Guidelines on Evaluating and Mitigating Lead in Drinking Water Supplies, Schools, Child Care Facilities and Other Buildings

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Ministry of Health

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1. Purpose and Scope

This document provides guidance to drinking water officers on the roles and responsibilities of stakeholders in the reduction of lead in drinking water at the tap. This document also provides guidance and tools for:

- Screening communities to identify those with increased risk of corrosive water;
- assessing typical lead concentrations in drinking water at the tap in communities;
- screening and assessing typical lead concentrations of water in schools, child care facilities and other buildings; and
- possible mitigation strategies and examples of communication material.

This document does not address collecting or assessing human exposure data such as blood lead reporting, or assessment of broader human lead exposure beyond drinking water. It also focusses on lead corrosion only, and does not discuss other corrosion products including copper and iron, that can cause significant aesthetic and economic impacts if unchecked.

2. Intro/Background

Ingestion of lead can be hazardous to human health, especially for young children and infants, as they absorb lead more easily than adults and are more susceptible to its harmful effects. Even low level exposure may harm the intellectual development, behaviour, size and hearing of infants and children. Lead can also cross the placenta during pregnancy to affect the unborn child, and can be released into breast milk.

The degree of harm from lead exposure depends on a number of factors including the frequency, duration, and dose of the exposure(s) and individual susceptibility factors (e.g., age, previous exposure history, nutrition, and health). The degree of harm also depends on an individual's total exposure to lead from all sources in the environment – air, soil, dust, food, and water. Common sources of lead exposure for children are chips and particles of deteriorating lead paint found in house dust and soil. While drinking water is the second largest source of exposure when lead levels in water are above 5 µg/L, there is currently no evidence that drinking water in BC is a significant source of dietary lead intake. It is important to note that people often consume water from numerous sources throughout the day (i.e. workplaces, schools, homes, restaurants), thereby the lead concentration in water from any one source may only represent a small portion of total daily intake. Nonetheless, it is important to minimize lead intake from all sources as much as possible, and where Drinking Water Officers consider drinking water is at risk of having elevated concentrations of lead, take steps to reduce lead in drinking water to levels as low as is reasonably achievable.

Under the *Drinking Water Protection Act* (DWPA), drinking water supply systems in BC are responsible for monitoring water they deliver to verify it is within acceptable limits for lead and other metals. The Guidelines for Canadian Drinking Water Quality (GCDWQ) suggest:

The maximum acceptable concentration (MAC) for total lead in drinking water is 0.005 mg/L (5 µg/L), based on a sample of water taken at the tap and using the appropriate protocol for the type of building being sampled. Every effort should be made to maintain lead levels in drinking water as low as reasonably achievable (or ALARA).
Note: Five micrograms per litre (µg/L) is also sometimes expressed as 5 parts per billion (ppb).

Most drinking water supply systems in BC deliver water that has levels of lead well below 5 µg/L. Lead is usually not found in drinking water when it leaves the treatment plant. Instead lead tends to leach out of pipes and fixtures in buildings or homes, or service lines connecting homes to water mains[1]. The extent of leaching depends on the nature of the plumbing materials used, the corrosiveness of the water (i.e. the extent to which the water can cause a chemical reaction that will cause a deterioration in the material used in the pipes), and the length of time that the water is stagnant in the plumbing. The longer water remains in contact with leaded plumbing, the more opportunity there is for lead to leach into the water. As a result, older facilities with intermittent water use patterns and older plumbing materials, such as schools, child care facilities and office buildings, may have elevated levels of lead in their drinking water. The water sits in the pipes of these facilities for long periods (overnight, weekends, and holidays), which

> Under the National Plumbing Code (NPC), all fittings must comply with the American Society of Mechanical Engineers (ASME) 112.18.1 / Canadian Standards Association (CSA) B125.1 standard for plumbing supply fittings. In 2012, these standards revised the requirement for "lead-free" components from 8% down to 0.25% lead as a weighted average with respect to the wetted surfaces of pipes, pipe fittings, plumbing fittings, and fixtures. This means that fixtures produced as late as 2012 could legally contain 8% lead – enough to cause an exceedance of the MAC on stagnant ("first flush") water samples.
>
> **Anecdote:** A city in Northern BC was conducting a survey of lead content in the drinking water in their various facilities. In one new building, built in 2013, the lunchroom tap surprisingly failed its first-flush sample. The City responded by changing the tap to a newer model with an NSF certification. The retest for lead was lower, but again exceeded the MAC. Only when the shutoff valve was also replaced did the sink pass the first-flush lead test.

[1] Service lines connect individual buildings to the water supply system distribution main. Service line ownership is shared. The utility typically owns the portion up to the property line and the home or building owner owns the portion on their property. Before the 1960s, service lines were commonly made of lead in some communities.

allows the leaching of lead to occur. If the water entering the building is corrosive, the lead will leach more quickly. Corrosive water may sometimes be described as "acidic" or "aggressive."

Since 1989, the BC Building Code has restricted the lead content in components in the construction of potable water lines and fixtures. This restriction reduces the amount of lead available to react with corrosive water and lowers the risk of lead leaching into drinking water supplies. As a result, in buildings constructed on or before that time, there may be a greater probability of finding elevated lead levels in the water from service plumbing, especially if the corrosiveness of the water entering the building and the water use patterns in the building are conducive to lead leaching.

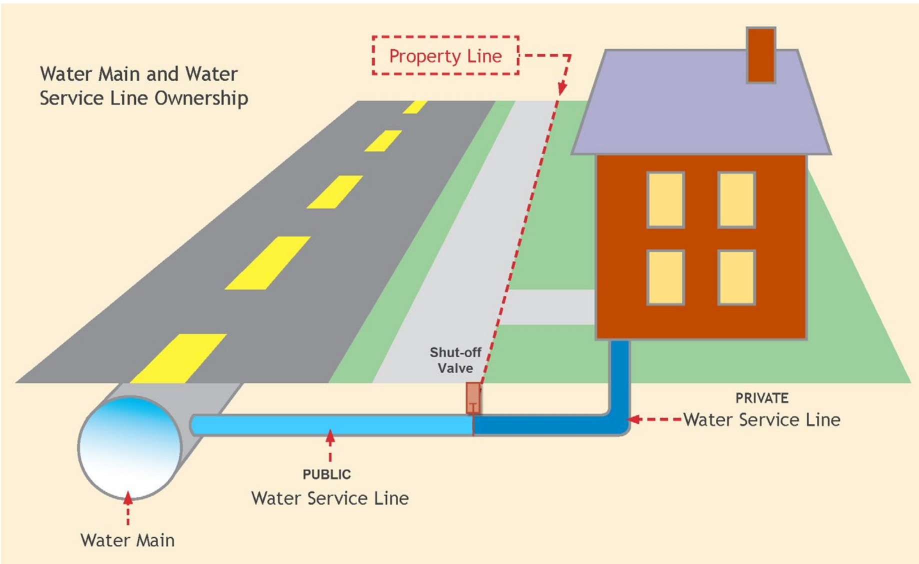
The quality and characteristics of the delivered water not only impact lead solubility and lead speciation (i.e., the chemical and mineral form of lead), they also impact the behaviour of pipe scales (i.e., a coating that forms inside of pipes) that contain lead. Physical disturbances or changes in water quality and flow velocity can cause lead particles found within pipe scales to become dislodged and released into drinking water. These lead particles can cause intermittent spikes in the lead concentrations found in drinking water. Screened aerators on kitchen taps may trap these particles and should be periodically cleaned.

3. Roles and Responsibilities

The question of responsibility for lead in drinking water is unique in that water delivered by water suppliers may be potable at the point of delivery, but may have characteristics that make it susceptible to leaching lead and other metals from pipes, solder and fixtures after it is delivered to the property. This may result in significant portions of the community being affected or localized problem areas affecting some buildings or neighborhoods in a community but not others. The problems can also be localized within buildings, affecting only some taps depending on water use patterns, plumbing configurations and materials, and differences in plumbing fixtures.

The issue of who is responsible for lead in drinking water is complex given that lead in drinking water may come from the pipes and fixtures contained within private properties, or services lines. Water suppliers are not responsible for the maintenance or replacement of plumbing beyond service lines and other fixtures upstream of the curb stop where water is delivered, after which it becomes the responsibility of the property owner (see Figure 1). So while the water supplier may own the water supply system, property owners own the pipes and plumbing on their property. This shared ownership also means a shared responsibility to mitigate excessive lead concentrations found at the tap. Property owners are responsible for the condition of their building's plumbing and for taking any necessary remedial action to minimize lead exposure deriving from the plumbing and fixtures in their property, such as replacing leaded plumbing and fixtures, installing treatment devices to remove lead, or implementing a flushing program. Where the characteristics of the water (i.e., the corrosiveness) are expected to significantly contribute to leaching, the water supplier has the responsibility to take reasonable steps to mitigate likelihood of a hazard being associated with the water being delivered to the end user.

