# Responding to Water Stagnation in Buildings with Reduced or No Water Use

## A Framework for Building Managers

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Importantly, this guide draws on many other useful and informative documents. The following provided the foundation for this guide:

### *FEDERAL GUIDANCE*

- Centers for Disease Control and Prevention (CDC): Guidance for Reopening Buildings After Prolonged Shutdown or Reduced Operation Guidance
- USEPA: Information on Maintaining or Restoring Water Quality in Buildings with Low or No Use
- UK HSE: The control of legionella bacteria in hot and cold water systems

### *STATE GUIDANCE*

- WA DOH: COVID-19 Guidance for *Legionella* and Building Water System Closure[1,5]
- WA DOH: Shock Chlorination Guidance for Building Water Systems
- OH DPH: Recommendations for Unoccupied to Partially Occupied Buildings for Flushing and Disinfection to Reduce *Legionella* Growth[1,5,6]
- IL Plumbing Group (IDPH): Plumbing Systems & Water Quality Guidance

### *CODE OR INDUSTRY CONSENSUS DOCUMENTS*

- IAPMO: Tips and Recommendations for the Safe and Efficient Flushing of Plumbing Systems in Buildings
- UPC Code 2021 Appendix N: Impact of Water Temperature on the Potential for Scalding and *Legionella* Growth[1,4]
- ASHRAE Standard 188: Legionellosis: Risk Management for Building Water Systems[4]
- ASHRAE Guideline 12: Managing the Risk of Legionellosis Associated with Building Water Systems[4]

### *PEER-REVIEWED LITERATURE*

- Proctor et al., 2020: Considerations for Large Building Water Quality after Extended Stagnation[1–6]

### *PRIVATE ORGANIZATIONS*

- National Academies of Sciences, Engineering, and Medicine (NASEM): Management of *Legionella* in Water Systems[2]
- *Legionella* Risk Management, LLC: Developing a Building Potable Water System Flushing Program[1,4]
- Environmental Science, Policy, and Research Institute (ESPRI): Advice from ESPRI and AH Environmental on Building Flushing
- American Industrial Hygiene Association (AIHA): Recognition, Evaluation, and Control of *Legionella* in Building Water Systems

### *INTERNATIONAL ORGANIZATIONS*

- European Society of Clinical Microbiology and Infectious Diseases (ESGLI): Guidance for managing *Legionella* in building water systems during the COVID-19 pandemic

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# Foreword

This document provides a decision-making framework for building managers to design responses to building water system stagnation. This collaborative effort started April 2, 2020, with an AWWA Premise Plumbing Committee conference call to discuss the impact of COVID-19 stay-at-home and shelter-in-place orders on water quality in buildings. When EPA, CDC, and others released guidance related to COVID-19 water system stagnation, there was a need to provide additional information, context, and limitations to some of the specific recommendations being disseminated. This document can serve as a basis for discussions when making decisions. Beyond the documents referenced in the acknowledgements and the resources hyperlinked within the text, there are no other references provided, as access to peer-reviewed literature is limited.

CDC and EPA guidelines recommend developing a water management program as a key step for addressing stagnation and for long-term building water management. However, there are important limitations to water management programs that this document attempts to address. First, developing and fully implementing water management programs can require a lot of institutional resources (i.e., time, funds, personnel, expertise). This document provides information to address the immediate need to respond to stagnation. Building managers then can update or create water management programs. Second, this document provides some "how to" resources for building managers assessing their building plumbing systems after/during stagnation and deciding what level of actions are needed.

An additional limitation in this document is the focus on *Legionella*. Most industry resources are focused solely on growth of *Legionella*, the cause of legionellosis (Legionnaires' disease and Pontiac Fever). *Legionella* are not the only opportunistic pathogen whose growth can be supported by water stagnation, nor are biological issues the only water quality issues that may arise due to stagnation. However, because consumption-based exposure to metals can be addressed with appropriate filters in most scenarios and widely recognized industry documents do not exist for other opportunistic pathogens beyond *Legionella*, we have provided information centered around *Legionella*.

On behalf of myself, the co-authors, and the reviewers of this report who gave their time and expertise to improve this work, as well as AWWA and IAPMO, I hope this document is helpful in directing discussions regarding building water quality and public health.

Sincerely,

William J. Rhoads, PhD

# 1 Background and Introduction

## 1.1 Purpose of this document

Stagnation within building water systems is the condition in building plumbing when water is not being used and water remains still within the plumbing network. During stagnation, water quality issues may develop. ***Stagnation related issues can occur at an outlet (e.g., faucet, showerhead, water fountain/bubbler, etc.), a group of outlets, or throughout an entire building water system during periods of low or no use.*** Controlling water stagnation is one important aspect of water management programs and managing health risks related to building water systems. Water management programs are highly tailored to an individual building's risk factors and available resources and can be very effective in helping building managers maintain long-term water quality.

The purpose of this document is to help building managers without a water management program or without a program that addresses building water system stagnation assess and react to building water stagnation. The information provided herein may be helpful to building managers executing the CDC's "Guidance for Reopening Buildings After Prolonged Shutdown or Reduced Stagnation" or US EPA's "Maintaining or Restoring Water Quality in Buildings with Low or No Use." The US EPA also developed a "Restoring water quality in buildings for reopening" checklist.

In this document, reduced water use will also be referred to generally as stagnation, as it may result in the same water quality challenges for building managers.

## 1.2 Limitations of Available Guidance

Low occupancy in buildings and building water system stagnation do not always cause water quality issues. This makes determining when, and to what extent, to perform preventative or remedial actions responding to stagnation difficult. There are also large differences in building water system operation and design. ***Consequently, one set of instructions will not be appropriate for all buildings. This document provides a framework for building managers to consider as they tailor their approach to their building's circumstances.***

### 1.2.1 DEFINING A "LOW OCCUPANCY" LEVEL

Stagnation at an outlet, a group of outlets, or throughout an entire building can increase health risks associated with use and exposure to building water. There is not a certain minimum level of occupancy that prevents water quality problems from occurring in all buildings. ***Generally, decreases in occupancy lead to increases in water stagnation.***

### 1.2.2 DEFINING A "PROLONGED STAGNATION" TIME

Building water stagnation events are very common (e.g., overnight, weekends), and prolonged stagnation routinely occurs due to seasonal building use (e.g., schools), construction activities, periods between occupancy (e.g., while on the real-estate market), and building type (e.g., entertainment venues, hotels). Other events such as natural disasters and emergency changes to building operation policy (e.g., "stay-at-home" orders during the COVID-19 global pandemic) also cause prolonged stagnation. ***There is not a defined period of stagnation that causes problematic water quality conditions to develop in all buildings.***

## 1.3 Response Options to Building Water Stagnation

Flushing water consists of opening outlets to replace water within the building plumbing with fresh water from the water supplier and can occur as a regular practice or as a remedial action. Replacing and replenishing the water in the plumbing network with a one-time intervention ***(Remedial Flushing)*** or through routine use and/or flushing ***(Routine Flushing)*** are two common strategies to reduce health risks associated with deteriorated water quality due to stagnation. After a remedial flush, regular building occupancy or routine flushing can maintain acceptable water quality. Routine flushing can help maintain water quality until normal occupancy is reestablished. Routine flushing at low-use and high-risk outlets can reduce health risks at those outlets regardless of occupancy.

While many buildings share common construction practices, there is not a "rule of thumb" for the duration of a particular flush event. Buildings that have water management programs in place may already have flushing protocols that are appropriate. These facilities have the advantage of having already evaluated their building water systems and developed a building specific strategy.

***A generally applicable approach is to flush cold water until it is representative of the cold water entering the building***

***and to flush hot water until water temerature at the outlet reaches a maximum steady temperature.*** Additional flushing beyond this level may still be beneficial for some buildings or portions of building plumbing (e.g., flushing to verify disinfectant residuals or to flush hot water systems with elevated temperatures for a longer duration). Building mechanical systems and specialty water systems may also benefit from additional interventions. If a building has water filters or other treatment devices installed, precautions to protect these devices during flushing (e.g., bypassed) is warranted. Manufacturer-specified maintenance and replacement of expendable treatment device components like filters after flushing and prior to resuming use warrants consideration.

### 1.3.1 REMEDIAL FLUSHING

Remedial flushing is a one-time event intended to replace all the water in the system with fresh water from the water supplier to reduce the presence and/or risk of exposure to contaminants. ***Remedial flushing is a first step in solving water quality issues, but it may only temporarily reduce the level of contaminants in the building water system.*** There is a range of remedial flushing actions that can be taken, including:

1. Maintaining and flushing only specific pieces of equipment and/or components (e.g., water heater)
2. Flushing only primary plumbing pipes
3. Flushing all outlets to replace water volume
4. Flushing all outlets while also removing aerators, showerheads, etc. to increase flow rate and remove debris that may have accumulated.

***While described as a one-time event, repeated remedial flushing on a series of days can be advantageous in some buildings. Building managers should assess systems/components in their building and choose appropriate remedial flushing actions based on the risks identified in their building water system. After remedial flushing, a rapid return to normal building water use and/or or active ongoing routine flushing may be needed to maintain water quality.***

**CAUTION**

Engage knowledgeable personnel **(See Section 3.1)** or seek professional assistance as mistakes can lead to property damage.

Be sure water released during flushing is directed to adequately sized basins and piping for velocity and volume of flow or flooding and water damage could result.

Take necessary steps to avoid damaging inline devices, water treatment systems, and other connected mechanical systems.

Adhere to relevant health and safety precautions including personal protective equipment (e.g., electrical hazards, enclosed space, aerosolized hazards, etc.).

Communicate with building occupants so that they can take appropriate actions.

Installation of treatment such as supplemental disinfection may require state regulatory approval. Consult with state drinking water program.

### 1.3.2 ROUTINE FLUSHING

Routine outlet flushing is a preventative action performed during periods of low water use throughout a building or at specific unused outlets. Flushing consists of opening outlets to flush water through the outlet and drop legs connected to risers or headers. This practice can be beneficial if water usage is sufficient to replace water in the primary hot and cold plumbing pipes, and only certain areas within the building remain unused. There are not default recommendations with respect to duration, location, or frequency that will reduce or eliminate risks in all settings. ***The amount of routine flushing necessary to prevent water quality issues will vary by building.*** Building managers must assess the water use and occupancy patterns of their buildings, health risks, and the resources available to design an appropriate flushing plan. Incomplete flushing may increase the levels of some contaminants by not thoroughly removing stagnant water or renewing water frequently enough.

