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Flushing Guidance for Premise Plumbing and Service Lines to Avoid or Address a Drinking Water Advisory

Flushing Guidance for Premise Plumbing and Service Lines to Avoid or Address a Drinking Water Advisory

Prepared by:

Timothy Bartrand, Sheldon Masters, and Jennifer Clancy
Corona Environmental Consulting, LLC

Lisa Ragain
Metropolitan Washington Council of Governments

Andrew J. Whelton and Karen Casteloes
Purdue University

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For more information, contact:
The Water Research Foundation

Alexandria, VA Office
1199 North Fairfax Street, Suite 900
Alexandria, VA 22314-1445
Tel: 571.384.2100
www.werf.org
werf@werf.org

Denver, CO Office
6666 West Quincy Avenue
Denver, Colorado 80235-3098
Tel: 303.347.6100
www.waterrf.org
Info@WaterRF.org

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EXECUTIVE SUMMARY

Simple flushing (turnover of water) is often an effective response to potential entrainment of contaminants into premise plumbing. The advantages of flushing over other responses such as boil advisories and do not use advisories are that it is a relatively simple procedure that most water customers can perform unassisted and it directly addresses the unwanted presence of contaminants in premise plumbing systems. Despite these advantages, there are currently no clear, vetted, evidence-based guidance materials for flushing premise plumbing, and no tested strategies for communicating such guidance materials to water customers. This report responds to these gaps by providing a guidance for premise plumbing flushing based on expert input, as well as a communications strategy for delivering the guidance based on analysis of past flushing guidance documents and water communication best practices. The guidance and communications strategies are initial steps toward the development of evidence-based flushing guidance materials and communications strategies. Additional research and assessment will be needed to make the guidance and strategy evidence-based and more effective; suggested research activities to achieve those ends are presented.

OBJECTIVES

Specific objectives of this study were to (1) use available resources to develop a guidance for flushing premise plumbing and service lines, and (2) develop a communications strategy to deliver the guidance to audiences consisting of homeowners, building managers, and others with control over premise plumbing systems. The report also explores the properties of contaminants, how those properties influence whether and how a particular contaminant can be flushed, the make-up and properties of premise plumbing, the impacts of premise plumbing configuration on flushing efficacy, and data gaps in our understanding of premise plumbing flushing and communication with water customers regarding flushing.

BACKGROUND

Flushing can be used to respond to the intrusion of contaminants into premise plumbing in an acute contamination event or in response to chronic water quality degradation in premise plumbing systems themselves. This study is primarily concerned with acute contamination events. Despite the importance of premise plumbing flushing as a tool for maintaining water quality, few studies published to date provide hard data that inform when and how plumbing and endpoint devices can be flushed, and no studies address flushing of premise plumbing.

A partial list of distribution system or treatment events that could prompt premise plumbing flushing includes:

- Spills upstream of treatment plant intakes
- Deliberate contamination in distribution systems
- Distribution system low pressure transients
- Overfeeds of treatment chemicals
- Free chlorine burns
- Aesthetic concerns
- Distribution maintenance or failure

- Backflow from premise plumbing into the distribution system.

Each of these events is associated with different contaminants and extent of contamination. The extent of contamination is important both for determining the response to the contamination event and for targeting delivery of guidance materials and advisories to impacted premises.

Premise plumbing is the portion of the potable water distribution system beyond the property line and in buildings (Pruden et al. 2013). The building potable water system can be comprised of many components such as pipes, valves, faucets, water heaters, toilets, water treatment and conditioning devices, water-using devices (e.g., washing machines and dish washers), other water-using devices such as cooling towers, and water features such as fountains. Each of these components has the potential to harbor contaminated water and should be considered in the development of flushing guidance materials.

