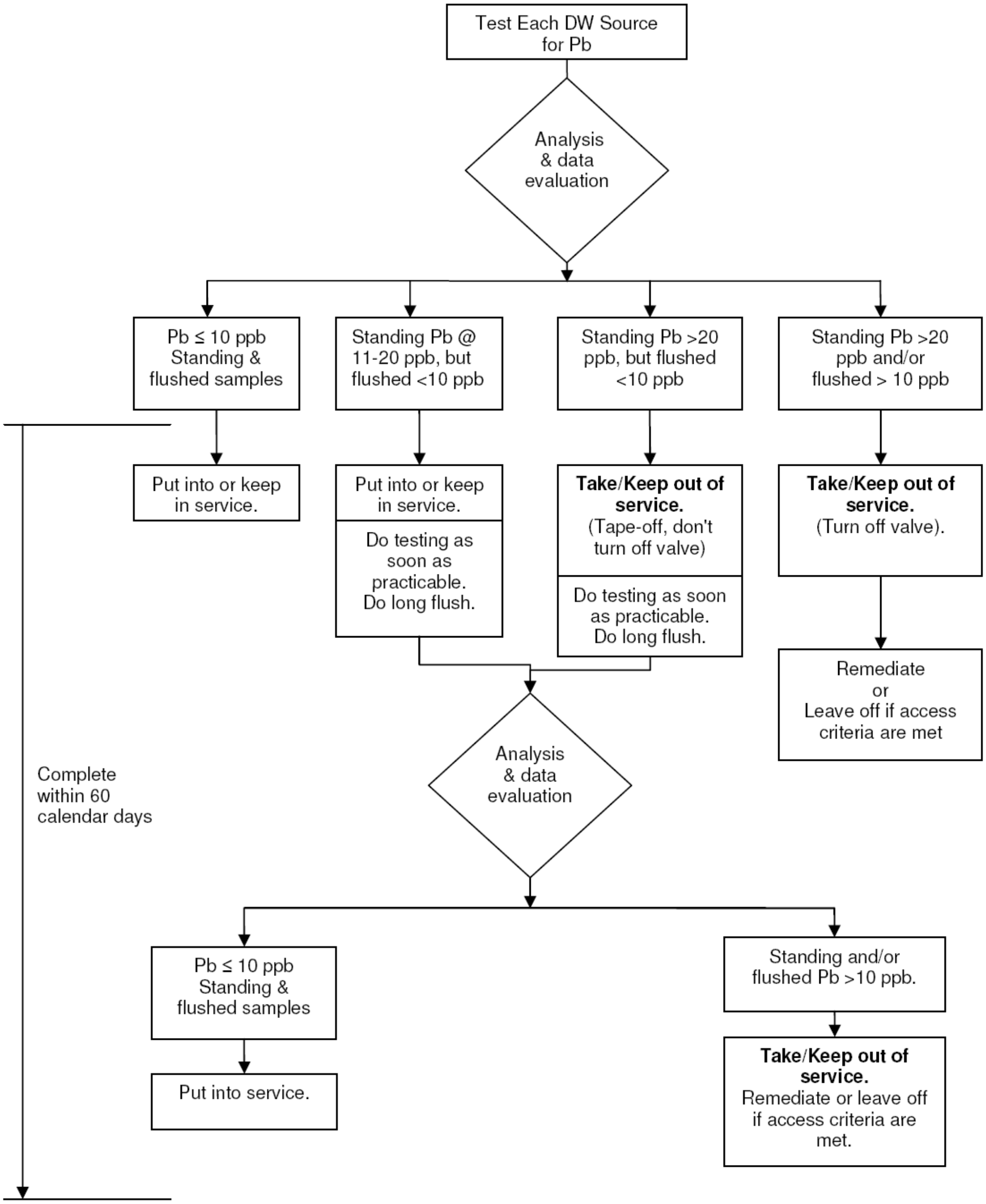



**Figure 6-1. A Proposed Approach for Lead Exposure Control – Decision Chart for Testing of Drinking Water Sources**

## 6.3 Water Quality Monitoring Plan (WQMP)

The Water Quality Monitoring Plan (WQMP) is a long-term approach to continuing to monitor and address potential water quality problems at drinking water sources. While drinking water sources have all been addressed and remediated as appropriate, recurring monitoring provides the opportunity to both maintain this status, and address any changes as they become apparent.