In the US, many healthcare buildings are required by Centers for Medicare and Medicaid Services to have a water management program. Many water management programs specify flushing unoccupied, unused, or high-risk outlets weekly. While not all buildings have the high concentration of immunocompromised or susceptible individuals that are found in healthcare buildings, flushing outlets once per week may be a starting place for occupied buildings that have infrequently used outlets or some unoccupied spaces. ***As occupancy decreases, it can become difficult to manually flush plumbing in all the unoccupied spaces and water quality issues may develop.*** Routine flushing practices can be expanded or reduced based on building occupancy patterns and may need to be targeted to certain low-use or unoccupied floors, wings, or suites as occupancy changes.

If all outlets cannot be flushed, outlets at strategic locations can be identified by building managers to ensure adequate water flow throughout the building.

### 1.3.3 OTHER REMEDIAL ACTIONS

Determining and addressing the root-cause of ongoing water quality issues is the most reliable long-term solution. However, shock disinfection is used in some instances **(See Section 2.4)**. Shock disinfection consists of temporarily introducing a chemical disinfectant or high temperatures to a portion or all of the building plumbing system.

There are few specific regulatory criteria that trigger disinfection of building plumbing systems. Shock disinfection of building water systems is performed as part of the commissioning process for new construction and major renovations, in response to a specific water quality issue, in response to a waterborne disease outbreak, or as part of a water management program. Shock disinfection, if performed properly, decreases the levels of pathogenic organisms in the water, but is only temporarily effective without addressing the source(s) of the problem(s).

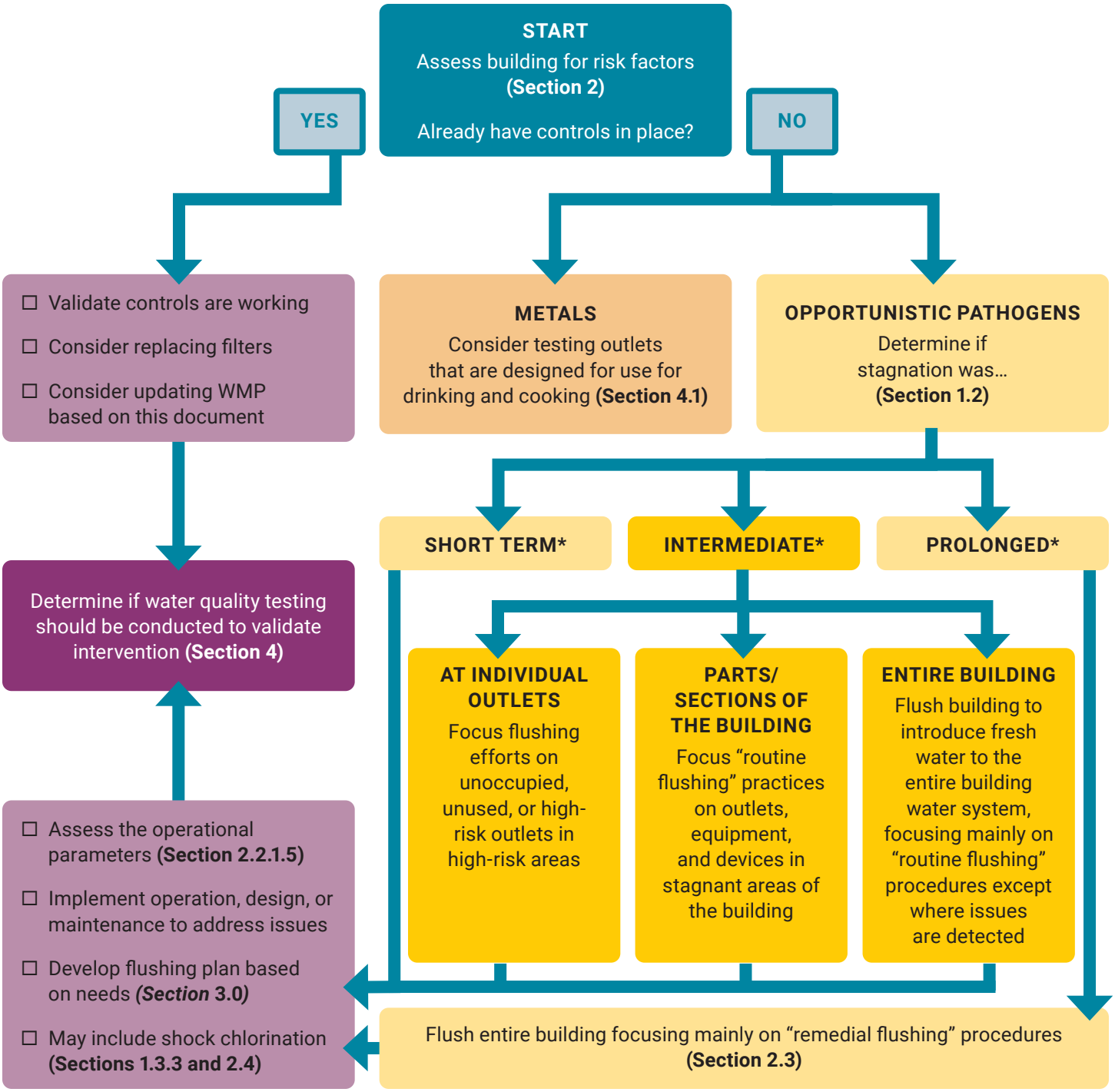
***Shock disinfection must be carried out carefully. If the building manager does not have experience performing building disinfection, they should do so under the guidance of regulatory, public health, and/or water treatment professionals.***

## 1.4 When To Consider Varying Levels of Responses

Building managers will want to assess their resources when designing an appropriate reopening strategy for their building(s). Responses to stagnation can be based on the waterborne hazards and associated remedial actions discussed in **Section 2** and the information and resources needed to assist building managers discussed in **Section 3**. Due to the variation in building design and use, the actions broadly described in **Section 1.3.1–1.3.3** may need to be combined, scaled to match changing occupancy patterns, and otherwise adapted to an individual building's situation.

Figure 1 provides an overarching framework for deciding what level of response or type of action(s) to take. This framework is not a prescriptive procedure for responses. Rather, it can guide discussions regarding the type and level of response implemented. Available research does not support defining one duration of stagnation that will lead to water quality issues that pose an increased health risk in all buildings. The committee that drafted *ASHRAE Standard 188 — Legionellosis: Risk Management for Building Water Systems* included a threshold of two weeks for implementing preventative actions, and a threshold of four weeks for considering remedial actions, including disinfection. The ASHRAE committee judged these to be feasible time periods when applied to new construction and aimed to prevent outbreaks of Legionnaires' disease as weeks to months may pass between building commissioning and building occupancy. This document follows a similar framework as there has not been a consensus process to determine a period of stagnation that is appropriate for broader application. Site-specific conditions, including preexisting water quality, complicate predicting the length of stagnation that will pose a significant increased health risk for all or most buildings **(See Section 2.2.1.5)**.

Table 1 provides a general overview of the possible responses and when to consider performing them.




** Site-specific conditions, including preexisting water quality, should be used to define short-term, intermediate, and prolonged stagnation.*

*In this document, **short-term stagnation** is defined as routinely or regularly occurring in buildings and is commonly associated with no documented adverse effects on water safety. Little to no additional intervention may be required for short-term stagnation. **Intermediate length stagnation** is defined as a moderately extended period beyond short-term stagnation where disinfectant residuals or temperatures are below desired levels. Some focused interventions may be required at outlets or areas within buildings that have low water use. **Prolonged stagnation** is defined as long-term decreases in water use within a building. Extensive interventions that focus on the entire building may be required.*

**Figure 1.** *Framework for deciding types and level of actions on an individual building basis.*

**Table 1.** *General overview of types of preventative or response actions and interventions available to building managers*

| STRATEGY | PRO | CON | WHEN TO CONSIDER |
|---|---|---|---|
| **Flushing** | | | |
| Intensive flushing of all outlets, removing aerators, showerheads, etc. | Targets removing contaminants and fully replacing water volume; Remediates or prevents issues with specific system components | High effort; Not always effective if all outlets are not flushed within system; Not effective long-term without addressing source of problem(s) | Buildings with intermediate stagnation* , particularly if building or occupancy risks factors are present **(See Section 2.2.1)** |
| Intensive flushing of all outlets, not removing aerators, showerheads, etc. | Fully replaces water volume to introduce fresh water | One-time flush may only temporarily improve water quality; High effort; Not effective if all outlets not flushed within system; Not feasible for all systems; Not effective long-term without addressing source of problem(s) | Buildings with intermediate stagnation* |
| Maintain mechanical equipment | Remediates or prevents issues with specific system components | May temporarily increase contaminant levels if not done thoroughly | Buildings with intermediate stagnation*; Routinely per manufacturer recommendations |
| Flush primary water pipes (risers, headers, pipes) | Fairly easy; May be automated in some systems; Ensures water is replaced in core systems even with very low water use | Does not prevent or remediate issues in pipes where opportunistic pathogens are more likely to be found | Buildings with intermediate stagnation*; Prior to flushing point of use outlets; Unclear if conducting flushing of main portions of building systems without addressing individual stagnant outlets will be helpful |
| Flush only point of use outlets | Easy and implementable once a procedure is established and validated; Likely best applied when daily water use is sufficient to replace volume in main pipes; Can focus on high-risk outlets | Incomplete flushing may allow more growth of waterborne pathogens if target disinfectants or temperatures are not attained; Could take a very long time flushing to achieve target water quality in unoccupied buildings or long water pipes serving point of use outlets | Partially occupied buildings or building conducting routine flushing with enough water use to regularly replace the water; Can be focused on low-use or high-risk areas/outlets |
| **Shock Disinfection** | | | |
| One-time chemical disinfection | Can be implemented quickly in small buildings; Reduces public health risks temporarily | Not effective if not dispersed throughout system; May damage plumbing; may pose risks to occupants during disinfection (consider requiring water restrictions); Not effective long-term without addressing source of problem(s) | Documented issues with waterborne pathogens; Buildings experiencing prolonged stagnation* that also have building or occupant risk factors **(See Section 2.2.1)** |
| One-time thermal disinfection | Can be implemented quickly in small buildings; Can be simple and achievable in small buildings; only applicable for hot water systems; Reduces public health risks temporarily | Highly dependent upon thermal capacity of water heater and ability to achieve target temperatures throughout system; Elevated risk of scalding when using water; May damage plumbing components; Not effective long-term without addressing source of problem(s) | No issues with cold water system; Small buildings or buildings with enough water heating capacity to maintain target temperatures. |
| **Other** | | | |
| No action | Restoring water quality can be addressed immediately before reoccupancy | May result in water quality that causes illness or aesthetic concerns. | May be appropriate if building is completely unoccupied for short durations; or when supplemented with remedial actions before reoccupancy |

** Site-specific conditions, including preexisting water quality, should be used to define short-term, intermediate, and prolonged stagnation.*

# 2 Identifying Hazards and Potential Responses

The hazards potentially related to stagnation addressed in this document include release of metals and waterborne pathogen growth. It is possible to avoid or mitigate conditions that contribute to the potential for hazards to develop by recognizing and responding to them. Reducing these hazards is a strategy to prevent potential health risks.