APPROACH

This project was conducted in four phases. First, a literature search was conducted to assemble and synthesize available information on the science and practice of building plumbing flushing. Second, an expert workshop was conducted to establish a premise plumbing guidance based on the best information currently available, to identify utility and public health agency communication needs and constraints, and to identify research needs related to premise plumbing flushing. Third, outcomes from the workshop were used to develop a guidance for flushing simple premise plumbing systems and to identify approaches for developing flushing strategies for larger, more complex systems. Finally, a communications strategy for informing water customers about the need and importance of flushing, as well as the steps involved in flushing, was developed.

RESULTS/CONCLUSIONS

Generally, decisions about when and how to flush are specific to the contaminant(s) suspected to be present in premise plumbing. The most important contaminant properties that dictate whether and how a contaminant should be flushed include the contaminants' toxicity (via all relevant exposure routes), specific gravity, volatility, and tendency to adsorb/absorb to premise plumbing materials or biofilms. A research need identified in this project is the development of a decision support tool that facilitates assessment of contaminant properties and assessment of whether and how flushing should be conducted.

Outcomes from the expert workshop and a relatively simple analysis suggested by experts were used to develop the following guidance, written at an appropriate reading level, for flushing of a simple premise plumbing. If contaminant volatility is an issue, customers should be instructed to appropriately ventilate the premises.

Flushing Cold Water Taps

- If the house has a point-of-entry filter, isolate the unit from the water system before beginning the flush protocol. If a point-of-use filter is being used, ensure that the filter is being bypassed.
- Begin by running the cold water faucet closest to where water enters the house. Starting from the point closest to where water enters the house, open all the other cold water taps sequentially and allow the water to run for a total of 20 minutes. Remove and clean

all aerators where possible. If a bathtub has a spout and showerhead, direct flow through the spout.
- Next, flush toilets at least once.
- Flush all outside spigots for 10 minutes.
- After flushing all cold taps, direct the flow from the bathtub spout to the showerhead, if applicable.

Flushing Hot Water Taps and Water Heater

- Run the hot water tap closest to the water heater and proceed to open all hot water taps. The closest tap will usually be a bathroom or kitchen faucet, depending on the location of the hot water heater.
- If a bathtub has a spout and shower head, direct flow through the shower head first.
- Allow the water to run for a total of at least 75 minutes (for 80-gallon heaters) and then turn off the faucets.
- If applicable, direct shower head flow to bathtub tap for 2 minutes.

Flushing Appliances

- Run empty dishwasher and washing machine once on rinse cycle after flushing of taps is completed.
- Replace all water filters (e.g., whole-house filter, refrigerator filter, etc.). Empty ice from ice maker bin; run ice maker and discard 2 additional batches of ice.

Assumptions

- Contaminant(s) is nonreactive, non-sorbing, does not volatilize
- Flow rate = 0.8 gpm (EPA mandated minimum flow for low-flow faucets; Green and Maddaus 2010); No point-of-use house or faucet filters are present anywhere in the building.
- Pipe diameter = 1 inches
- Length of service line = 150 ft (1.5 times greater than the average service line length in the US; NSF and ANSI 2013)
- Total number of cold water faucets inside the residence = 4
- Total number of hot water faucets inside the residence = 4
- Concentration of contamination in distribution main = zero, non-detectable
- Flow in the pipes is plug flow (i.e., the contaminant is carried along with the water and there is very little mixing in the pipes)
- Target concentration after flushing = 1-log reduction (i.e., the flushing reduces the contaminant concentration in the water heater by 90%)
- Water heater tank volume = 80 gallons

In communications to customers related to premise plumbing flushing, message content is likely to address (1) information on why the customers are being asked to flush their premise plumbing, (2) the importance of refreshing the water in their premise plumbing, (3) how to flush their drinking water pipes of contaminants, and (4) utility contact information in case customers have questions or feedback. Additional content will depend on the event that prompted flushing,

what audiences are being addressed, what information you want them to absorb, and what action you want them to take. Effective communication will likely require a layered approach and should be based on explicit attention to the readability of messages and the terminology used in the messages. Many of the terms used routinely by the drinking water community can be unfamiliar to water customers. Further, many building occupants are unaware that they can play a role in maintaining or improving the water quality in the plumbing system. As flushing communication strategies and messages evolve and are applied, efforts should be made to evaluate their efficacy and refine them.