Figure 1: Water service line responsibilities. Modified from: https://www.alexandriava.gov/uploadedImages/health/info/AlexandriaWaterService.jpg



Several statutes play a role in ensuring that drinking water does not pose a health risk for consumers. These include: the *Drinking Water Protection Act,* the *BC Plumbing and Building Code,* the *Public Health Act,* the *School Act* and the *Community Care and Assisted Living Act.* As these statutes apply concurrently, the overlap indicates a shared responsibility of all parties involved.

- The *Drinking Water Protection Act:*
  - Requires water suppliers to deliver potable water to customers. While the DWPA may not directly compel water suppliers to ensure potability beyond the point where it is delivered to the consumer, health authorities may impose conditions on permits that require water suppliers to take actions to reduce the likelihood that the water they deliver contributes to a drinking water health hazard.
- The BC Building Code:
  - Speaks to plumbing standards within buildings. However, this statute is only applied at the time of construction and many buildings constructed prior to 1989 can be assumed to be at an increased risk for lead leaching from plumbing under certain water conditions.
- The *School Act* and the *Community Care and Assisted Living Act* (Child Care Licensing Regulation):
  - These Acts protect children in schools and in licensed child care facilities. Medical Health Officers may act as School Health Officers under the *School Act* and may conduct inspections, and where necessary impose requirements for the

construction and/or operation of the facilities. Similarly, Licensing Officers (who are delegates of the Medical Health Officer) inspect child care facilities, issue licences to operators of child care facilities, and where necessary impose requirements for the health, safety and well-being of children who attend child care, the physical premises and/or operation of the facilities. Similarly, where there is reason to believe there are children at risk due to lead exposure in residential care facilities, action may also be warranted to assess and mitigate these situations.

- The *Public Health Act:*
    - Requires landlords to provide potable water to tenants. The *Public Health Act* may also be used as a legal tool where a lack of action by water suppliers, building owners, or others may contribute to a health hazard.

Successful reduction of lead in tap water depends on a multi-barrier approach with participation and actions of all parties as it is difficult to achieve lead reduction through centralized mitigation alone. The following table lays out high level expectations of roles and responsibilities of each stakeholder in this process. More specific roles and responsibilities related to each stakeholder are discussed below.

Table 1. Stakeholder Responsibility for Lead in Drinking Water

Responsibility	***Responsible Stakeholders***		
	Drinking Water Supply systems	***Schools/Child Care Facilities***	***Private Buildings***
Screening & Prioritizing	*HA* + Water supplier*	*HA + SD + IS + CF*	*Building owner*
Planning to Test	*HA + Water supplier*	*HA + SD + IS + CF*	*Building owner*
Testing	*Water supplier* *Building owner***	*SD + IS + CF*	*Building owner*
Interpretation	*HA*	*HA*	*HA upon request*
Planning to Mitigate	*Water supplier + HA review & permitting*	*SD + IS + CF + HA review*	*Building owner*
Implementing Mitigation	*Water supplier*	*SD + IS +CF*	*Building owner*
Verification of Mitigation	*Water supplier + HA review*	*SD +IS +CF + HA review*	*Building owner*
Communication/ Education	*Water Supplier (system specific)* *HA (community level)*	*SD + IS +CF (facility specific)* *HA (community level)*	*Building owner (building specific)* *HA (community level)*

** HA- Health Authorities; SD – School Districts; IS – Independent Schools; CF – Care Facilities*
***As lead testing is done at the tap, building owners are key participants in testing programs*

3.a Roles and Responsibilities of Health Authorities

The high level roles of drinking water officers (DWO), medical health officers (MHO), environmental health officers (EHO), public health engineers (PHE) and licensing officers (LO) are to:

- Screen communities to identify those likely to have lead issues, and for those identified;
- work with water suppliers to determine if elevated lead concentrations in community tap water pose an unacceptable risk to end users, and where there is an unacceptable risk; and
- advocate for, or mandate the evaluation and mitigation of lead risks by all stakeholders through appropriate and reasonably achievable mitigation measures.

In communities likely to have lead issues due to corrosion concerns, PHEs and DWOs may need to determine with water suppliers whether concerns are best addressed through centralized mitigation measures at the water supply (e.g., pH and alkalinity adjustment or the addition of corrosion inhibitors at treatment), decentralized measures by users (e.g., flushing, point-of-use treatment devices, leaded plumbing replacement, etc.), or by a combination of both.

The role of the health authority in evaluating and mitigating the risk of lead in a community should include actively working with all stakeholders to ensure they are aware of risks and of the actions they should take to evaluate and reduce risks. Where necessary, health authorities may also need to take progressive enforcement actions with regulated facilities. The priority of any enforcement action should be directed towards large community water systems where the corrosiveness of the water supply contributes to excessive lead levels known to exist in public and private buildings.

As infants and children are more susceptible to health effects from lead, schools and care facilities where children may be exposed to elevated lead concentrations in drinking water should be the focus of health authority efforts. Health authorities should include evaluation of risks for lead in drinking water as part of their engagement with schools and child care facilities and re-assess the frequency of monitoring in areas where lead has been found to be a problem. Drinking water officers should work with licensing officers to introduce testing for lead and ensure appropriate mitigation measures are in place as part of inspections and licensing requirements for child care facilities.

Details of specific roles and responsibilities of health authorities in relation to stakeholders are outlined below. Technical information on assessing risks and sampling are in the appendices of this document.

3.b Roles and Responsibilities of Water Suppliers

The *Drinking Water Protection Act* requires water suppliers to deliver potable water to users, but does not directly compel water suppliers to ensure potability after delivery to customers. However, where it is probable that the nature of the water is likely to pose a potential health risk to users after delivery, the DWO may be justified in requiring the water supplier, through conditions on the operating permit, to take steps to assess whether corrosivity of the water, and/or resulting water lead concentrations in buildings presents a risk to the population, and if necessary, to take steps to reduce risks.

To assess corrosion risks in community water supplies, water suppliers, in collaboration with the local health authority, should develop plans to conduct surveys, tests, inventories or studies to:

- Screen water for indicators of corrosivity;
- survey the prevalence of lead service lines in communities;
- survey the prevalence of buildings with plumbing and fixtures with elevated lead content; and
- implement testing, including surveys of representative samples taken at consumers' taps to evaluate impact of the corrosivity of the water supply in the community.

Results of assessment programs should be reviewed with health authorities. Where the corrosive nature of water quality is determined to contribute to lead exposure from interaction with plumbing at the community level, building owners and the water supplier may need to take steps to reduce risks as described later in the document. For water suppliers, these risk mitigation steps may be done informally through agreement, or may be formalized by the health authority through conditions on its operating permit.

Table 2. Health authority and water supplier roles

Health Authority	Water Supplier
• Liaise with water supplier and advise them as necessary to conduct community risk assessment for corrosion and typical lead exposure. • If necessary, in consultation with the Water Supplier, place conditions on the operating permit, to ensure that an adequate assessment of population health risks from lead in drinking water is undertaken. • Provide direction and advice to water supplier on sampling protocols.	• Liaise with health authority on the necessity to conduct a community risk assessment for corrosion. • Design and implement a residential testing strategy to evaluate lead exposure burden from drinking water in the community, if necessary. • Conduct sampling, tests and surveys in the community. • Report any potential health hazards associated with water supply to end

Health Authority	Water Supplier
• Interpret surveys and studies to advise water suppliers on the risks that the water supply system poses. • Advise water suppliers on public education messaging and provide information on risks. • Follow up on complaints or concerns regarding potential health hazards in the community. • Provide progressive enforcement to mitigate health hazards under the *Public Health Act* and/or DWPA.	users of water supplies related to the corrosivity of water. Provide messaging and information to the public regarding what is being done to mitigate hazards by the water supplier, and what the public can do to protect itself. • Minimize leaching impacts through planning and implementing corrosion control programs.

3.c Roles and Responsibilities of School Districts and Independent Schools

Schools districts and independent schools are responsible for operating schools in a manner that does not adversely affect the health of their students. School districts and independent schools should work with heath authorities to establish a plan to identify where lead risks might occur, as well as to mitigate any identified risks. Details on developing a plan are found in Section 4.

Table 3: Health authority and water supplier roles relative roles of school districts, independent schools, health authorities, and the provincial government in determining risk and actions that should be taken to identify and reduce lead risks in schools.