## 2.1 Metals

Metals can be released to water from the corrosion of pipes and plumbing components in the distribution and building water systems. Metals may also be deposited in building water systems scales and sediments. Stagnation provides the time and, in some cases the water quality conditions, that allow scales to destabilize or concentrations of metals in the water to rise to levels that can cause health effects and/or aesthetic concerns. When water use is resumed, water may contain elevated levels of metals.

Both lead and copper are regulated through the Lead and Copper Rule for public water suppliers and have the most evidence-based information regarding managing health risks associated with their exposure. Stagnation can cause other metals to be present in the water, which also have adverse health effects and/or aesthetic concerns. USEPA's drinking water health advisories are one available guide to concentrations of potential concern. This document provides information specific to lead and copper.

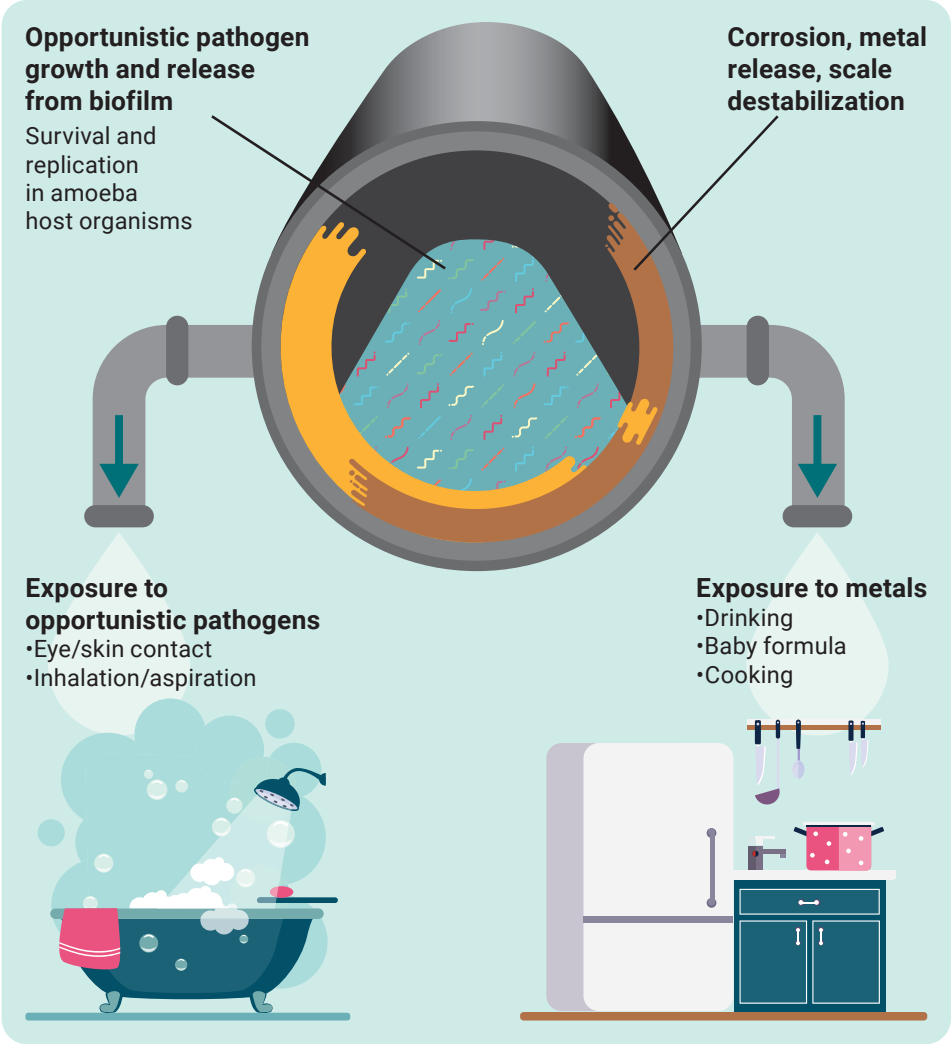



**Figure 2.** *Opportunistic pathogen and metal exposure*

Metals in water can occur in dissolved (i.e., soluble) and/or particulate forms. Particulates may be associated with high concentrations of more than one metal. For instance, the appearance of red/brown water can be associated with presence of iron in the water, which may, in turn, be associated with elevated levels of lead.

Flushing can replace water in the building water system and decrease levels of metals that have accumulated during stagnation. However, flushing may not immediately correct or be a long-term solution to water quality issues related to corrosion. In addition, routine flushing may need to be continued to reestablish stable corrosion scales.

### 2.1.1 LEAD

Buildings that have lead-bearing plumbing components are at an increased risk of having lead in water. Lead service lines (100% lead) and lead solder (50/50 lead-tin alloy) were banned after 1986. Brass was allowed to contain up to 8% lead by weight and the interior surface coating of galvanized iron pipes were allowed to contain up to 2% until 2014.

These legacy sources of lead may still be present in older buildings. Currently, only components that contain less than 0.25% lead (average weight on wetted surface) may be used in potable water plumbing. US EPA has resources to help identify products certified to leach low amounts of lead. Lead exposure is of special concern for occupants that are children less than 6 years old, formula-fed infants, and pregnant women. Children are particularly at risk for developmental health effects of lead exposure. Lead can be harmful to adults as well.

### 2.1.2 COPPER

Copper leaching from building plumbing materials (copper pipe, brass fittings or outlets) can decrease over the life of the material with the formation of a protective scale. This passivation does not occur under all water quality conditions. Regardless of building age and passivation, periods of stagnation are likely to increase copper levels when a source of copper is present. High levels of copper exposure can be a health concern regardless of age. Copper is of greatest concern for individuals with Wilson's disease and children, particularly particularly formula-fed infants.

### 2.1.3 POSSIBLE ACTIONS TO TAKE

***Because the exposure route for metals is ingestion (i.e., drinking, cooking, preparing infant formula), building managers can reduce or avoid occupant exposure to metal released caused by stagnation by:***

1. Cleaning, replacing, or otherwise maintaining aerators and point of use treatment filters regularly
2. Encouraging occupants to not drink or cook with the water until flushing has occurred
3. Providing and maintaining designated water outlets with filters certified to remove metals of concern (e.g., water bottle filling stations, water fountain/bubblers). US EPA has resources to support decision making regarding point of use filters.
4. Providing an alternative water supply such as bottled water

Building managers should consider testing outlets dedicated for drinking/cooking purposes after any intervention is implemented and prior to resumed use **(See Section 4.1)**.

Flushing is a frequently recommended action in guidance to reduce lead and copper. Recommendations for flushing are part of US EPA's "3T's for Reducing Lead in Drinking Water" recommendations for reducing lead exposure in schools.

## 2.2 Waterborne Pathogens

The waterborne pathogens that are most likely to grow to harmful levels during stagnation in building water systems are "opportunistic pathogens." These pathogens tend to infect individuals who are susceptible due to underlying health or lifestyle factors (e.g., the elderly, smokers) compared to healthy individuals. Exposure routes for opportunistic pathogens from water systems include inhalation of respirable aerosols (small droplets), aspiration of ingested water containing pathogens, and/or contact through open wounds or the eyes (Figure 2). Microbial risks often focus on *Legionella*, for which inhalation of small droplets is the principle exposure risk. ***Opportunistic pathogens tend to grow best when temperatures are suitable, disinfectant residuals are low, and there are available nutrients and host organisms. These conditions can be found in building water systems that have low water use and/or are not properly designed, operated, or maintained.***

### 2.2.1 BUILDING RISK FACTORS FOR COLONIZATION AND AMPLIFICATION OF OPPORTUNISTIC PATHOGENS

Certain building types, operational settings, features, and specific devices increase potential for opportunistic pathogen growth and exposure. CDC highlights these characteristics in its guidance for water management programs. These characteristics are also important in deciding to take action to prevent water quality issues from developing or perform remedial actions prior to occupancy.

#### 2.2.1.1 STAGNATION

During stagnation hot water temperatures cool to ambient temperatures at point of use outlets. In cold and hot water, disinfectant residual decays. Water use after periods of stagnation can release opportunistic pathogens that have grown or become detached from the biofilm. As described in **Section 1.2**, if, when and how quickly stagnation leads to problematic levels of opportunistic pathogens is very challenging to generalize. **Section 2.3.2 with 2.3.7** describe how to assess the need for flushing in partially occupied buildings. When stagnant water conditions worsen water quality issues caused by engineering, mechanical, or operational deficiencies, flushing may temporarily decrease the presence of conditions that allow opportunistic pathogens to proliferate. Once problematic conditions have been established in a portion of a building water systems, interventions beyond flushing may be necessary.

#### 2.2.1.2 BUILDING TYPES

Building types that are generally at elevated risk of opportunistic growth due to their complex design and susceptible occupants include:

1. Healthcare facilities, particularly in-patient, transplant, senior living/retirement communities, or cancer treatment facilities. The CDC has specific resources for outpatient care standards. Many of these facilities are already required to have a water management program by Centers for Medicare and Medicaid Services.
2. Dental facilities. CDC has infection prevention practices in dental settings.
3. Hotels, motels, or resorts. The CDC has guidance for hotels.

***In following CDC and US EPA guidance, building managers for these types of buildings are more likely to undertake intensive responses to stagnation, perform remedial actions followed by routine flushing actions until occupancy resumes, and validate interventions through testing (See suggested water quality measurements in Section 3 and microbial testing considerations in Section 4).***

#### 2.2.1.3 BUILDING FEATURES

Building features that are associated with growth of opportunistic pathogens and disease incidence include:

1. Cooling towers; see the Cooling Tower Institute cooling tower manual for maintenance and disinfection procedures and ASHRAE Guideline 12
2. Pools, spas, hot tubs, whirlpools or therapeutic baths; See ASHRAE Guideline 12 resources on maintenance and disinfection.
3. Decorative water features, such as fountains and water walls. See ASHRAE Guideline 12.
4. Systems with dead-end sections (e.g., future planned risers/chases, unused duplicate/parallel pipes). **See Section 2.3** for details on flushing.