APPLICATIONS/RECOMMENDATIONS

The guidance and communications strategy provided in this report can be considered a starting point. They are based on the best current knowledge and can be used as resources when water providers must respond to contamination events. They will certainly be reviewed and assessed by the water community and, once they are vetted, can be posted in locations easily accessible to water providers responding to contamination events. It is strongly recommended that utilities consult with their local public health and state primacy agencies before, during, and after contamination events to provide the most appropriate and timely response and to access the widest variety of available resources.

Significant research and assessment are required to refine the guidance and communications strategy and make them the evidence-based, tested materials that would best serve the water community. Key research activities identified by experts in the field are presented in Figure ES.1.

Improved understanding of premise plumbing systems

- Premise flushing model development, verification, and validation – determine what it takes to turn over water in a system, including commercial buildings.
- Assess the economics of flushing large occupancy and commercial buildings; determine the impacts of discontinued water flow on continuity of government and hospitals.
- Build large building flushing guidance based upon findings for residences.

Develop flushing guidance

- Develop a model of nested conditions that lead to a flushing strategy – decision tree leading to strategy tied to action steps. Note that actions drive messages and actions are determined by contaminant properties/behavior.
- Develop classifications of contaminants that can be flushed similarly.
- Develop a model to estimate indoor air exposures due to flushing activity.

Improved understanding of the fate of contaminants in premise plumbing systems

- Pick a small number of contaminants; prioritize based on past incidents; determine how the selected contaminants behave in a pipe and on water fixture. Contaminants can be chosen because they are representative of a group (volatile, toxic, reactive, etc.).
- Conduct laboratory experiments evaluating the impact of flushing on concentration in premise plumbing (e.g., materials that sorb to premise plumbing components).
- Evaluate the impact of chemical properties on flushing efficacy; conduct studies to allow comparison with well-studied chemicals.
- Conduct short-term, high impact experiments (e.g., flushing studies of crude oil using pilot systems).
- Establish funding sources and relationships for rapid response flushing studies.
- Conduct pilot and field studies for flushing strategy efficacy; pilot is only representative of the pilot site configuration. Rapid turn-around capability to understand basic efficacy of a flushing strategy.
- Link utilities to pilot facilities in national labs or research institutes for quick turn-around studies.

Evaluate the impact and effectiveness of flushing messaging and strategies

- Conduct a systematic evaluation of how messages resonated with consumers.
- Conduct a post-flushing retrospective analysis using flow data to determine customer response to flushing guidance; also analyze distribution pressure data to determine impacts of flushing on supply.

Enhance capacity for conducting flushing programs

- Develop a “strike team” for helping local utilities respond to emergencies.
- Integration of premise flushing as a viable public health intervention and through comparative analysis with current public health response toolbox (Centers for Disease Control and Prevention, National Association of County and City Health Officials response guidance).
- Assess behavioral attributes of communities predictive of premise flushing efficacy during a drinking water contamination event.
- Develop models supporting public health and water utility collaborative approach to successful premise flushing during a drinking water contamination event.