School Districts / Independent Schools	Health Authority	Ministry of Health and Ministry of Education and Child Care
• Inventory and characterize schools and identify whether they are on a community water supply or school district operated water supply. • Plan and carry out screening/testing programs in consultation with the health authority.	• Work with water suppliers to identify where schools are at increased risk. • Assist school officials to develop plans to evaluate lead risks in schools. Provide advice on sampling protocols.	• Provide policy and guideline direction. • The Minister of Health under the School Act can require the school medical officer to conduct inspections of schools and can require the MHO to provide a report.

School Districts / Independent Schools	Health Authority	Ministry of Health and Ministry of Education and Child Care
• Plan and implement lead mitigation programs for school buildings. • Communicate risks to parents and students. • Send annual reminders to school maintenance staff regarding flushing or other mitigation measures that might be necessary. • Maintain records and report findings to HAs including a summary of the mitigation strategy that identifies flushing schedules and the locations being flushed.	• Interpret results and provide information on mitigation options. • Review the effectiveness of mitigation options. • Advise school officials on risk messaging for the schools. • Engage with schools to verify lead mitigation programs are adhered to, and follow up on complaints or concerns. • Provide progressive enforcement where necessary if health hazard remains unabated.	

3.d Roles and Responsibilities of Licensed Child Care Facilities

Licensed child care facilities are responsible for operating in a manner that will promote the health, safety and dignity of persons in care. Licensed child care facilities should work with heath authorities to evaluate lead risks in their facility, as well as mitigation planning to identify and mitigate the risks.

Table 4: Relative roles of licensed child care facilities and health authorities in determining the actions that should be taken to identify and reduce the risks of lead in drinking water.

Child Care Facilities	Health Authority	Ministry of Health and Director of Licensing
• Plan and carry out screening/testing programs in consultation with health authority where there is a risk of lead in drinking water. • Plan and implement lead mitigation programs for their facilities. • Communicate risks and mitigation steps to parents. May consider sharing with parents new to a facility upon child enrollment, and include in parents handbook. • Send annual reminders to staff regarding flushing, alternate sources of water, or other mitigation measures necessary.	• Provide education materials relating to lead in drinking water. Work with water suppliers to identify where conditions might exist that put facilities at increased risk. • Assist affected facilities to develop plans to evaluate lead risks. Provide advice on sampling protocols. Interpret results and provide information on mitigation options. • Review the effectiveness of mitigation options. • Work with child care facilities to develop messaging to users and their families on lead risks in the child care facilities. • Include lead education in inspections. Verify lead mitigation programs are adhered to and effective. Follow up on complaints or concerns regarding lead in child care facilities. • Provide progressive enforcement where necessary if health hazard remains unabated.	• Provide policy direction • Develop educational materials on lead in drinking water. • Recommend or require testing for lead in high risk child care facilities.

3.e Roles and Responsibilities of the Owners of Homes and Other Buildings

The BC Building Code provides plumbing standards within buildings; however this statute is only applied at the time of construction. As a result, it can be assumed that most homes and other buildings constructed or altered prior to the 1989 revisions of the BC Building Code have a higher risk of lead leaching into drinking water from their plumbing. Under the *Public Health Act*, the owners of these properties are responsible for ensuring that the plumbing does not create a drinking water health hazard for those who consume the water.

While there are no specific regulations that require lead to be tested and mitigated in individual homes and buildings, owners are required to provide tenants with potable water that is fit to drink without further treatment. Owners are responsible for testing their own water and taking mitigation steps (e.g. flushing, service line/plumbing fixture replacement), and health authorities may provide reference information on the best practices for doing so.

Table 5: Relative roles of building owners and health authorities in determining risk and actions that should be taken to identify and reduce the risks of lead in drinking water.

Building/Home Owners	Health Authority
• Provide potable water to rental units intended to be living accommodations. • Learn about the risks of corrosion from communications from the water supplier (system specific info) and/or the health authority (general info). • Plan and carry out testing on building water. • Provide information and communications to tenants and/or employees. • Develop and implement a mitigation strategy for lead in their buildings.	• Work with water suppliers to ensure that risks are communicated to users. • Provide information to the public on the risks of lead in drinking water, lead testing, the interpretation of test results, and mitigation options.

3.f Role of Provincial Government

Ministry of Health is the main agency for provincial drinking water policy development. The Ministry will work with Health Canada, BC's health authorities, the Ministry of Education and Childcare and other stakeholders to provide advice and policy on best practices for assessing lead risks from drinking water, to develop educational material, and to advocate for the reduction of lead exposure to the public from drinking water.

4. Assessment and Mitigation of Lead Risks in Drinking Water

4.a Water Supply System/Community Level

Evaluate and Prioritize

Screening water supply systems for high risk of corrosion:
Health authorities should work with water suppliers to screen water supply systems for characteristics that suggest potential corrosion risks, and/or the prevalence of buildings at risk. These systems may be prioritized for further investigation of the potential for unacceptable lead concentrations in water for consumers.

The chemistry of corrosivity is complex, typically involving many different factors (chemical, physical or microbiological), which can make it challenging to predict how it will impact leaching when it comes into contact with leaded components.

Many indexes such as the Langelier Saturation Index (LSI), the Ryzner Index, the Aggressiveness Index, the Momentary Excess and the Calcium Carbonate Precipitation Potential, were developed to assess the calcium carbonate–bicarbonate equilibrium, and were historically used as an indicator of the corrosivity of water. However, Health Canada's *Guidance on Controlling Corrosion in Drinking Water Distribution Systems* and Ontario's *Guidance Document for Preparing Corrosion Control Plans for Drinking Water Systems*, report significant empirical evidence contradicting the presumed connection between corrosion and the most common of the corrosion indices, the Langelier Index. The American Water Works Association Research Foundation recommends that the use of corrosion indices for corrosion control practices be abandoned. Because of these limitations, these authorities recommend lead and/or other metal sampling at the tap as the most reliable indicator of corrosive water. This is critical, because corrosivity of the water is under control of the water supplier, whereas the lead content in the plumbing is largely under control of the building/home owner. Because the most reliable indicator of corrosive water is actual corrosion as detected in sampling at the tap, water suppliers should not conclude that their water is not corrosive until that is confirmed by sampling inside buildings and homes.

This being said, the chemistry of the water in water supply systems can be proactively evaluated for risk factors that indicate a higher probability that it will be corrosive. Water supplies with one or more of the following water chemistry characteristics should be *prioritized* for further evaluation of potential lead risks from corrosion of plumbing in the community:

- Lower pH (<7)
- Low alkalinity (<30 mg/L)

- Low hardness, i.e., "soft water" (<60 mg/L as calcium carbonate $CaCO_3$)[2]

Other drinking water quality parameters that might impact corrosivity may also be considered such as: higher temperatures, fluctuations in free chlorine residual, chloramines, chloride, sulphate, natural organic matter (NOM), oxidation-reduction potential (ORP), and chloride-sulphate mass ratio (CSMR) (see Table 6).

Table 6. Water Quality Factors Affecting Corrosion.

Factor	**Effect**
pH	Low pH causes iron, lead, and copper corrode rapidly.
Alkalinity and Dissolved Inorganic Carbonate (DIC)	Neutralize strong acids and provide buffering capacity against a pH drop. Affect many reactions in corrosion chemistry.
Hardness	In combination with alkalinity, promote the formation of a protective passivating film.
Disinfectant Residual	Gaseous chlorine lowers pH. Higher chlorine residuals (2 mg/L) may cause protective lead scales.
Dissolved Oxygen	Increases corrosion of copper; effect on lead less certain.
Oxidation Reduction Potential, Redox Potential (ORP, Eh)	High ORP and high pH promote protective lead scales.
Ammonia	Interfere with the formation of passivating films. Oxidation of ammonia (nitrification) lowers alkalinity and pH, increasing corrosion.
Chloride and Sulphate	Chloride (Cl^-) and sulphate (SO_4^{2-}) cause dissolved metals to remain soluble. Increase the salinity (TDS) and electrical conductivity of water. High chloride-to-sulphate-mass ratios (CSMRs) increase corrosion rates for lead solder connected to copper pipe.
Salinity (TDS)	The higher the TDS, the higher the ionic strength and electrical conductivity.
Natural Colour and Organic Matter	May form a protective film and reduce corrosion. May react with the corrosion products to increase corrosion. Food for microorganisms growing in biofilms in the pipes.