***If maintenance per manufacturer recommendations and the above linked guidance is not up-to-date and documented, then these features can be taken out of service and access can be restricted at building reopening until maintenance is performed.***

#### 2.2.1.4 SPECIFIC DEVICES

Specific devices that present higher risk of opportunistic pathogen growth due to the construction and function of the plumbing component include:

1. Water storage tanks (e.g., storage water heaters and hot water storage tanks) **(See Section 5.1)**
2. Pressure tanks/expansion tanks **(See Section 5.2)**
3. Water softeners **(See Section 5.4)**
4. Showerheads **(See Section 5.5)**
5. Hot water tempering devices (mixing valves) **(See Section 5.7)**
6. Safety features and outlets that create dead legs (e.g., eye wash station, safety showers) **(See Section 5.8)**

***Routine flushing during periods of stagnation to simulate normal water use can reduce the effect of low building occupancy. Following prolonged stagnation periods, cleaning, descaling, and disinfecting (if applicable) may be necessary prior to returning devices to services.*** Additional specific recommendations for these items are in **Section 3** and **Section 5**.

#### 2.2.1.5 OPERATIONAL SETTINGS

How the building water system operates is an important element to manage risks associated with opportunistic pathogens. Hot water systems should reach high enough temperatures to manage opportunistic pathogen growth and deliver hot water to points of use. Similarly, if water reaching points of use has disinfectant levels similar to that entering the building, then the water has likely not sat stagnant long enough for water quality to deteriorate. Each building manager can assess the impact of building water system stagnation on each building's water quality:

1. Measure cold water supply disinfectant residual and temperature at the point of entry to the building after flushing water until temperature stabilizes.

   Disinfectant residual level and temperature at the point of entry should be representative of what is expected to be delivered by the water supplier **(See Section 3.4)**. If it is not, point of entry flushing should be conducted **(See Section 2.3.2)**.

2. Measure cold water disinfectant residuals and temperatures at point of use outlets throughout the building (e.g., faucets, showerheads) after flushing until water temperature has stabilized.

   Disinfectant residuals that are detectable and ideally approach levels measured at the building point of entry demonstrate fresh water is reaching the outlet. If disinfectant residuals levels are not similar to those in water provided by the water supplier, flushing of primary

water pipes, out of use outlets, and/or specific devices can improve water quality **(See Sections 2.3.3–2.3.7)**.

3. Measure hot water temperature in the water heater prior to any centralized mixing.

   Tank-type water heaters should be set to >140°F for heaters with storage capacity and >131°F for instantaneous or on-demand water heaters. Producing hot water >131°F increases the risk of scalding for some users and scaling of hot water components for systems served by hot water without softening.

4. Measure the time it takes for hot water temperature to stabilize at hot water outlets throughout each service area in the building and the temperature at which it stabilizes.

   Water temperature is expected to stabilize quickly (~1 minute for most systems) to similar temperatures throughout the building and not fluctuate dramatically during flushing (i.e., should steadily increase to steady hot temperature). Recommendations for hot water temperature delivered to point of use outlets range from >120 °F to >131 °F. Maintaining temperatures >131 °F provides greatest risk management for *Legionella* but may require greater intervention to prevent scalding. Scald reduction methods are required by plumbing or health codes. Tempering of water temperatures (i.e., mixing hot and cold water to a desired temperature) may pose an additional risk for opportunistic pathogen growth, and this risk may increase as the volume of water held within the plumbing after the point of tempering increases **(See Section 5.7)**.

***Engineering, design, and/or operation adjustments to the cold and hot water systems may be necessary to achieve the recommended operational settings.*** If hot water criteria are not met, the hot water system may require mechanical/engineering interventions.

## 2.3 Flushing Approaches to Address Stagnation

Flushing actions are organized within a building water flushing plan. Plans can be developed by building managers and other appropriate personnel **(See Section 3.1)**. Effective plans contain specific, measurable criteria to be met during flushing. Flushing begins at the building service line and works systematically through the building systems to avoid introducing or moving contaminants from one location to another (Figure 3).

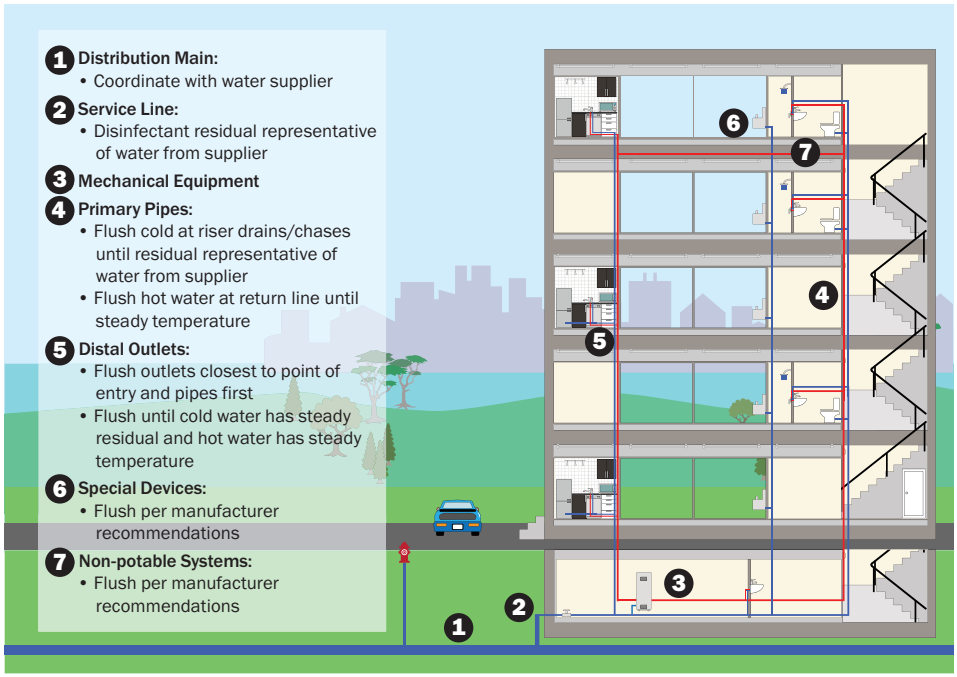



**Figure 3.** *Flushing proceeds from the service line toward locations farther from the point of entry (from #1 to #7)*

This section provides a general approach for flushing and disinfection actions. The success of flushing procedures is likely dependent upon meeting the recommended operational settings with respect to cold water residual disinfectants and hot water temperatures **(See Section 2.2.1.5)**. If these are not met, the following flushing practices are modified and repeated until performance objectives are reached.

### 2.3.1 WATER SUPPLIER DISTRIBUTION MAINS

Distribution mains may be flushed by the water supplier via hydrants for several reasons, including to refresh the water provided to customers. This task is undertaken by the water supplier or in close consultation with the water supplier if hydrants are located on private property. Distribution system

flushing to renew water quality does not reach scouring velocities, but sediment is released through hydrants and while it is in suspension can be drawn into building water systems. Distribution system main flushing can also cause a water pressure drop sufficient to trigger automated alarms on building water systems.

***Building managers that observe low disinfectant residuals in water supplied to them, can obtain information about disinfectant residual levels and anticipated distribution system flushing activities from their water supplier (See Section 3.4).***

## 2.3.2 POINT OF ENTRY SERVICE LINE(S)

General information about point of entry services line flushing:

1. Some buildings have multiple water service lines that supply potable water and/or parallel/back up piping that all need to be flushed.
2. Point of entry devices (e.g., strainers, backflow preventers) are a good place to conduct service line flushing, as they can usually accommodate a hose attachment and achieve high flow rates (NOTE: Do not place the hose into a drain. Maintain an air gap or use a hose with a vacuum breaker to avoid creating a cross connection. Use a hose dedicated for use with potable water. Always disconnect the hose after flushing).
3. Water discoloration may occur due to flushing at high flow rates. If discoloration appears, flush until the water runs clear.
4. Point of entry service line flushing can be automated using a solenoid valve and timer. Consult a plumbing design engineer to find an appropriate location for this and a plumber for installation if this is a desired approach.

**Partially Occupied Buildings.** Partially occupied buildings, buildings with high amounts of water use for heating, ventilation, and air conditioning (HVAC) or other purposes, or buildings that are conducting routine flushing practices may have enough water use in the building to draw in fresh water from the water supplier. Therefore, the service line(s) may not require flushing. Test water entering the building periodically to confirm fresh water is being delivered:

1. Flush cold water at an outlet nearest the point of entry until water temperature stabilizes.
2. Measure disinfectant residual concentration after the system temperature has stabilized.

***Disinfectant residual entering the building should be representative of what is delivered by the water supplier (See Section 3.4). If it is not, point of entry remedial flushing (immediately below) may improve the residual level.***

**Remedial Point of Entry Flushing.** Remedial flushing replaces the water in the service line with water from the water supplier:

1. Open an outlet near where the service line enters the building with the highest available flow rate, adequate drain capacity, and controllability. Flush until the water runs clear.
2. Adjust the outlet to a moderate flow rate, and flush until fresh water from the water supplier is reached **(See Section 3.4)**. Three ways to determine fresh water from the water supplier is entering the building include:
    - Measure the disinfectant residual while flushing. When the observed residual is approximately equal to the disinfectant residual expected from the water supplier, stop flushing.
    - Measure water temperature while flushing. When the water temperature is not changing and is approximately equal to the temperature expected coming from the water supplier, stop flushing. In some geographical locations where water temperature is close to ambient air temperature, this method may be difficult or impossible to apply.
    - Calculate the time of flushing needed to replace the volume of water stored in the service line(s).[8] Consider flushing several times this amount of time to ensure complete replacement of water in the pipes. See **Section 5.13** for more resources.

***Contact the water supplier for information about distribution system residual levels and steps that can be taken to improve disinfectant levels reaching the building if disinfectant residuals are not similar to expected residual levels after flushing (See Section 3.4).***

*8 Volume of a pipe in gallons is calculated using the following formula, V = (π(d/2)2h) x 7.48, where V= volume, π = 3.14, d = inside diameter of pipe (in feet), and h = length of pipe (in feet). Measure the flow rate achieved during flushing. Flow rate can be determined with a stopwatch by timing how long it takes to fill a bottle (in minutes) of a known volume (in gallons). Flow rate (in gallons/minute) is the volume (gallons) divided by the time (minutes). Theoretical flushing time required (in minutes) = Volume of service line (in gallons) / Flow rate of flushing (in gallons/min)*

## 2.3.3 MECHANICAL EQUIPMENT AND DEVICES

Individual components and equipment should be checked for physical integrity, general function, and that maintenance activities are up to date. If maintenance is out of date, or a specific issue is identified, equipment should be maintained according to manufacturer instructions. Equipment to consider include:

1. Backflow preventers **(See Section 5.11)**
2. In-line filtration including strainers **(See Section 5.9)**
3. Pressure/expansion tanks **(See Section 5.2)**
4. Water treatment devices including softeners **(See Section 5.4)**
5. Boilers, hot water tanks, and other in-line water heating devices **(See Section 5.1)**
6. Hot water recirculation pumps and balancing valves **(See Section 5.12)**
7. Other specialty equipment, if applicable

## 2.3.4 PRIMARY COLD AND HOT WATER PIPES

Most building water systems have a limited number of larger water pipes that deliver water to smaller diameter piping throughout the building. Flushing these larger pipes, if possible, will speed up delivery of fresh water to point of use outlets. This step may not be necessary in smaller buildings or buildings without complex water systems. Some general notes about flushing primary water pipes:

1. Flushing is conducted for both cold and hot piping through the building

   Disinfectant residual and water temperature can be used as indicators that flushing has successfully brought fresh water to the cold piping. Hot water temperatures should stabilize at recommended settings to manage opportunistic pathogen growth **(See Section 2.2.1.5)**. Water temperature should gradually increase to the maximum hot water temperature. Fluctuating hot water temperature during flushing may be indicative of a cross-connection with the cold water system, issues with hot water system balancing, or dead-leg pipe segments **(See Section 5.12)**.