Figure ES.1 Key research activities

RESEARCH PARTNERS

American Water Works Association
Arlington County, VA
District of Columbia Water & Sewer Authority
Loudoun Water
Prince William County Service Authority
City of Rockland, MD

Table ES.1
Workshop participants

First Name	Last Name	Organization	Job Title
John	Aulbach	VDH- Office of Drinking Water	Director
Tim	Bartrand	Corona Environmental Consulting	Drinking Water Quality & Treatment Engineer
Jeanne	Bennett-Bailey	Fairfax Water	Public Affairs Manager
Paul	Biedrzycki	City of Milwaukee Health Dept.	Director, Disease Control & Env. Health
Rob	Blake	Centers for Disease Control and Prevention	Branch Chief, Environmental Health Services
Tom	Buckley	Washington Suburban Sanitary Commission	Code Planning and Cross Connection Coordinator
Gary	Burlingame	Philadelphia Water	Laboratory Director
Ritchie	Casimir	Metropolitan Washington Council of Governments	DEP Intern
Karen	Casteloes	Purdue University	Graduate Student
Russell	Chambers	Town of Leesburg	Plant Manager
Pierre	Constant	DC Water	Supervisor, Compliance Programs
Susan	Crosby	Loudoun Water	Manager of Outreach & Education
Darrick	Day	DC Water	Cross Connection Specialist
John	Deignan	Metropolitan Washington Council of Governments	CEC Outreach
Scott	Deitchman	Centers for Disease Control and Prevention	Associate Director, Emergency Preparedness
David	Donahue	City of Vienna	Director
David	Dyjack	National Environmental Health Association	Executive Director
Hugh	Eggborn	Virginia Department of Health - Office of Drinking Water	Engineering Field Director
Marlee	Franzen	DC Water	Manager of Water Distribution Maintenance
Matthew	Gallagher	Metropolitan Washington Council of Governments	Environmental Planner

First Name	Last Name	Organization	Job Title
Julia	Gargano	CDC Waterborne Disease Prevention Branch	Drinking Water Epidemiologist
Patrick	Gurian	Drexel University	Associate Professor
Tom	Hargy	Corona Environmental Consulting	Senior Scientist
Vincent	Hill	CDC Waterborne Disease Prevention Branch	Environmental Engineer
Walter	Ivey	Office of Environmental Health Services	Director
Nicole	Kaiser	DC Water	Water Communications Coordinator
Jeffrey	Kempic	U.S. Environmental Protection Agency	Senior Environmental Engineer
John	Kingsbury	Fairfax Water	Director, Transmission and Distribution
Lorena	Kowalewski	Metropolitan Washington Council of Governments	DEP Intern
Jasen	Kunz	Centers for Disease Control and Prevention	Environmental Health Specialist
Andy	Le	DC Water	Digital Communications Manager
Matthew	Magnuson	U.S. Environmental Protection Agency	Research Chemist
Sheldon	Masters	Corona Environmental Consulting	Senior Environmental Engineer
Susan	Miller	Fairfax Water	Public Information Officer
Kevin	Morley	American Water Works Association	Security and Preparedness Emergency Program Manager
Sarah	Neiderer	DC Water	Strategic Planning Officer
Caroline	Nguyen	Washington Suburban Sanitary Commission	Principal Environmental Engineer
George	Nunez	George Washington University	Director, Office of Emergency Management
Julia	Painter	George Mason University	Assistant Professor
Lisa	Ragain	Metropolitan Washington Council of Governments	Principal Water Resources Planner
Alan	Roberson	American Water Works Association	Director of Federal Relations
Aaron	Rosenblatt	Gordon & Rosenblatt, LLC	Principal
Andy	Rozcak	National Association of County and City Health Officials	Senior Director, Environmental Health, Pandemic Preparedness and Catastrophic Response
Jenny	Schitter	Metropolitan Washington Council of Governments	Principal Health Planner
Maureen	Schmelling	DC Water	Water Quality Supervisor