[2] According to Health Canada's Guideline Technical Document for Hardness, soft water can lead to corrosion of pipes. The degree to which this occurs is also a function of pH, alkalinity and dissolved oxygen content. According to the Water Research Centre, in water that is soft, corrosion occurs because of the lack of dissolved cations, such as calcium or magnesium in the water. In scale forming water (hard water), a precipitate or coating of calcium or magnesium carbonate forms on the inside of the piping called scale. This scale coating can inhibit the corrosion of the pipe by acting as a barrier, but it can also clog the pipe (i.e., incrustation). Health Canada recommends hardness levels between 80 and 100 mg/L (as $CaCO_3$), which are generally considered to provide an acceptable balance between corrosion and incrustation from scale. (Source: http://healthycanadians.gc.ca/publications/healthy-living-vie-saine/water-hardness-durete-eau/index-eng.php)

Factor	Effect
Corrosion Indices	Langelier Saturation Index (LSI) measures calcium carbonate ($CaCO_3$) scale-forming tendency. LSI does not correlate well with actual corrosion, so LSI is less reliable than sampling at taps for corrosion products.
Temperature	For every 10°C rise in temperature, chemical reaction rates, including corrosion, typically tend to double.
Flow velocity	High velocity: increases the supply of dissolved oxygen; erodes pipe walls if abrasive suspended solids are present. Zero velocity: Stagnation may cause pitting and tuberculation, especially in iron pipes, as well as promoting biological growth
Microbiological	Microbiologically induced corrosion (MIC) ≡ localised high corrosion zones (pinholes) sheltered inside biofilms.
Orthophosphate	Corrosion inhibitor added to water to form a passivating film on the pipe surface.

Based on: ON (2009) Guidance Document for Preparing Corrosion Control Plans for Drinking Water Systems. Section 2.3 Water Quality Factors Affecting Corrosion.

To confirm whether corrosion is an issue for a community's water supply system, the most reliable approach is sampling surveys of lead at consumers' taps as described in Health Canada's *Guideline Technical Document on Corrosion Control*, and Appendix C of this document.

Health Authorities may also consider data from lead testing programs in schools, child care facilities or other buildings, which may serve as sentinel information for a community, and help flag the need to further investigate.

Where the initial screening of water chemistry (pH, alkalinity and softness) indicates increased risk factors for corrosive water, a survey of the prevalence of service connections and of the typical age and condition of buildings in the community can also help determine the magnitude of risk. This information can also be used in later steps to assist in determining where to focus lead sampling program from consumers' taps. Communities where a high proportion of buildings were constructed prior to 1989, that have not upgraded their plumbing to lower lead content are likely to be at the highest risk of having lead in their plumbing.

Large communities with older housing stock and buildings as well as a water supply with corrosive characteristics should be targeted for further sampling first. Additionally, communities where there has been a change in water source or water chemistry or treatment processes should also be flagged for testing.

Testing and Evaluating Results

Those drinking water systems identified as being at the highest risk by the screening step should develop and implement lead sampling programs conducted at consumers' taps. The objectives of these sampling programs are to:

- Determine whether community level lead mitigation measures are warranted to reduce corrosion;
- establish base lines to help evaluate the effectiveness of any mitigation measures that are adopted; and
- evaluate if the water typically consumed by customers exceeds the maximum acceptable concentration (MAC) level for lead set out in the *Guidelines for Canadian Drinking Water Quality*.

High level descriptions of sampling protocols for corrosion risks, as well as for determining whether concentrations of lead typically found in the community's water meets the *Guidelines for Canadian Drinking Water Quality* are outlined in Appendix C.

Mitigation

Both centralized and decentralized mitigation measures can be taken to address concerns from lead at user's taps resulting from corrosive water. The most appropriate method will depend on a number of factors. In areas where the nature of the water supply itself is reasonably believed to contribute to a health risk from lead at users' taps, water suppliers should work with health authorities to determine feasible strategies for mitigating lead risk. Reducing risk will usually involve a combination of communicating how consumers can reduce their own risks as well as planning long term corrosion control strategies as follows:

1. Communicate the results of testing programs to consumers and inform them of the appropriate measures that they can take to reduce their exposure to lead. Corrective measures that consumers can take could include any or a combination of the following:
    - flushing the building plumbing system;
    - replacing their portion of the lead service line (if applicable);
    - replacing brass fittings or in-line devices (pre-2012);
    - using drinking water treatment devices certified to reduce lead; and
    - using an alternate water supply for drinking water or food preparation.[3]
2. Implement appropriate corrective measures to control corrosion in the drinking water supply system. Results of sampling should be used to help determine the best corrective measures for the system, which may include any or a combination of the following:
    - replacing lead service lines;

[3] Exposure through bathing and other household purposes is not a health hazard.

- adjusting drinking water pH and alkalinity;
- adding corrosion inhibitors;
- replacing brass fittings or in-line devices containing lead;
- carrying out *ad hoc* or unidirectional flushing, swabbing, or pigging of water mains to reduce accumulated sediment and biofilms; and
- maintaining a disinfectant residual to avoid reducing conditions and to control biofilms.

Corrosion control programs have been shown to significantly reduce leaching, but may not eliminate it. Careful consideration should be given to the potential effectiveness, potential unintended effects on water, public acceptance, and the cost of mitigation measures and programs to determine the most appropriate course of action to follow. Bench-scale and pilot testing should be carried out for any proposed change to distribution water chemistry. No matter what type of mitigation measures are employed, an evaluation of the effectiveness of the mitigation measures should be done after they are implemented. Community level assessment and mitigation steps are outlined in the flow chart set out in Appendix A.

4.b Individual Buildings

Evaluate and Prioritize

Owners and operators of buildings (particularly school boards and child care facilities), particularly those on water systems identified to be at risk from corrosive water, should evaluate their buildings for plumbing components that can leach lead into drinking water. The complexity of the evaluation may vary depending on whether the building in question is a single family home, a multi-family dwelling, an industrial/office building, a school, or a child care facility; however the overlying evaluation principles will be the same. [4]
Evaluations should include:

- Developing a plumbing profile for the building that identifies plumbing components such as service lines, pipes, solder or fixtures that contain lead, and inventories drinking fountains and other points of consumption that might contain lead or brass;
- identifying potential problems and health hazards to users through screening tests and/or more comprehensive testing;

[4] For the purpose of this document:
"buildings" includes private residences and private schools served by a community water system;and
"schools" and "facilities" mean those that are connected to an approved water supplier and are not themselves a water supplier under the DWPA. Schools and other facilities that are their own water supplier may need to also take on roles of water suppliers in this document.

- maintain records and communicate plans and results with stakeholders; and
- taking routine, interim and permanent mitigation measures.

An example of school and child care facility assessment and mitigation steps is outlined in the flow chart set out in Appendix B. The following publication from the Province of Ontario (2009) is an excellent reference for evaluating risks from their plumbing and identifying options to remedy any excess lead in facilities: *A Manual for Operators of Schools, Private Schools and Day Nurseries with Excess Lead in their Drinking Water: A resource guide on how to locate the source and remedy the problem.*

Testing and Evaluating Results

For schools, licensed child care facilities and other buildings that have plumbing containing lead components, or where there is a lack of information about the plumbing that is in place, screening tests and/or more comprehensive testing programs should be planned and implemented in consultation with regional health authorities.

When testing water, it is important to determine the sampling objective, so that the appropriate sampling protocol is used. Sampling protocols differ depending on the desired objective: e.g. whether it is screening of schools for potential lead problems, identifying fixtures/sources of lead for replacement or to estimate health risk from exposure to lead. In order to provide meaningful results, multiple samples are needed. Health authorities can provide advice on what sampling method is appropriate and can help evaluate and interpret the results. Specific results of lead concentrations in sampled water and the method of sampling used should be included in reports to aid in decision making.

A high level description of how, when and where to test buildings is outlined in Appendix C. Health authorities can provide advice on how it should be applied to individual facilities, and can help evaluate and interpret the results against the guidelines.

Subsequent to initial screening and evaluation, schools and child care facilities should develop a plan for long term routine lead monitoring. Annual testing would be ideal, however risk-based decisions on frequency may be warranted from a resource perspective. In general, higher risk facilities where lead has been found as a problem may require more frequent testing than facilities where lead is not known to be an issue or risk. In BC, the Ministry of Education and Child Care has developed policies for schools districts and independent school authorities regarding expectations for lead sampling, reporting and mitigation. These policies (see links below) require regular screening for lead in all schools. This guidance document serves as a guide on how to meet this testing requirement.

BC Ministry of Education (Sept 26, 2016) *Testing Lead Content in Drinking Water of School Facilities*

BC Ministry of Education (January 1, 2017) *Testing Lead Content in Drinking Water of Independent School Facilities*

Mitigation

In buildings where the risk of exposure to lead in drinking water is determined to be unacceptable, mitigation measures should be taken. Owners should communicate results of evaluations, and identify what consumers can do to reduce exposure to lead in the short term, and what building owners can do to reduce exposure in the long term. In situations where the drinking water is at risk of elevated lead and testing to establish water quality has not yet been done, it would be prudent to err on the side of caution and adopt interim measures (flushing, bottled water) to reduce the risks associated with the presence of lead in drinking water while awaiting assessment results.