2. Flushing begins at outlets near where water enters the building and continues from there through the building. Flushing continues to the points in the primary water pipes farthest from the point of entry. If the building has hot water recirculation, hot water flushing should occur near the point of hot water return.
3. Flushing can be conducted at riser drains or services sink outlets to achieve high flows during flushing activities. If these locations are not available, multiple outlets in each service area can be flushed simultaneously to speed up the point of use outlet flushing process.
4. Flushing of pipes can be automated using solenoid valves and timers. Consult a plumbing design engineer to find appropriate locations for these and a plumber for installation if this is a desired approach.

## 2.3.5 POINT OF USE OUTLETS

**Routine Flushing in Partially Occupied Buildings or Buildings that Conduct Routine Flushing.** The amount of routine flushing required will depend on building design and how much water is being used in the building.

1. Buildings with greater occupancy or routine flushing may require shorter flushing durations to achieve target water quality
2. If only a sub-set of outlets are flushed, longer flushing periods may be required to achieve target hot water temperatures and/or cold water disinfectant residuals
3. High risk outlets or outlets in high-risk areas can be flushed more frequently or for longer durations if all outlets cannot be flushed.
4. Maintaining a record of the frequency, duration, order, and water quality achieved during flushing can be used to both ensure reliable execution of the building flushing plan and provide information to improve it.

There is no documented flushing frequency or duration that will be effective for all building water systems for routine flushing of point of use outlets. Consider all unoccupied spaces in developing the flushing plan.

The recommended flushing procedure for outlets without point of use mixing valves includes:

1. Flush the cold water until it is representative of the water entering the building based on disinfectant residual, temperature, or volume flushed (as described for point of entry flushing)
2. Flush hot water until temperatures stabilizes. Hot water temperatures should stabilize at recommended settings to manage opportunistic pathogen growth **(See Section 2.2.1.5)**.

3. Flush the cold water again for 10 seconds to introduce cold water with a residual back to the point of use outlet. Residuals are more stable and opportunistic pathogens are less likely to grow in cold water.

***Where in a building and how often flushing occurs is a building-specific decision. Low-use outlets, high-risk outlets, or outlets in high-risk areas can be prioritized to be flushed more frequently.***

Flush outlets where point of use thermostatic mixing valves are used for at least as long as other outlets to achieve steady hot and cold water temperatures **(See Section 5.7)**.

**Remedial Flushing.** For this one-time flush, it may be beneficial to remove the aerators and showerheads, as these flow restricting devices become colonized with biofilm that can harbor opportunistic pathogens and accumulate particulates that contain metals. Some aerators require special keys to be removed. When aerators and devices are removed, the flow rate through the outlet will be significantly higher. A towel or bag may be necessary to direct the flow to the outlet drain. If existing aerators and showerheads are not replaced, they are cleaned (descaled and disinfected) and rinsed prior to reinstallation **(See Section 5.5)**.

The same process for routine flushing can be used for outlets without thermostatic mixing. More intensive flushing procedures can be considered for outlets with thermostatic mixing by bypassing the mixing valves **(See Section 5.7)**. Not all mixing valves can be bypassed and doing so increases the potential for scalding. Altering the plumbing to facilitate bypassing the valve poses additional challenges as such bypasses create dead ends and are susceptible to contamination.

## 2.3.6 TOILETS/URINALS

There are multiple plumbing approaches for groups of urinals. Installation of water conservation toilets and urinals in the United States is extensive. Consequently, it is not possible to suggest a generalized approach to flushing these devices. If toilet/urinal flushing is conducted after flushing the primary pipes and other point of use outlets, it is more likely that pipe to the individual toilet/urinal outlets are replaced with fresh water.

## 2.3.7 SPECIFIC END-USE DEVICES

There are a number of end-use devices plumbed directly into building water systems that warrant maintenance per manufacturer's instructions prior to returning these devices to use:

1. Ice makers
2. Soda, coffee dispensers / kiosks
3. Eyewash stations and safety showers
4. Point of use filters (within outlets, refrigerators, and drinking water fountains)
5. Misters/foggers (These devices may exist in a variety of settings, including groceries, restaurants, etc.)

If no documentation is provided by the manufacturer, lines supplying these devices should be flushed until representative of cold water entering the building and any filters/strainers cleaned or replaced. Ice makers require cycling several times and discarding ice from these cycles prior to returning ice makers to service.

Building managers may need to coordinate with tenants and tenant's contractors to accomplish this aspect of returning a building's water systems to service after prolonged stagnation. Local and state health codes can also contain applicable requirements for businesses engaged in food preparation and other services.

***Particular attention should be given to maintenance/ replacement of point of use filters installed to reduce lead and copper.***

## 2.3.8 NON-POTABLE WATER SYSTEMS

Non-potable water applications are those not meant for human consumption in buildings. Some of these systems can pose a significant exposure risk. The presence of such equipment is one of the risk factors CDC uses to identify which buildings would most benefit from a building water management program. There have been outbreaks of waterborne disease associated with inadequately maintained non-potable water systems.

After a period of prolonged water stagnation, ensuring that non-potable water systems are ready for use includes:

1. Appropriate cleaning
2. Ensuring any associated treatment systems, including disinfectant systems are operating properly
3. Checked for physical integrity and general function

While this document focuses on the building water system and equipment that may be a route of human exposure to contaminants, buildings may contain other devices that use water. Building managers will want those business units or tenants to be aware of measures being taken to renew water quality in the building and so that they can consider if there may be any implications for their water using equipment.

Systems include but are not limited to:

1. Cooling towers
2. Spas / pools / hot tubs
3. Decorative Fountains
4. Humidifying systems
5. Recycled water (e.g., gray water and rainwater systems)

There may be local or state health codes that contain applicable requirements for these water using devices.

***Buildings also include systems for recycled water, graywater, and wastewater. Under low occupancy conditions, these systems also become stagnant. Building operators will want to bring these systems back into regular working order and may need to evaluate wastewater flow paths prior to initiating flushing of the potable water system.***

## 2.4 Shock Disinfection

Shock disinfection is typically applied when commissioning a new building water supply. It is also common as a direct response to incidence of disease or to microbial sampling results indicating concerning levels of pathogens in the water system (after reviewing and assessing system performance). However, some building managers may consider preventative shock disinfection as part of a building recommissioning procedure when the building has been unoccupied for extended periods based on the operational settings **(See Section 2.2.1.5)** and building-level risk factors present **(See Section 2.2.1)**.

**WARNING**

*Consult drinking water primacy agency. Some states require agency oversight of shock disinfection in buildings.*

Shock disinfection poses risks of its own. There are worker safety considerations, potential impacts on building water system components, and additional need to coordinate with water users in the building.

Building managers who decide that building water system disinfection is necessary, that are not familiar with performing shock disinfection, should contact a water quality consultant or water treatment professional with experience sampling and disinfecting building water systems. Prior to performing shock disinfection, all building backflow protection devices are checked to ensure that they have been inspected as required by the plumbing codes. Shock disinfection should not be performed where backflow protection cannot be verified. If shock chlorination is performed, disinfectant residual samples are collected to confirm the disinfectant is dispersed throughout the building water system (or targeted portion of the building water system). Microbiological validation samples are collected after shock disinfection **(See Section 4)** to evaluate treatment effectiveness in instances where prior presence was documented.

Some situations where disinfection of plumbing systems in response to stagnation may apply include:

1. Reopening buildings that have been completely vacant

Vacant buildings in this context refer to buildings that have had no legal occupancy, rather than low or no occupancy. Disinfecting vacant buildings reflects guidance in ASHRAE 188, in that it would treat a vacant building prior to a return to legal occupancy the same way one might commission new construction or major building renovations where there are known susceptible populations.

2. Buildings that have had prolonged stagnation caused by low or no occupancy

Periods of a few weeks of low or no occupants are common in buildings (e.g., winter holidays, summer vacation). In these instances, building managers can use their prior experience and consider the risk factors identified when developing their responses. Some facilities have start-up procedures that include flushing potable water systems (e.g., seasonal systems, schools, universities).

For buildings with risk factors or concentrations of at-risk occupants, preventative shock chlorination may be appropriate after longer periods of stagnation. As noted previously, ASHRAE 188 calls for considering such steps after four weeks has elapsed in the absence of other preventative interventions for new buildings. The operational settings of the building can also factor into the decision to implement preventative shock disinfection **(See Section 2.2.1.5)** and building-level risk factors present **(See Section 2.2.1)**.

Specifics of how to perform disinfection are beyond the scope of this document. Additional resources for performing shock chlorination of building plumbing can be found on Washington Department of Public Health Webpage and in *Legionella* Risk Management, Inc. protocol. Note, the Washington Department of Public Health protocol only includes disinfection by free chlorine; the *Legionella* Risk Management, Inc. protocol includes information on free chlorine and chlorine dioxide; other disinfectants may be appropriate for some situations.

# 3 Developing a Flushing Plan

While building managers may not have the time and resources to undertake developing a complete building water management program immediately, initiating steps to address building water quality begins with assessing the situation and developing a flushing plan. Additional information and assistance may be required to make final decisions about what is best for individual buildings. In addition to guidance from CDC and US EPA, there is guidance available from several state agencies and some individual communities. Building managers can seek additional help from applicable regulatory bodies, local and state public health departments, and subject matter experts.