First Name	Last Name	Organization	Job Title
Jin	Shin	Washington Suburban Sanitary Commission	Water Quality Manager
Don	Smith	Washington Suburban Sanitary Commission	Sr. Plumbing Inspector
Mary	Smith	Water Research Foundation	Research Manager
Toni	Stiefel	Washington Suburban Sanitary Commission	Community Outreach Manager
Jon	Stewart	DC Homeland Security and Emergency Management Agency	Consulting PMP
Lynn	Thorp	Clean Water Action	National Campaigns Director
Samantha	Villegas	Virginia American Water	Communication Consultant
Stephen	Walz	Metropolitan Washington Council of Governments	Director of Environmental Programs
Marlo Thomas	Watson	Prince William County Service Authority	Community Relations & Outreach Manager
Andrew	Whelton	Purdue University	Assistant Professor
Damion	Lampley	DC Water	Deputy Director, Operations and Maintenance
Ralph	Rogers	Philadelphia Water	Environmental Engineer
Jennifer	Clancy	Corona Environmental Consulting	Chief Scientist
Lauren	Thompson	Loudoun Water	Communications Specialist
Lili	Wang	U.S. Environmental Protection Agency	Environmental Engineer

CHAPTER 1
INTRODUCTION

PROJECT MOTIVATION

At present, there is no standard guidance for water utilities to decide when to or how to advise premise plumbing flushing or to understand all of the factors that should be considered in a flushing guidance. Yet, premise plumbing flushing and instructing customers in conducting it are essential components for responding to a drinking water contamination event and protecting public health. This project provides a guidance for how to flush after a contaminant has entered premises and a communications strategy for delivering the guidance to drinking water customers. The guidance and strategy were developed using the outcome of an expert workshop on flushing conducted as a part of this project.

Premise plumbing systems are complex, contain a diverse array of metals and plastics, designed in widely different ways, and often are operated by people with limited knowledge of how they work or are configured. Additionally, the make-up of premise plumbing systems is evolving. For example, trunk and branch systems that utilize copper and iron pipe are common, but cross-linked polyethylene (PEX) manifold systems are becoming more popular. These manifold systems enable isolation of a single faucet, but result in longer-stagnation periods resulting in water quality degradation. Adding to the complexity, premise plumbing and the distribution system (DS) are connected and efforts between the water utility and premise plumbing owner to flush out contaminants must be coordinated. For example, a water utility might be flushing the distribution system in a specific pressure zone, then have owners flush, as was done by West Virginia American Water in their response to the January 2014 spill of a chemical mixture Shurflott 944 into their source water, that contained 4 methylcyclohexanemethanol (MCHM), among other compounds.

The Safe Drinking Water Act (42 U.S.C. §300f et seq. 1974) has no regulatory authority over premise plumbing, nor do drinking water utilities. However, when drinking water supplies are contaminated or the distribution system is disrupted, utilities are expected to communicate actions to customers. Flushing is a de facto public health intervention, where individuals choose to take an action to prevent exposure and consequential health effects. Because flushing is an action to prevent possible exposure to contaminated drinking water, it is one strategy that can be used in compliance with the Public Notification Rule. In the instance of chemical contaminants, possible but unconfirmed microbial contamination or in a simultaneous compliance scenario, such as a Total Coliform Rule during a lead exceedance, flushing could well be the intervention of choice. However, there are limited data to establish the effectiveness of current utility practices and recommendations.

Recent drinking water surveillance data indicate that premise plumbing is responsible for a considerable portion of water-related morbidity and mortality (Centers for Disease Control and Prevention, 2013b). Exposure assessment experts concur that household exposures present a greater health risk to individuals than those from the greater environment (Nieuwenhuijsen et al. 2006). As such, the need for evidence-based flushing guidance for premise plumbing are more critical than ever. Though premise plumbing is an identified and significant exposure for drinking water related illnesses, public health professionals, particularly in local health departments, have limited expertise and capacity in this area.