Options for reducing lead in buildings may include short and long term solutions such as:

- Educating the occupants of the building (e.g., teachers, child care providers, students) and other interested parties (e.g., parents, occupational health and safety committees) on the sampling results and the interim and long-term corrective measures that are being undertaken;
- flushing all water taps used for drinking water or food preparation at the start of each day or after periods of stagnation;
- providing an alternative water supply such as bottled water;
- installing point-of-use (POU) filtration units designed specifically to remove lead;
- installing corrosion control equipment at the point-of-entry (POE) into the building to adjust pH to reduce the likelihood of lead leaching into water (however complexity of maintenance may pose challenges in many situations);
- where lead sample results identify particulate vs dissolved lead, this may help decide whether it is better solved by filtration than conditioning for corrosion control;
- removing drinking water taps from service that contain unacceptable levels of lead;
- posting signs that identify "designated drinking water taps" (DDWTs) and "Do not drink" taps (non-DDWTs);
- replacing lead containing outlets, fixtures, fountains, pipes and fittings with low-lead alternatives;
- replacing old water lines and solder that might contain lead;
- working collaboratively with the water supplier to ensure that the water delivered to the building is not corrosive.

Evaluation of the effectiveness of mitigation measures should be done after they have been implemented, and at regular time intervals afterwards. No matter what type of mitigation measures are employed, re-sampling should be done to verify the effectiveness of the mitigation measures and to ensure that the concentration of lead falls below the GCDWQ maximum acceptable concentration.

Communication

Users of drinking water systems and buildings need to know the risks that exist, if any, and what is being done to mitigate the risks. Users should be advised regularly on lead risks associated with their drinking water and the need for regular testing, and mitigation measures. Communication should be clear and transparent to avoid confusion and ensure the goals, message and actions are understood.

Simple handouts for the public and other stakeholders such as Health Files, as well as those specific to school testing, and daycares may be helpful in communicating key messages.

Table 7: Communication Expectations

Who and What?
Health Authorities
• General messaging about lead and health risks to the public • General technical medical questions • Audience: General public, media, water suppliers, school boards; operators of child care facilities
Water Suppliers
• What is known about water corrosivity • What the drinking water supply system is doing about it • What users need to do to protect themselves • Audience: users of the water supply system
School Boards, Child Care Facilities and Other Building Owners
• What assessments are being done • Results of the assessments • Mitigation measures being taken • Audience: building users, parents of children and students in care
How?
• Written and media communication: Targeted mail outs, flyers in water bills, media releases, annual reports, newsletters, e-mails, websites and social media • Face to face conversations: interviews, public events • Signage: Warning signs on taps. Where flushing is the mitigation measure of choice, signage should be posted by fountains warning users to flush until the water runs cold
When?
• Whenever new, reliable information is available • Prior to and after lead screening and testing programs • Reminders should be done regularly in problem areas

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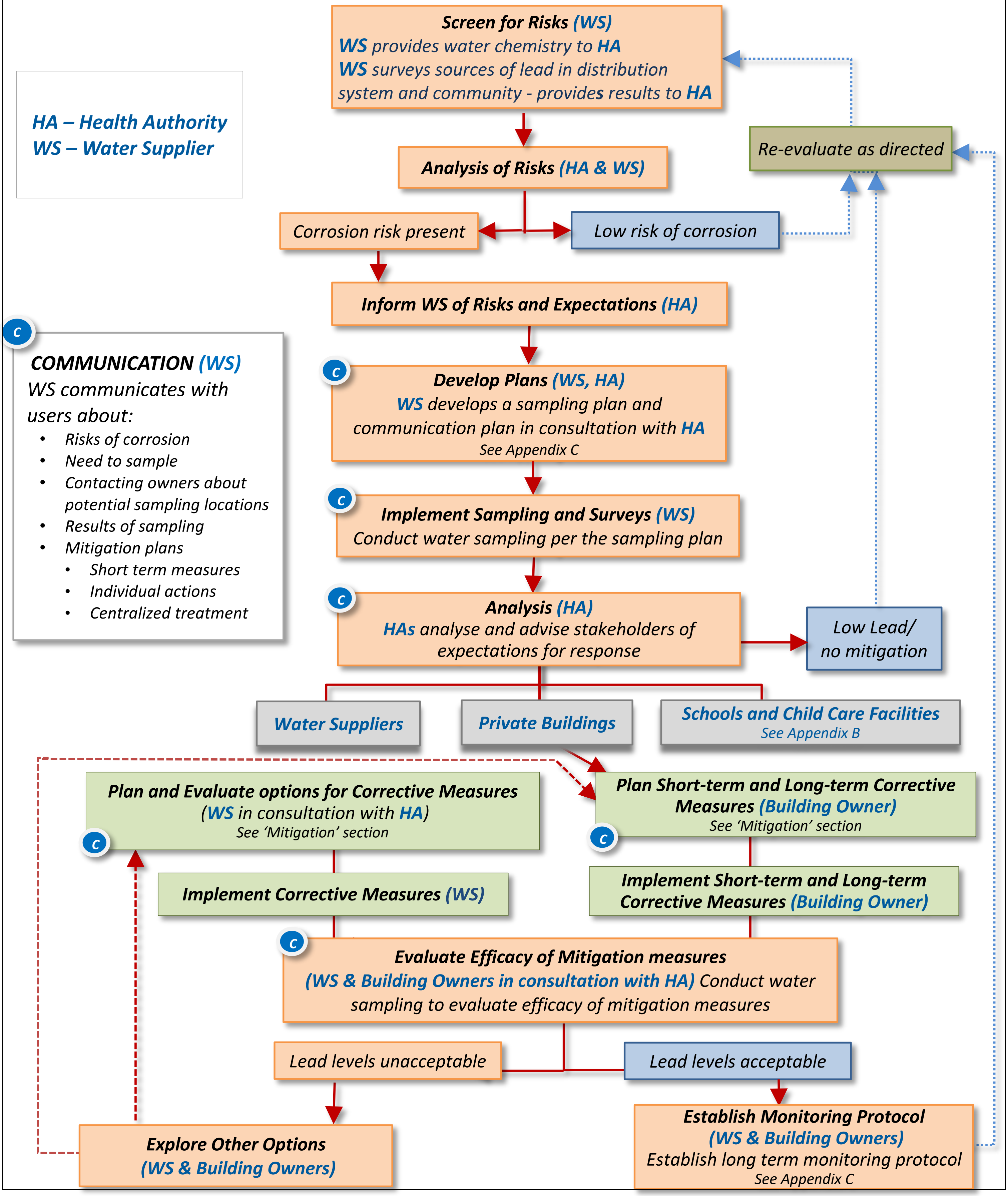
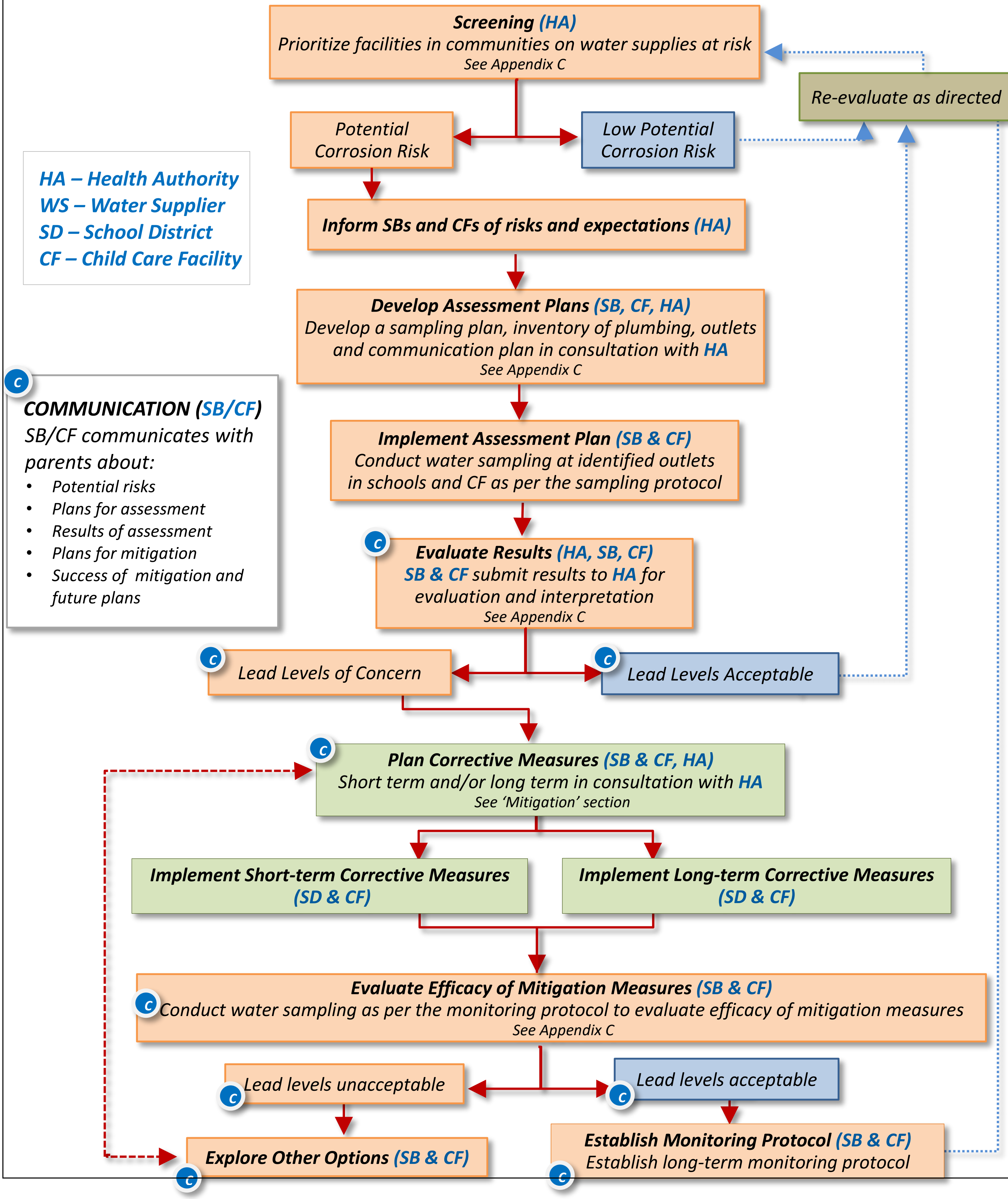
Appendix A – Process Flow for Evaluating Corrosion Risk in Water Supplies