## 3.1 Engage the Right People

Working with individuals from within their building is important for building managers assessing risks and determining appropriate responses that are feasible with available resources and site-specific constraints. Individuals with relevant knowledge include:

1. Facilities/maintenance managers and staff (with engineering or water systems experience)
2. Custodial managers and staff
3. External contractors and/or consultants that support building staff (e.g., mechanical systems contractors, professional plumbers, consulting engineers)

   There are consultants that specialize in building water management program development and execution as well as environmental monitoring. Such consultants can be a useful resource for building managers who are seeking assistance developing a plan, want a professional with relevant expertise to review an initial planning effort, or need a guide to potential regulatory requirements. There is not a ready listing of reputable consultants with relevant expertise.
4. Authorities with jurisdiction over various aspects of building operations (e.g., environmental health and safety officers, code enforcement officials)

## 3.2 Steps in Developing a Flushing Plan

Developing a flushing plan requires:

1. Understanding the building water system(s)
2. Recognizing which portions of the building have little or no water use and what components of the building water system are most affected by that lack of use
3. Selecting an approach to refreshing the water where it is stagnant while taking precautions to not harm building water systems components or other end use devices

A building water system inventory documents the plumbing components relevant to preparing a flushing plan. Starting with a clear understanding of the building water systems components expedites developing an effective flushing plan.

1. Identify and locate
   - All water service lines from the water supply to a building point of entry
   - Water storage tanks (e.g., water heaters, water softeners, pressure tanks)
   - Mechanical equipment supplied by potable water
   - Devices in building water system (e.g., backflow preventers, filters, disinfection systems, softeners, etc.)
2. Review potable water plumbing design with maintenance and management personnel. Consult as-built drawings if available. If as-built drawings are not available, then construction drawings may be used as substitutes, recognizing that they are less accurate than as-built drawings.
   - Identify cold and hot water supply pipes (risers) and manifolds (headers)
   - Identify outlets furthest away from the point of entry (the longest plumbing run)
   - Separate outlets into different service “zones,” (e.g., systems, risers, floors) organized by proximity to the source(s) of water supply to that zone
   - Locate outlets at which plumbing can be flushed efficiently (e.g., service sinks, riser drains, hot water return pipes, industrial kitchen faucets)
   - Identify discharge points for flushed water capable of accepting anticipated flows without creating a backflow or flooding hazard
   - Reconcile available drawings with staff knowledge and experience

3. Identify and locate specialty devices plumbed into the building water system (e.g., ice/coffee/soda machines, drinking fountains, dishwashers, eye-wash stations, safety showers, medical equipment, salon chairs, or other devices serviced by potable water), organized by zone
4. Identify and locate non-potable water systems
    - Equipment (e.g., cooling towers, closed loops, boilers)
    - Water features (sprinklers, swimming pools, spas, hot tubs, decorative fountains)
    - Irrigation systems
    - Alternate water source systems including storage tanks, piping, and outlets served by these systems (e.g., potable and non-potable rainwater catchment, on-site treated non-potable water systems).
5. Assess water quality **(See Section 2.2.1.5)** to determine if and where flushing activities are needed. Using the information organized about the building water systems, it is possible to identify outlets and organize their use for flushing strategy being planned **(See Sections 1.3 and 2.3)** and identify key valves and protocols to protect building water system components
6. Establish protocols to prevent
    - Water hammer (e.g., slowly opening and closing valves during flushing activities)
    - Backsiphonage
    - Flooding
7. Identify monitoring locations to confirm flushing achieves target water quality

## 3.3 Manage Risk to Workers

The steps in **Section 3.2** address the fundamental aspects of the flushing plan. Flushing activities have several related considerations, including managing potential health risks to workers and building occupants during flushing:

1. Exposure to high water temperatures (scald risk); outlets with water >130 °F pose a risk for scalding
2. Exposure to aerosols generated during flushing activities (inhalation risk); outlets that generate the most aerosols (e.g., showerheads, sprayer attachments) and outlets that have low flow or tempered water <120 °F (e.g., outlets with low flow aerators, point of use thermostatic mixing valves) pose the highest risk for exposure to opportunistic pathogens
3. Risk of electrocution; releasing large volumes of water within a building in spaces that also have electrical wiring poses the risk of electric shock
4. Risks associated with confined space entry
5. Exposure to metals (ingestion risk); outlets that are used for drinking and food preparation have the highest potential for exposure to metal.

To the extent that flushing can occur when the building is not occupied, there is less potential for the above exposures for building occupants. The following are measures that can be taken to manage risks to workers.

### 3.3.1 ENGINEERING CONTROLS

While engineering controls will not eliminate risks, they can be used to reduce risks. A specific concern is worker exposure to aerosols that may contain opportunistic pathogens like *Legionella*. This is especially a concern

during flushing in enclosed spaces with inadequate ventilation. Controls include:

1. Fill water drain and vent systems with water by slowly pouring water down the drain of all outlets and floor drains prior to increasing ventilation
2. Increase HVAC system outdoor air make-up during major flushing activities (NOTE: fill drain traps first)
3. Turn on vent fans, close windows and eliminate the use of other devices that might stir up air (NOTE: fill drain traps first)
4. Remove aerators, showerheads, and other sprayer devices that create aerosols during flushing activities (NOTE: if removed, they need to be cleaned, rinsed, and replaced after flushing. Special tools are required to remove some aerators. **(See Section 5.6)**
5. Take steps to reduce aerosol generation during flushing activities appropriate to the outlet while maintaining flushing flow rates. Measures used should not create backflow hazards. Use of dedicated equipment and adequate cleaning between uses reduces potential for inadvertent contamination of outlets.

### 3.3.2 ADMINISTRATIVE CONTROLS

Building managers must adhere to state and federal worker safety regulations. It is important to:

1. Inform workers of potential health risks
2. Describe how workers may be exposed to those risks during flushing activities, including advising workers not to drink the water from their flushing activities.
3. Encourage workers to discuss their personal risk factors and if they should engage in flushing related tasks with a medical professional prior to engaging in this activity
4. Provide relevant training (e.g., personal protective equipment (PPE), practices to reduce exposure, etc.) **(See Section 3.3)**

Reviewing safety procedures periodically with workers is a useful strategy to assess exposures and revise procedures to reduce risks, as necessary. "After action" debriefings can be used to collect information to improve the safety and efficiency of flushing procedures.

### 3.3.3 APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT

In addition to any building or business-specific PPE requirements and situation-specific PPE (e.g., COVID-related guidance), building managers must determine what additional personal protective equipment is necessary for tasks described here. The activities described include working within enclosed spaces, working with very hot water, and generation of aerosols that may pose a health risk. Relevant PPE may include:

1. Safety glasses
2. Gloves (e.g., when scald or burn risks are present)
3. N-95 respirators with appropriate medical clearance, fit-testing, and training. Personal Protective Equipment (PPE) (29 CFR 1910.132) and Respiratory Protection (29 CFR 1910.134) standards apply. There may be additional local requirements that can be identified by OSHA or health and safety officers.
4. Alternative water supply (workers should not consume water that is being flushed).

Training is important to ensuring proper use of PPE.

## 3.4 Know Your Water Supply

Review consumer confidence reports, visit your water supplier's webpage, or contact your water supplier to determine the following information:

1. The type of disinfectant residual (free chlorine or chloramine) and level (ppm or mg/L) in water distributed by the water supplier. This determines what type of residual to measure if residual monitoring is conducted.

   National survey data indicates water from the water supplier will typically have free chlorine levels between 0.5 and 1 mg/L depending on the building location. In communities where disinfectant residuals are chloramines, levels typically range from 1 to 2 mg/L but may be lower. Both free and total chlorine residual levels may be as high as 4 mg/L; there is a regulatory limit on how much chlorine residual is allowed. Free chlorine and chloramine residuals of 0.2 mg/L or less may be observed in some locations.
2. If there are planned changes in residual disinfectant levels or type. Some water suppliers that maintain a chloramine residual change to free chlorine for part of the year or in response to distribution system water quality conditions. During these times, the building manager would need to measure free chlorine instead of total chlorine and would expect the concentration of residual present to change. ***Contact your water supplier to understand what steps are taken to inform affected customers when this type of change is made.***

3. When and where there are water supplier distribution system flushing activities. Distribution system flushing in the vicinity of the building will impact water quality reaching the building. Flushing is used to refresh water reaching buildings improving water quality. ***Contact your water supplier to understand what steps are taken to inform affected customers when these activities are planned or underway.***
4. If there is difficulty establishing disinfectant residual at the point of entry, determine if the water supplier can provide assistance.

***Stay informed regarding boil water orders, do not use orders, and other notifications from the water supplier regarding water quality.***

## 3.5 Get the Right Tools

1. Acceptable method to measure residual disinfectants

When measuring disinfectant residuals, it is necessary to measure free chlorine for buildings supplied with water with a free chlorine residual and total chlorine for buildings supplied with chloramine residual. US EPA-accepted field test methods are colorimetric-based using N,N-diethyl-p-phenylenediamine (DPD) reagents. Digital meters are available that provide rapid and consistent analytical results. ***Carefully review manufacturer's directions with staff responsible for disinfectant residual testing.***

***Test strips for chlorine residual are not sufficiently accurate for the tasks described in this document at chlorine (free or total) concentrations found in drinking water.***

2. Rapid response digital thermometer

   Rapid response thermometers are useful for accurately documenting the time of flushing required to achieve target water temperatures.

# 4 Considerations for Testing

Collecting samples to assess contamination beyond what is required by local ordinances, state regulations, and federal requirements is generally limited to specific circumstances. Health care facilities for instance will want to follow their water management program protocols and associated testing. There are also federal and state requirements for returning seasonal water systems back to service. Additional sampling should be appropriate to the concern as detailed immediately below.

## 4.1 Testing for Metals

### 4.1.1 LEAD

Sampling for lead typically focuses on outlets that are a source of water for drinking or cooking. It is beneficial to test for lead at outlets used for consumption (drinking, cooking, making baby formula). This can be conducted after any regular or remedial flushing occurs, or after replacing filters certified to remove lead to confirm lead levels are low prior to resuming use. Samples collected should include the first volume of water that exits the outlet after at least 8 hours of stagnation. The USEPA "3T's for Reducing Lead in Schools" describes specific sampling protocols in school buildings for lead in drinking water.

Neither CDC nor USEPA recognize a "safe" level of lead. The goal is always to reduce lead levels as much as possible over time. US EPA does not have guidance as to what level of lead in building water plumbing warrants further remediation. Health Canada has set an at-the-tap guidance of 5 µg/L based on feasibility.

### 4.1.2 COPPER

There are no evidenced based recommendations for a sampling protocol for copper developed for this situation. General practice is to analyze for copper as well as lead when sampling for lead. In general, copper levels can decrease after flushing if the contaminated water is replaced with fresh water from the water supplier but may not remain low after flushing is ceased. Confirming copper levels are low at outlets used for consumption (drinking, cooking) can be beneficial. The lowest US EPA provided health-based level of concern for copper in drinking water is 1.3 mg/L, but there is a 1.0 mg/L level based on aesthetic effects of copper. Health Canada has set an at-the-tap health-based limit of 2.0 mg/L.