As noted in a research study conducted by the United States Environmental Protection Agency (US EPA) and the National Institute of Standards and Technology (NIST) (EPA, 2012), decontamination best practices (including flushing) depend on premise plumbing configuration and the nature of the contaminant that must be flushed. Contaminant fate and transport in premise plumbing can differ widely, as can their damage to the premise plumbing or to customer or residents' health (e.g., via volitalization, Moya et al. 1999). Table 1.1 presents events that may prompt the need for premise plumbing flushing and lists contaminant types and properties for consideration when recommending flushing. These considerations are important for operators who are applying Hazard Analysis and Critical Control Point (HACCP) principles to premise plumbing systems (NSF, 2014).

Table 1.1
Premise and service line flushing differences by scenario, contaminant, and system configuration

Scenarios resulting in service line and premise plumbing flushing	Classes of contaminants that could require flushing	Contaminant properties that could influence flushing best practice
Contamination event	Susceptible pathogens	Volatility
DS low pressure transient	Resistant pathogens	Miscibility
Overfeeds	Sediments, particles	Toxicity (oral, inhalation, dermal)
Free chlorine burns	Chemical compounds	Reactivity
Aesthetic concerns	Radioactive elements	Retention on premise plumbing surfaces
DS maintenance or failure	Unknown contaminants	Odor threshold
Backflow		Appearance/color
Premise plumbing contamination		
Premise plumbing disinfection		

Decision makers who opt to recommend flushing must recognize that the decision to flush and the flushing procedure may have human health and infrastructure consequences. Most, if not all of the available flushing guidance materials in existence are based on utility experiences and best estimates. It is possible that this lack of knowledge and clear guidance that reduce human health risks result in the underuse of flushing despite drawbacks of alternative responses to contamination.

Explicit attention to the flushing of premise plumbing is a high-priority, time-critical need within the drinking water community for several reasons. First, premise plumbing configuration and operation are critical determinants of the quality of water consumed and used by the public and flushing can be an effective means for managing water quality. Second, in many cases flushing is a more effective, less problematic response to contamination than boiling water or other customer actions (Raucher et al. 2014). But flushing might not be used as often as it should because water sector guidelines and communication tools are lacking. Finally, public education regarding premise plumbing operation and maintenance could increase public awareness about their responsibility in determining the quality of water they are exposed to and options for control of lead, disinfection byproducts (DBPs), opportunistic pathogens and other hazards in their water.

PROJECT OBJECTIVES

Specific objectives of this study are to (1) use available resource to develop a guidance for flushing premise plumbing and service lines and (2) develop a communications strategy to deliver the guidance to audiences consisting of home owners, building managers and others with control over premise plumbing.

REPORT ORGANIZATION AND PERSPECTIVE

This project was conducted in four phases:

- A scientific and data gaps survey to establish the current knowledge of premise plumbing flushing;
- An experts workshop to establish flushing best practices and communication needs;
- Formulation of a premise plumbing flushing guidance; and
- Development of a communications strategy that utilities and public health agencies can use to communicate with customers when premise plumbing flushing is needed.

Each of these phases is described in a separate chapter of this report.

As noted above, current knowledge of premise plumbing operation and flushing is relatively sparse. Consequently, the guidance and communication strategy devised in this project meet a pressing need, but comprise a starting point for further investigation. Future guidance will benefit from basic research on the hydraulics, chemistry, and biology of premise plumbing systems and will be evidence-based, not based on expert judgment. Future communications strategies will have the benefit of focus group reports, retrospective analyses of guidance effectiveness following contamination events, and research into the communication channels water customers associate with drinking water.

CHAPTER 2
BACKGROUND – FLUSHING AND PREMISE PLUMBING

FLUSHING AND PREMISE PLUMBING OVERVIEWS

Flushing can be used to respond to intrusion of contaminants into a premise plumbing in an acute contamination event, or in response to chronic water quality degradation in premise plumbing systems themselves. Examples of chronic water quality degradations that can be addressed, in part, by flushing are DBP formation, lead and copper corrosion, and the proliferation of opportunistic pathogens. The WRF flushing study is primarily concerned with acute contamination events. Flushing in response to acute water quality contamination events is addressed in chapters 2 and 3. Flushing to address chronic water quality degradation arising in premise plumbing is addressed briefly in Chapter 4.