The Water Quality Monitoring Plan (WQMP) consists of the following:

- Recurring water quality monitoring will be conducted on a 3-year cycle for all schools that are on line (i.e., normal water service). All drinking water sources in these schools will be tested for lead, cadmium, copper, and iron. Standard sampling and analytical protocols will be used.
- Recurring monitoring will be staggered so that a manageable number of schools are tested at one time due to the number of schools involved and work effort in sampling and analyses.
- For the locations that have previously exhibited elevated arsenic, a round of testing will be conducted in summer 2007. The results from this round of testing will be used to determine if recurring monitoring for arsenic is warranted or not.
- As part of the investigations and/or to confirm that a particular water quality problem has been mitigated, the special testing plan may include recurring water quality monitoring on a frequent basis, such as once daily for several days. If an unanticipated water quality problem or potential problem is found at a school a special testing plan will be developed to provide the necessary water quality data.
- Regular flushing (after every break period longer than four days, i.e. four times annually). Details of the flushing protocol are provided in Attachment Q.1.a.
- Annual check of sources that are in or out of service. This check is conducted by the custodians each August as part of the flushing procedures before school commences after summer break.

## 6.4 Communications and Status Reports

### 6.4.1 Website Water Quality Pages

The most current water quality testing results and the general remediation status for each school are posted and maintained on the SPS website. Procedures for preparation and updating the water quality web pages are contained in Attachment P.

### 6.4.2 Notification Letters

Special notification letters to parents and staff of a particular school will be sent when regular water service is stopped or restored to a school and at other times when necessary to keep parents informed. Letters shall be translated into the appropriate languages needed for each school.

## 6.5 Oversight Committee

In February 2005, the School Board Executive Committee appointed an Oversight Committee that was responsible for oversight of the implementation of the Remediation Plan for conformance with the specific requirements and intent of SPS Water Policy

(Procedure E10.01). The charge of this committee was approved by the Board Executive Committee and is included as Attachment C.

## 6.6 Coordination with Other Agencies

Coordination and communication with the three agencies listed below will be maintained to address technical water quality concerns, regulatory guidance, public notification, and media relations, as required. The public information officers from SPS and each of the agencies below shall maintain liaison.

**Public Health Seattle/King County (PHSKC).** A point-of-contact liaison at PHSKC has been established so that specific water quality inquiries and issues can be addressed expeditiously between SPS and PHSKC.

**State Department of Health (DOH).** A point-of-contact liaison at DOH has been established so that specific water quality inquiries and issues can be addressed expeditiously between SPS and DOH.

**Seattle Public Utilities (SPU).** Regular communication will be carried out between SPS and water quality specialists at SPU. A point-of-contact liaison at SPU will be established so that specific water quality inquiries and issues can be addressed expeditiously between SPS and SPU.

# 7.0 Recommended Next Steps

The following are recommended next steps for the Drinking Water Quality Improvement Program. The overall objective is to convert the Program from a special effort into a routine operational function by summer 2007.

- Continue with piping refurbishments and/or replacements in those schools with galvanized steel pipe, with the priority of refurbishment based on key criteria such as the extent and magnitude of water quality problems and the age of the school. Attachment N describes the recommended prioritization approach for replacement of piping in schools.
- Implement scheduled, recurring water quality monitoring as per the WQMP described in Section 6.3 of this report, or as required to comply with Board-approved policies for water quality.
- Develop a Public Information Protocol that describes when to provide information to the public, how to distribute the information and a template for standard notification language.

# 8.0 References


Camper, A. 2004. Personal communication – Letter to Ron. English, Deputy General Counsel, Seattle Public Schools.

Economic and Engineering Services, Inc. [EES]. 2004. Results of Water Quality Testing in Schools and Associated Facilities, prepared for Seattle Public Schools, August.

SPS. 2007. Seattle Public Schools – Accessed 04/03/2007. http://www.seattleschools.org/area/facilities/WaterQuality/water_quality_reports.htm