## 4.2 Testing for Microbial Contaminants

Building managers without experience collecting microbial samples should seek additional information from regulatory authorities, public health department, or subject matter experts. These individuals can help them determine if monitoring is recommended and which pathogens or indicators to monitor, how to design appropriate sampling procedures to assess risk, and how to interpret and respond to the results. The rest of this section provides some general information regarding sampling potable water systems for microbial pathogens.

Testing for microbes can play a valuable role within a water management program framework. If a water management program is not in place, compelling reasons to collect samples for microbial analysis include:

1. If a building is potentially associated with an incidence of disease (e.g., an outbreak),
2. Significant issues with function of the building water system or other mechanical system where water is used are identified **(See Section 2.3.3)**, or
3. To confirm interventions were successful (i.e., testing after implementing preventative or remedial actions) particularly for systems with centralized hot water systems and/or a concentration of showers (e.g., apartment buildings, commercial gyms and dorms).

### 4.2.1 SELECTING MICROBES TO MONITOR

#### 4.2.1.1 FECAL INDICATORS

***Total coliform, E. coli, and coliphages are not useful indicators when evaluating the impact of stagnation on water quality.*** Testing for *Escherichia coli* and total coliforms is routinely used to evaluate drinking water supplies. While some *E. coli* serotypes, like *E. coli* O157:H7 are pathogenic, standard analytical methods used for water quality monitoring do not select for pathogenic organisms. *E. coli* and total coliform are appropriate for evaluating if a community's water source is contaminated (primarily by fecal contamination), there has been a breakdown in drinking water treatment, or if there is a source of contamination in a water supplier's distribution system. There are a number of approved analytical methods. Coliphages are also used to evaluate potable water supplies. Application of coliphage monitoring in building water systems are much the same as one would use *E. coli* and

total coliform. Sample procedures are described in US EPA's Quick Guide to Drinking Water Sample Collection.

Within buildings these indicators can serve a similar function, indicating external contamination (e.g., a cross-connection or a problem with a building's well). When used for these purposes sampling systems and analytical capacity are robust and inexpensive.

#### 4.2.1.2 HETEROTROPHS

Heterotrophic plate counts (HPCs) are a well-established analytical method that is fully described in Standard Methods For the Examination of Water and Wastewater and other standardized analytical method texts, and a useful diagnostic tool. Sample procedures are described in US EPA's Quick Guide to Drinking Water Sample Collection.

HPC is used as an indicator of microbial activity. There is no defined acceptable maximum level of HPCs in potable water systems in buildings, but HPCs can be used to better understand conditions in a building water system. HPCs can be useful assessing if there are issues with recirculation and/or delivery of disinfectant under normal operating conditions. HPCs are not correlated with the occurrence of *Legionella*, Mycobacteria avium, or incidence of associated disease. Some opportunistic pathogens grow and may be isolated from HPC culture media, but associations between these pathogens and high levels of HPCs are highly variable. ***Thus, while HPCs may be useful as a diagnostic tool, HPCs are not a useful indicator for health risks.***

#### 4.2.1.3 OPPORTUNISTIC PATHOGENS

Opportunistic pathogens exist in potable water supplies at levels that are unlikely to cause disease. How to react to positive samples is not well defined for all opportunistic pathogens without a baseline understanding of the occurrence of these pathogens and associated disease in a given community, or in this context, an individual building. Developing such an understanding for individual buildings is a component of developing a building water management program and is beyond the scope of this document.

Neither Centers for Medicare and Medicaid Services nor ASHRAE describe testing opportunistic pathogens in water beyond *Legionella*.

Culture-based methods are the gold standard for assessing risk for many pathogens. CDC has described a culture-based analytical method for understanding levels of *Legionella* in water samples. CDC also distributed guidance for sampling for *Legionella* in the context of an outbreak investigation. For Legionnaires' disease outbreak investigations, a laboratory that meets CDC's ELITE certification for proficiency in culturing *Legionella* should be used. There are also laboratories accredited through TNI for analyzing *Legionella* samples using CDC, international standard, or other culture-based methods that are appropriate for routine monitoring of *Legionella*. When choosing a lab, ensure that the lab is accredited to perform *Legionella* analyses and that the method of testing for *Legionella* is included in the laboratory's scope of accreditation.

Molecular methods can be used to screen samples prior to culture. Molecular methods can be used to obtain test results more quickly than culture-based methods, which may be helpful in validating effectiveness of control measures. However, many molecular methods do not detect the pathogens to the species level. Since most recognized Legionnaires' disease is caused by *Legionella* pneumophila, particularly serogroup 1, this lack of specificity can complicate interpretation. Molecular methods that only identify the genus or family levels should not be used for risk assessment.

### 4.2.2 DESIGNING A MICROBIAL CONTAMINANT SAMPLING PLAN

By measuring water temperature and residual disinfectant level at the same time as microbial sampling, building managers can inform interpretation of microbial occurrence data. For example, temperature and residual can be measured in the first volume of water that exit hot and cold outlets and after steady water temperature is reached. The levels water temperature and residual can be compared to the desired levels described in **Section 2.2.1.5**.

When planning to sample for microbial indicators or frank pathogens, building managers will want to consider:

1. What question(s) are they hoping to resolve through the planned sampling?

2. Does their team have sufficient expertise to:
    a. Select what to sample
    b. Select where to sample
    c. Select how many samples to take
    d. Select when to take samples
    e. Maintain adequate hygiene during sampling
    f. Select additional data to help interpret the microbial occurrence data
    g. Determine what actions to take while waiting on sample results
    h. Assess the quality of the data obtained
    i. Interpret the results
    j. Respond to results
3. What are appropriate response actions? Available guidance for building managers for *Legionella* includes ESGLI's European Technical Guidelines for the Prevention, Control and Investigation, of Infections Caused by *Legionella* species and ASHRAE guideline 12
4. What communications will be necessary and how will outreach be accomplished upon receipt of results **(See Section 4.2.3)**?

Depending on the design and complexity of the building water system and the building manager's resources, the number and type of samples used to answer the questions at hand will vary. Factors that influence data quality and resource allocation include:

1. Adhering to appropriate sampling protocols
    a. Including, ensuring sampling is preceded by stagnant conditions
    b. Using hygienic sampling protocols
2. Prioritizing sampling locations based on the purpose of the sampling effort
    a. Focus on high exposure risk outlets and areas within the building
    b. Targeting more critical to manage components of the building like hot water systems
3. Reserving more complicated sampling protocols such as biofilm swabs from inside of water building outlets or components to events like responses to actual cases of disease potentially related to building water systems

### 4.2.3 COMMUNICATING RESULTS

Building managers will want to be prepared to respond to observations of opportunistic pathogens before collecting samples. Preparation should include:

1. Communication tools for the following audiences describing the results of the testing, the risks present, and steps the building is taking to reduce those risks, and steps message recipients can take to minimize their risk
    a. building staff
    b. current occupants
    c. building users that have not yet returned
2. Communication protocol for when and how to share test results with
    a. regulatory agencies
    b. public health agencies

# 5 Information about Specific Devices

## 5.1 Water Heater Tanks

**Flushing water heater tanks** involves flushing the heater at the water heater drain valve until the volume of the tank has been replaced and the water runs clear. The time required can be calculated as follows:

*Theoretical Flush time required (minutes) = Volume of tank (gallons)/Flow rate of flushing (gallons/minute)*

Due to non-ideal flow, and inaccuracies in volume estimation and flow rate measured, it is advisable to flush two or more times the volume of the system. Flushing to replace the water in the tank can be done on a regular basis and can be automated.

Fully draining the tank to remove sediment is a different and more complicated form of cleaning that is difficult to carry out in many commercial/industrial water heaters. Draining the tank involves turning off the unit (gas or electric), shutting off the fresh water supply and draining the tank via the drain valve through a hose to an available drain (repeat if needed to remove accumulated sediment), and then returning the tank to service. Fully draining a heater tank may be recommended if recommissioning a building that has been unoccupied but is not commonly done in response to stagnation.

## 5.2 Pressure Tanks

Pressure tanks can act as very low flow water storage tanks. Sediment and biofilm can accumulate and degrade water quality. Pressure tanks may be in potable water systems, heating systems, and other mechanical systems. This guide focuses on maintaining those expansion tanks that are part of a water system containing water to which people might be exposed. There are several tank designs. Consult manufacturer recommendations for how expansion tanks should be drained and returned to service.

If the manufacturer does not have information on how to clear debris or sediment, contact the manufacturer for instructions.

## 5.3 Emergency Water Storage

Following the September 11, 2001 attack on the World Trade Center and August 2006 Hurricane Katrina, emergency planning for businesses and institutions has increasingly included storage for several days of water supply on-site in the event of a water service disruption. This practice can lead to a substantial volume of water that could be becoming stagnant under normal water usage. If such storage exists and it is an element of the regular potable water supply, building managers will have to take it into account when developing their responses to prolonged periods of stagnation.

## 5.4 Water Softeners

Softeners can prevent failures in hot water systems by removing minerals that precipitate in hot water tanks, pipes, and other devices. However, water softener design and operation can lead to stagnant water in contact with media which in turn can support biofilm growth. This biofilm may contribute to lower disinfectant residual and it can harbor opportunistic pathogens.

Maintain softeners according to manufacturer instructions which could include cleaning and/or disinfecting brine tanks and resin after prolonged stagnation. The cleaning process includes cleaning solutions used to remove scale, biofilm, and debris from the softener prior to returning softeners to service.

A routine check on water softener risk can be conducted. This involves measuring the chlorine residual at the inlet and outlet of each column or system. If the disinfectant residual decreases significantly from the inlet to the outlet, investigate why. There are no rules of thumb on how much a decrease is “significant.” A decrease of 10% is expected, and a loss of more than 25% can be used as a starting point as a cause for concern. If there is disinfectant residual at the inlet, a residual should be present at the outlet.

## 5.5 Showers

Showers have been shown to be a source exposure to *Legionella* in outbreaks of Legionnaire's disease. Showers that have not been regularly used and develop biofilm containing *Legionella* can distribute inhalable aerosols containing high levels of those bacteria.

When showers are not in regular use, routine flushing can prevent the development of problematic conditions:

1. Flush the cold water if cold-only flow is possible until it is representative of the water entering the building based on disinfectant residual, temperature, or volume flushed
2. Flush hot water until temperatures stabilizes (NOTE: Scald risk may exist depending on the water heater temperature setting)
3. Flush the cold water again until the water is as cold as the end of step 1

Try to minimize spray and splash when showers are flushed, particularly during the first several seconds of use.

Showers are often equipped with mixing valves. Mixing valves can either be located at each shower or at a central location upstream providing tempered water to a group of showers. If the mixing valve cannot be adjusted to provide only hot water, it can be adjusted for maximum temperature to conduct flushing.