Appendix B - Process Flow for Evaluating Lead in Schools and Child Care Facilities



Appendix C - Evaluating Lead in Drinking Water

Contents:

1. Why are you sampling?

The purpose of this appendix is to provide a reference of best practices for evaluating and sampling lead content in drinking water. As lead concentrations in drinking water vary both spatially and temporally, there are many sampling protocols that have been developed. Therefore consideration should be taken to choose the one that is the most appropriate for the situation.

Prior to embarking on a sampling program, the questions should be asked – what is the objective of sampling and what is it that one would like to demonstrate? Sampling protocols differ depending on the desired objective (e.g. identifying corrosive water, identifying fixtures and potential sources of lead in a building, and estimating if typically consumed lead concentrations in water meets guidelines). It is important that the selected protocol be appropriate to meet the desired objective.

1.1. Evaluating if centralized water system corrosion control is warranted

Depending upon the drinking water supply system and the characteristics of the drinking water produced, it may be necessary to determine whether the drinking water is capable of causing downstream corrosion problems in buildings with leaded plumbing components. Sampling results can be used to make decisions on whether community water system level actions are needed, and to evaluate the effectiveness of corrosion control measures after they are implemented. (See Section 2.1)

1.2. Evaluating sources of lead within a building

Where sources of lead are suspected in buildings, such as schools, child care facilities or other structures, testing should be done to determine if mitigation measures are warranted. This can range from simple screening for potential problems, to comprehensively testing to determine which specific taps/fixtures or other plumbing components within a building are contributors to lead. Results can be used to make decisions on whether building level actions are needed, and to evaluate the effectiveness of control measures after they have been implemented (See Section 2.2).

1.3. Evaluating whether lead concentrations in typically consumed tap water pose a human health risk

The health advice and the Maximum Acceptable Concentration (MAC) for lead in the *Guidelines for Canadian Drinking Water Quality* is based on samples representing typical or average concentrations of lead consumed throughout the day, not best or worst case scenarios. To evaluate whether the guideline for lead is being met, typical lead concentrations in drinking water ingested by users (i.e. representative of normal use) need to be determined. This may be done in the context of a building such as a school, a residence, or an entire community. The results can be used to determine what messaging should be delivered to advise of potential health risks, action plans to mitigate the risks, and to determine if mitigation measures are successful after they have been implemented. (See section 2.3)

Once sampling objectives have been determined, careful planning should be done to get meaningful results, and to ensure that the sampling objectives are met.

2. Sampling Protocols

2.1. To evaluate if centralized water system corrosion control is appropriate

The purpose of this type of monitoring program is to identify drinking water supply systems in which corrosion is an issue, to allow decisions to be made as to whether corrective measures at the water supplier level are warranted, and to determine what measures are likely to be the most effective. These programs can also be used to assess the effectiveness of corrosion control programs after their implementation. Results of this type of protocol do not represent typical concentrations of the lead in drinking water ingested by consumers, therefore, results should not be used for the interpretation of health risks, nor whether the Maximum Acceptable Concentration (MAC) in the Guidelines for Canadian Drinking Water Quality (GCDWQ) is being met.

For the evaluation of the risk of corrosion, "Option 1 (two-tier protocol)" from page 4 of Health Canada's *Guidance on Controlling Corrosion in Drinking Water Distribution Systems* (GCCDWDS) is the preferred protocol. A second option, "Option 2 (lead service line residences)" described in the document can be used as an alternate where the two tier protocol is impractical. A brief overview of the protocol is described below; however, the original document should be referred to for the details.

Investigators will need to determine the number and location of monitoring sites. These sites should include taps within residences. To provide meaningful results, investigators will need to collect between 5 and 100 samples, depending on the size of the drinking water system (i.e., the number of people served). The recommended minimum number of sites to be monitored is shown in Table A. Sampling at individual sites is conducted as follows:

First Tier: Sample to establish whether the community water system has corrosion concerns.

- 6 hour stagnation, then collect 1L of water.

- If more than 10% of the sampled residential sites have a lead concentration greater than the action level of 15 µg/L, go to second tier. Note that this action level is different than the MAC for lead, as this is a measure of corrosion risk, not health risk.

Second Tier: For systems with corrosion concerns, this will provide detailed information about how lead is typically entering the drinking water, and will help plan mitigation measures that most appropriately target the sources found.

- Sampling is conducted at 10% of the sites sampled in Tier 1, specifically, the sites in which the highest lead concentrations were measured.
- Four consecutive 1L samples should be taken at a consumer's cold drinking water tap after a 6 hour stagnation period. This will provide a detailed profile of the sources of lead from within each building (e.g., the faucet, plumbing (lead in solder, brass and bronze fittings, brass water meters, etc.) and the lead service line.
- Each sample should be analysed separately to determine where the highest lead concentrations come from.

Table A: Suggested minimum number of monitoring sites

System Size (number of people served)	Number of Sites (annual Monitoring)	Number of Sites (reduced annual monitoring)
>100 000	100	50
10 001-100 000	60	30
3 301-10 000	40	20
501-3 300	20	10
101-500	10	5
≤ 100	5	5

Adapted from USEPA (1991a)

Interpreting Results

Where the sampling program shows more than 10% of the sampled residential sites have a lead concentration greater than the action level of 15 µg/L the water supply system should consider mitigation programs. This may include any or all of those listed in section 4 of this Guideline. It is recommended that water supply systems considering mitigation options initiate the second tier to help pinpoint typical sources of lead (fixtures vs plumbing vs lead service lines), so that the most effective mitigation measures can be planned to target those sources.

2.2. Screening for and locating sources of lead within a non-residential building (including schools, child care facilities)

This protocol is designed to locate specific lead sources within a building's plumbing and to help identify where and how to proceed with remedial actions. It provides details that help identify specific cold drinking water outlets that have elevated levels of lead following periods of water stagnation.

This is based on Section A.2.5. of Health Canada's *Guidance on Controlling Corrosion in Drinking Water Distribution Systems* be used in conjunction with a systematic plan for lead sampling. While a brief overview of the sampling protocol is described briefly below, the original Health Canada document should be referred to for details.

2.2.1. Screening for lead

- Survey and inventory the building to identify all locations in the building where drinking water is likely to be consumed.
- Take a First Draw (FD) 250ml sample from each location after an 8 hour stagnation period.
- An additional fully flushed (FF) sample should be taken subsequent to the first draw sample.
- If lead concentration exceeds 5 µg/L[5] at any of the monitoring locations, further investigation and remedial action is warranted. This may include short term measures such as flushing programs, and/or long term measures to find and replace source of lead in plumbing (see below).