**Remedial flushing** of showers involves removing the showerhead, flushing in the same manner as routine flushing with the shower head removed. When showerheads are removed, they should be descaled, disinfected, rinsed, and reinstalled (or replaced) after flushing.

## 5.6 Aerators, Showerheads, and Other Outlets—Descaling and Disinfecting

***Choose cleaning solutions and disinfectants that are compatible with the materials used in an outlet and its external finish.*** Commercial cleaning and descaling products are available and may also include a disinfectant. Vinegar (5–8% acetic acid) solutions can be effective removing mineral deposits. Typically descaling requires soaking the outlet in solution, agitating with a scrubbing brush that can reach interior and exterior portions of the outlet, and thoroughly rinsing with fresh water.

If disinfecting the outlet, disinfection occurs after descaling. A dilute bleach solution (1 teaspoon of 5.25% unscented household sodium hypochlorite per gallon of water) can be used but may damage some materials.

## 5.7 Mixing Valves

Mixing valves are devices that deliver a mix of hot and cold water to outlets to prevent scalding, provide consistent temperatures, and/or hands-free operation (e.g., electronic or metered faucets). Mixing valves reduce thermal and chemical controls after the point of mixing, creating conditions that are more favorable to opportunistic pathogen growth than un-tempered hot or cold water. The risk management challenge associated with mixing valves is the volume of water downstream of the point of mixing. The potential for health risks increase as the volume of tempered water increases and as the complexity of the mixing device increases. For systems with numerous risk factors, replacing these devices might be warranted if they are installed in low-use or high-risk areas per recommended practice at health care facilities.

Point of use mixing valves serving one or several outlets should be differentiated from master mixing valves (Figure 4), which are centrally installed on hot water systems to temper water from water heater or hot water storage tank prior to distribution or recirculation. Master mixing valves are unlikely to pose an increased risk of opportunistic pathogen growth if operated at high enough temperatures (i.e., >131 F for greatest reduction in risk). They can decrease peak energy demand for water heating and introduce cold water with a disinfectant residual into the distributed

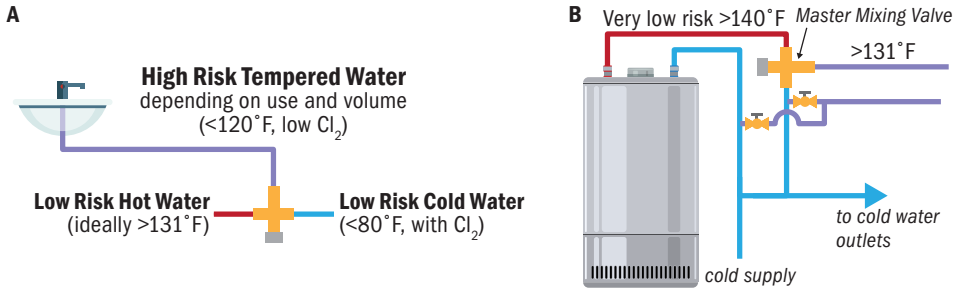



**Figure 4.** *A) Local mixing valves supplying tempered water (<120 °F) to multiple outlets B) Centrally located master mixing valves used to temper hot water from very high temperatures in the water heater or hot water storage tank to temperatures that are safe to distribute. A mechanical master mixing valve is displayed; electronic master mixing valves are also available and more accurately control distributed hot water temperature.*

hot water. Master mixing valves can be mechanical or electronic. Electronic master mixing valves generally control the temperature to a more narrower set point (+/− ~1°F) than mechanical mixing valves (+/− ~7°F).

**During routine flushing,** devices are flushed for at least as long as is required at other outlets in the building to achieve steady hot and cold water temperatures. Consider flushing longer due to the lower flow rate associated with some of these outlets.

**During remedial flushing** use the same procedure as routine flushing with the aerator removed. If the aerator is removed, it should be descaled and sanitized using the same procedures as showerheads in **Section 5.6**. Not all mixing valves can be bypassed. Altering the plumbing to facilitate bypassing the valve can create dead ends that are susceptible to contamination and is typically counter-productive. If possible and desired, the recommended procedure includes:

1. Bypass the mixing valve
2. Flush the cold water until it is representative of the water entering the building based on disinfectant residual, temperature, or volume flushed
3. Flush hot water until temperatures stabilizes
4. Reset the valve and set the temperature while flushing
5. Flush the cold water again until the water is as cold as the end of step 2

**Routine maintenance** of mixing valves is very important. While out of the scope of this document, mixing valves should be tested regularly based on the valve's performance. When mixing valves fail, they can create a cross-connection between the hot and cold water. There is information regarding the safe use of thermostatic mixing values in ASHRAE Guideline 12 and the UK guidelines for managing *Legionella*, which includes a recommendation that the valves be accessible for inspection, testing, and maintenance.

## 5.8 Safety Features that Create Dead-ends

Regular maintenance of safety features (e.g., eye-wash stations, safety showeres, fire suppression) is matter of compliance with OSHA requirements. Maintaining logs of maintenance is required per 29 CFR 1910.151(c). Maintenance logs document regulatory compliance and provide a resource for preparing the building flushing plan.

Building managers should also be aware of the consensus standard ANSI/ISEA Z358.1-2014 for the design and operation of emergency eyewashes and showers.

## 5.9 Strainers

Remove strainers, clear debris and clean or replace during remedial flushing activities.

## 5.10 Filters

Maintain according to manufacturer protocols. If performing remedial actions, consider replacing the filters after the action is performed. High amounts of flushing and building disinfection may release sediments that can accumulate on filters. Point of use filters should be replaced after prolonged stagnation events.

## 5.11 Backflow Preventers

Backflow preventers may be present to protect the water supply, building occupants, and building systems from unintentional backsiphonage. Cross-connection and backflow prevention is regulated through state and local plumbing codes, but some buildings may include additional backflow prevention measures. Annual maintenance and testing should be performed on backflow preventers if it is out of date. Backflow preventers should be checked for integrity prior to performing shock disinfection.

## 5.12 Hot water recirculation pumps and balancing

Hot water systems with multiple loops require balancing so that hot water is evenly distributed throughout the building. This is typically specified by the design engineer and balanced during the construction process. However, over its lifetime, the hot water system can become unbalanced due to renovations, changes in water use of the building, or differential calcification/precipitation in the system. When a hot water system is unbalanced, it does not provide the same hot water temperature to all recirculating portions of the system. This can result in portions of the system remaining at ideal growth temperatures for opportunistic pathogens for extended periods of time.

Verification that the hot water system is balanced can be incorporated into routine building water system maintenance. ***Hot water recirculation can be checked by flushing the hot water at outlets without thermostatic mixing (or with mixing bypassed) and recording the hot water temperature after temperature has stabilized. Temperature***

***can also be checked at the primary and secondary return locations, if accessible. An unbalanced system will have variable hot water temperatures during flushing, variable steady-state hot water temperatures, and/or variable times to reach final steady temperature.***

Verify that the hot water system is balanced and document on a routine basis.

Other useful actions include ensuring each pump is functional, installed correctly, and appropriately sized (due to renovations, pumps may become over- or under-sized over the life of a building).

If balancing issues are detected, a consulting engineer may be needed to identify and guide resolving system performance.

## 5.13 Point of Entry Service Lines

Service lines are sized to serve intended water uses in a building (e.g., fire suppression, sanitation, irrigation, heating and cooling systems, business-related applications), this can result in large diameter pipes. Also, due to initial construction or subsequent capital improvements, service lines may not be routed along the shortest path to the water main, leading to longer pipes (see Figure 5). So, for instance, every 10-foot length of 6-inch diameter service line holds 15 gallons of water (10-foot of 12-inch service line holds 30 gallons). This volume of water remains stagnant outside the building until such time as it is drawn into the building. Similar effects can be observed when a building is located on a campus of multiple buildings connected by water mains or extended service lines. In these instances, the building (property) manager will need to not only account for water that is stagnant in a building but in the entire piping network.

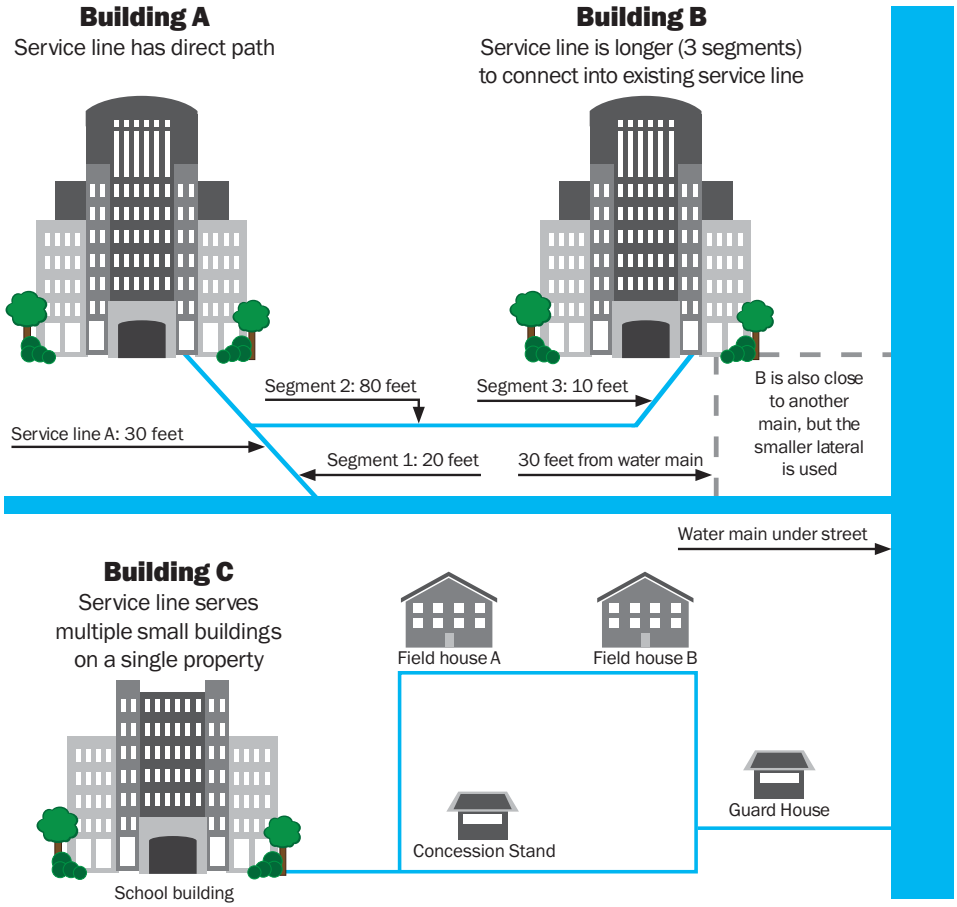



**Figure 5.** *Examples of different building service line designs*

American Water Works Association

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