2.2.2. Pinpointing specific sources of lead in the plumbing for remediation

- To evaluate whether lead may come from other sources within the building, monitoring locations (above) exceeding 5 µg/L*, a subsequent 250 ml sample should be taken at those locations after an 8 hour stagnation period plus 30 seconds of flushing.
- Alternatively, while it may initially require more samples be taken, it may be more cost efficient for investigators to simply take a second sample at all sampling locations 30 seconds after taking the first sample.
- An analysis of results against plumbing plans for the building can be used to pinpoint sources of lead.

Interpreting Results

A comparison of the results can be used to help determine sources of lead, and to plan corrective actions. For example:

- Where the first samples do not exceed the MAC – no further action would be required unless other samples in the building exceed the MAC.
- Where the first samples exceed the MAC, and subsequent samples do not, the fixture is the likely source of contamination and mitigation measures targeted at the fixture should be considered.
- Where the first and subsequent samples exceed the lead action level, mitigation measures targeted to the entire building should be considered.

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[5] *Health Canada's corrosion control guidelines and the USEPA's Lead and Copper Rule refer to an action levels as thresholds beyond the MAC, however these action levels are targeted at optimizing corrosion control, not screening for further investigation of building problems, The Corrosion control document also instructs samplers to inform users where the values exceed the MAC, so using the revised 5 µg/L MAC is a more appropriate trigger for further investigation of building plumbing.*

Successful determination of lead sources within buildings is dependent on developing and implementing a systematic sampling plan to ensure meaningful results. Sampling plans should be tailored to specific situations. Ontario's [Manual for Operators of Schools, Private Schools and Day Nurseries with Excess Lead in their Drinking Water]() published by the Ontario Ministry of the Environment and Climate Change provides an excellent resource for school and other buildings to locate the source of problems and mitigate them. This manual guides users through four key steps:

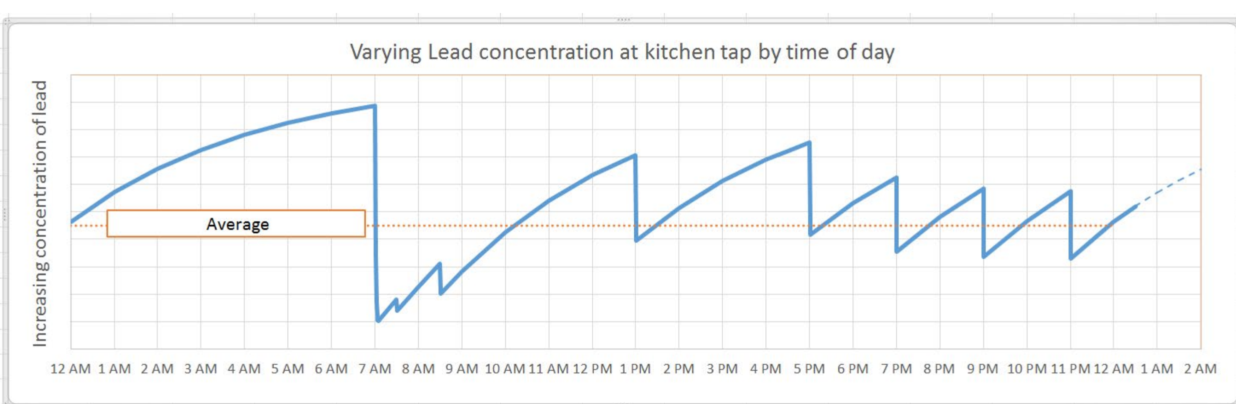
- Assessing plumbing;
- developing a sampling strategy;
- executing the sampling strategy and using the test results to remedy the problem; and
- taking routine, interim and permanent measures.

The manual may describe slightly different sampling protocols and action levels than this document, but its description of the processes for sampling still applies. The general process in this manual could also be applied to non-school settings.

Ideally, schools should be monitored at least once per year with consideration for reductions in the sampling frequency if monitoring shows that the results are acceptable. The BC Ministry of Education and Child Care may recommend alternative frequencies, however the health authority should be consulted in order to help determine an appropriate health-based sampling frequency based on the data available. In circumstances where Ministry of Education and Child Care lead sampling policies require testing at a frequency greater than what a DWO would typically recommend, the frequency set by the Ministry's policy should be followed.

2.3. To evaluate health risks

The Maximum Acceptable Concentration (MAC) published in the *Guidelines for Canadian Drinking Water Quality (GCDWQ)* is intended to apply to the average concentration in the water consumed. This implies that when evaluating health risk, the sampling protocol should be designed to estimate the average or typical exposure to lead in drinking water not the worst possible case scenario. (See conceptual figure A below.)



As water that has remained stagnant in pipes is at highest risk for lead content, it would be expected that concentrations in plumbing will be highest in the morning, and drop over the day with use. Assessing whether or not typical concentrations consumed meet the GCDWQ should therefore be based on sampling at times and places where water is usually consumed, and not a worst or best case scenario.

The following describes specific approaches to estimate typical concentrations in different scenarios, including community risk, and risks with individual dwellings or larger buildings.

2.3.1. Evaluating health risk at the community level:

While it is relatively simple to sample lead concentrations in drinking water as it leaves the treatment plant, it is not representative of what is consumed by users as building plumbing can significantly impact lead content. To establish a typical concentration of lead being consumed by customers, a series of either Random Daytime Samples (RDT) or Thirty Minute Stagnation (30MS) samples should be taken at multiple points of consumption. These samples should be averaged. Details of the pros and cons of each method are discussed in part three of this document.

Sampling plan designs should consider:

- Producing reliable results typically requires 20 or more samples, taken at different consumer locations and at different times of year;
- choosing sampling points from consumer's taps that are balanced between public and private buildings;
- identifying homes with lead service lines for inclusion in the sampling program, as these are likely to have the highest lead concentrations;
- dividing larger distribution networks into neighbourhoods or zones of similar age and evaluating the risk of each community independently may be advisable in some areas; and
- taking samples of the water supplied to the distribution network to establish baselines of the lead concentration of water supplies.

After selection of the taps being sampled, either:

a) For RDT programs, the first 1 litre of water, from each tap is sampled without flushing at random times throughout the day, or
b) for 30MS programs, flush taps for 5 minutes, let stagnate for 30 minutes, then take two consecutive 1-litre samples.

Interpretation

Results should be averaged to determine a typical value for evaluation against the MAC set in the GCDWQ of 5 µg/L. Individual samples that exceed the MAC should not be cause for community concern, however further investigation of the cause might be warranted. Where averaged samples exceed the MAC, the Health Authority should be engaged with the water supplier to further investigate and plan mitigation options.

2.3.2. Evaluating health risks in individual dwellings:

Homeowners, operators of child care facilities in residential settings or occupants of dwellings with older plumbing may wish to investigate whether drinking water from their home meets the requirements of the GCDWQ. This scenario provides a challenge as it is unlikely that a series of samples will be taken and averaged to produce "typical" results. Where only one sample is practical to be taken, a 30MS sample should be done as it is the most reproducible for post mitigation evaluation, and can be done at any time of the day.

Interpretation

Where possible, multiple samples should be taken and averaged, and results evaluated against the MAC of 5 µg/L in the GCDWQ. Where the MAC is exceeded, further investigation should be done to determine the source of lead and/or the mitigation measures that can be implemented.

2.3.3. Evaluating health risks in schools and other larger buildings:

The purpose is to determine if water typically consumed by students in schools or occupants/residents of larger buildings are likely to be at levels that exceed the GCDWQ. This may be done after screening (See Section 2.3). If screening does not show exceedance of action levels, further sampling and calculation of the MAC is likely not warranted. As school plumbing tends to be complex in use patterns, age, and variability, there is typically no single sentinel site that can be established for most schools, thereby requiring the sampling of every drinking water location. Large buildings face similar challenges.

A RDT sampling protocol is recommended to capture typical exposures, including potential exposure to particulate lead. This should be conducted by sampling at all drinking water fountains and cold water taps where water is used for drinking or food preparation. Samples should be taken:

- At random times throughout the school day;
- preferably taken between May and September as leaching increases with higher water temperatures; and
- two consecutive 125 mL samples should be collected at each fountain or tap without a stagnation period and without prior flushing. Note: smaller samples are taken as it can provide valuable data for find and fix options if needed at a later date.

Interpreting Results

Results from a sampling program should be calculated by averaging the results from at least two samples and averaging sampling locations within a building. Averages should not exceed the MAC for lead that is set out in the GCDWQ.

Those schools and buildings with indicators of lead problems should undertake further screening and mitigation as per section 2.3 below. Taking two 125ml samples is preferable to taking a 1L sample as it can help determine if the fixture or the plumbing system is the problem by providing valuable data for further investigation and for determining mitigation options.

3. Definitions

3.1.1. Random Daytime Sampling (RDT):

Purpose: To capture typical exposures at residential sites, assess health risk, and set priorities.

A sample is taken at a random time during a working day directly from the tap in a property without previous flushing. The stagnation of water in a distribution system influences the concentration of lead in a random manner. Health Canada recommends taking a 1L samples for sampling programs conducted at the community level. For schools and other large buildings, Health Canada recommends taking two 125ml samples be taken as the data from smaller volumes can provide valuable data for identifying and mitigating problem fixtures and areas within buildings.

RDT sampling is relatively inexpensive and convenient (per sample), but needs to be repeated numerous times to provide confidence in the results. Results are close to typical use when averaged over many samples. RDT sampling is better suited for determining system wide health risks than for individual sites. It requires 2-5 times more samples that 30MS sampling to provide statistically significant results.

3.1.2. Thirty Minute Stagnation (30MS):

Purpose: To capture typical exposures at residential sites, assess health risk, and set priorities.

A typical 30MS sampling protocol is to flush a tap for 5 minutes, then allow water to stand for 30 minutes. Two consecutive 1L samples are then taken and the results of the two samples are averaged.

30MS samples are more reproducible than RDT samples, and may be the most appropriate for single samples estimating lead risk in individual dwellings. Using two consecutive samples allows the estimation of the relative contribution of the fixture to the lead concentration. 30MS sampling is time consuming and may underestimate typical exposure to lead in drinking water.

3.1.3. First Draw (FD)

Purpose: To capture the highest levels of lead using long stagnation times.

During the stagnation period no water should be drawn from any outlet within the property (this includes the flushing of toilets). If any water is drawn during the stagnation period the result will be invalid.

- 6-8hr stagnation period then the collection of a 250 mL or 1L sample.

First draw gives the "worst case scenario". This may also be useful in conjunction with flushed samples to help determine if a specific fixture is contributing lead to the water. This protocol is not appropriate for assessing health risk based on average exposure to lead in drinking water, unless it confirms samples are below thresholds of concern.

3.1.4. Fully Flushed (FF)

Purpose: To determine lead levels in plumbing after complete flushing of the system, or to infer lead levels from water mains.

Samples are taken after prolonged flushing of the tap in a premise in such way that the stagnation of water in the domestic distribution system does not influence the concentration of lead in the drinking water. In practice a sample is taken after flushing at least three plumbing volumes, a prescribed time, or after an observed temperature drop.

While fully flushed samples provide an indication of lead concentrations in systems that are under heavy use, they are not suitable for assessing average exposure to lead in drinking water, as they are likely to underestimate typical lead exposure. Calculating pipe volumes, flow rates and flushing times may be challenging for some larger buildings with complex plumbing systems.

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Appendix D: Guidance on Flushing for Mitigation

One option for mitigation of lead risks from drinking water in schools, licensed child care facilities, or other buildings is to implement a flushing program. The intention of flushing is to run the tap water until the water from the water main in the street or the water supply from within the well reaches the taps. This has been shown to significantly reduce lead levels in drinking water at the tap. However, the degree to which flushing helps reduce lead levels in drinking water can vary, depending upon the age and condition of a facility's plumbing and the corrosiveness of the water. Regardless of these limitations, flushing is still the quickest and easiest measure to reduce high lead levels in drinking water, especially when contamination is localized in a small area or in a small building.

Circumstances that indicate implementing a flushing program:

Where assessment and/or water sampling of a facility has identified risks for elevated lead in water mitigation actions should be taken. These circumstances include:

- Results of testing for lead in water (see appendix C) exceed the Maximum Acceptable Concentration in the *Guidelines for Canadian Drinking Water Quality or* action levels;
- any part of the plumbing was installed before January 1, 1990 that has not been assessed for lead content, and/or there is no sampling history for the last 24 months;
- it is recommended by the Regional Health Authority.

Mitigation should include implementing a flushing program until permanent measures can be taken to reduce the lead or until testing confirms that lead levels are within acceptable limits. Any additional flushing requirements will be determined by the results of the facility's plumbing profile and risk assessment in consultation with the local Environmental Health Officer.

When to flush:

- Flushing should be conducted daily when the facility or part of the facility is open.
- Flushing should be completed before the facility opens for the day. Where a facility is open for 24 hours on that day (e.g., a building housing student residences within a school property), flushing should be completed as early in the day as possible.

Where and how to flush:

- First, turn on the cold water for at least five minutes at the last tap on each branch or each run of pipe in the plumbing that serves a drinking water tap that is commonly used to provide water for consumption. In many cases, depending on the plumbing configuration, it may be necessary to flush the plumbing for a longer period of time. The actual amount of time that will be needed depends on the type of tap, diameter of pipes, and its location within the building plumbing (i.e. distance from the water main in the street or the distance to the water supply well). For best results, the volume of the plumbing and the flow rate at the tap should be calculated, and the flushing time should be adjusted accordingly – See **Calculating how long to flush** below.

- Then, turn on the cold water for at least 10 seconds at every drinking water fountain and every tap that is commonly used to provide drinking water for human consumption.
- Additional recommendations for flushing specific types of non-end-of-run outlets include:
    - For drinking water fountains without refrigeration units, the water should run for at least 15 seconds, or until the water is cold.
    - For drinking water fountains with refrigeration units, the water should run for at least 15 minutes. If it is not feasible to flush for such a long time, these outlets should be replaced with lead-free, NSF-approved devices.
    - For all kitchen faucets and other faucets where water may be used for drinking (including bathroom faucets where it is possible to obtain cold water), the water should run for at least 10 seconds or until the water is cold.
- Be careful not to flush too many taps at once. This could dislodge sediments that might create further lead problems, or could reduce pressure in the system below safe levels. If the flow from drinking water outlets is reduced noticeably during flushing, too many taps are probably being turned on at once.

Calculating how long to flush:

The amount of time it will take to fully flush a building's plumbing will vary depending on the diameter of the water supply pipe and the water flow rate during flushing. Some of the ways to determine how long to flush include:

- Calculating the pipe volume, in litres, between the outlet and the location in the plumbing being flushed using the formula: 3.14 x pipe radius^2 x pipe length (i.e., $\pi r^2 l$);
- measuring the outlet flow rate in litres per minute;
- dividing the pipe volume in litres by the outlet flow rate in litres per minute.

The following table and information from the 2016 Copper Tube Handbook[6] can assist in calculations.

Table B: Pipe Volume (per unit of pipe length) for different diameters of copper pipe

Pipe diameter	Volume of tube (litres per meter of length) Type L Copper
9.53 (3/8)	0.0938
12.70 (1/2)	0.1505

[6] Copper Development Association Inc.(2016) *Copper Tube Handbook: Industry Standard Guide for the Design and Installation of Copper Piping Systems*; CDA Publication A4015-14/16, NY

15.88 (5/8)	0.2248
19.05 (3/4)	0.3122
25.40 (1)	0.5323
31.75 (1 ¼)	0.8129
38.10 (1 ½)	1.1520
50.80 (2)	1.9974
63.50 (2 ½)	3.0751
76.20 (3)	4.3943

Establishing due diligence – recording and reporting:

- Keep written records of the date and time of every required flushing and the name of the person who performed the flushing. If auto flushers are used, record the name of the person who verified that the automatic flushing took place. Records for auto flushers need to be completed based on the frequency set out in the manufacturer's instructions or at least once a month if no instructions are available.
- Keep the written record on file and available for review by an Environmental Health Officer.

Additional information:

- It is not required to flush any tap or drinking water fountain in a part of a building that is not in use by children or staff during the day as well as in private student residences or in a public washroom (e.g., in a shopping mall).
- If a tap or drinking water fountain has an aerator, the aerator should not be removed when flushing.
- If a tap or drinking water fountain has an individual filter or other water treatment device, the filter should be bypassed when flushing if this can be done easily. A filter or treatment device is not required to be bypassed if it would require removing or dismantling the device to do so.
- To save water, thoroughly flush several designated drinking water outlets daily while taking all others temporarily out of service. Collect the water being flushed and use it for non-consumptive purposes.

References:

Copper Development Association Inc. (2016). Copper Tube Handbook: Industry Standard Guide for the Design and Installation of Copper Piping Systems. CDA Publication A4015-14/16, NY.

Ontario Ministry of the Environment and Climate Change (updated June 23, 2016). Flushing and sampling for lead: Rules for schools, private schools and child care centres to flush plumbing and test drinking water for lead. https://www.ontario.ca/page/flushing-and-sampling-lead

Ontario Ministry of the Environment (2009). A Manual for Operators of Schools, Private Schools and Day Nurseries with Excess Lead in their Drinking Water: A resource guide on how to locate the source and remedy the problem.
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