Treado et al. (2009) note that contaminants can enter the premise plumbing

- From far upstream of the building (above water treatment plant intakes),
- From distribution system mains lines,
- Via a building service line, or
- Within the building.

The location of the contamination event is significant because it determines the duration of the contamination event as well as the concentration of the contaminant in premise plumbing. A partial list of distribution system or treatment events that could prompt premise plumbing flushing includes:

- Spills upstream of treatment plant intakes,
- Deliberate contamination in distribution systems,
- Distribution system low pressure transients,
- Overfeeds,
- Free chlorine burns,
- Aesthetic concerns,
- Distribution maintenance or failure, and
- Backflow from premise plumbing into the distribution system.

Each of these events is associated with different contaminants and extent of contamination. The extent of contamination is important both for determining the response to the contamination event and for targeting delivery of guidance and advisories to impacted premises.

Premise plumbing can be comprised of many components such as:

- Pipes,
- Valves,
- Faucets;
- Water heaters,
- Toilets,
- Water treatment and conditioning devices,
- Water using devices (e.g., washing machines and dish washers),

- Other water using devices such as cooling towers, and
- Water features such as fountains.

These components differ in hydraulic characteristics (volume, mixing) as well as material. Casteloes et al. (2015) note that plumbing materials differ for new and old plumbing systems and provide a list of materials typically used for premise plumbing components (Table 2.1). Materials used in premise plumbing components can differ widely in their affinity for contaminants.

Table 2.1
Types of potable water plumbing materials in new and old residential buildings

Component	Plastics	Other Materials
Piping	Polyvinylchloride (PVC) High density polyethylene (HDPE) Crosslinked polyethylene (PEX) Polypropylene (PP) Chlorinated PVC (cPVC)	Copper Galvanized iron Concrete Lead-lined steel Black steel Brass
Pipe coatings	Epoxy Polyurethane Polyurea	
Faucets, Valves, and Fittings	Synthetic rubber (O-rings)	Lead Stainless Steel Brass Copper Aluminum
Gaskets	Ethylene-propylene-diene monomer (EPDM) Butyl Rubber Natural Butyl Rubber Styrene-butadiene rubber Neoprene	
Water Heater	Polysulfone dip tubes	Steel Glass Ceramic Interior Linings Anode Rod

Source: Casteloes et al. 2015

Casteloes et al. (2015) and Treado et al. (2009) developed models for predicting the impact of flushing on contaminants in premise plumbing. Hawes et al. (2017) subsequently tested Casteloes et al. hypotheses and expanded their models. The model developed by Treado et al. (2009) predicts desorption/removal of contaminants from pipe surfaces during flushing. The model developed by Casteloes et al. (2015) predicts contaminant transport through a full residential plumbing system including a water heater. Water heaters are critical premise plumbing components and should be considered explicitly when developing flushing guidance. As noted by Casteloes et al. (2015), water heaters are core components of premise plumbing and are complex. Aspects of water heaters that should be considered when developing flushing guidance include the

following:

- Intake/discharge configurations that promote short circuiting and incomplete mixing.
- Frequent presence of sediments accumulating in the tank or resulting from corrosion and scale.
- Incorporation of recirculation loops, particularly for systems in larger buildings.

Casteloes et al. (2015) conducted a literature review to identify flushing procedures that have been used in response to acute premise plumbing contaminations (Table 2.2). Procedures recommended in past events differ widely in their flushing times and the degree of detail related to staging of flushing of different taps in premises. Examples of prior guidances provided to the public are provided in Appendix A. The wide variation in guidances could reflect differences in the contaminants for each event, but is also likely a result of uncertainty within the drinking water and public health communities regarding premise plumbing and flushing. Ideally, in addition to guidelines on the duration and staging of flushing, flushing guidance and recommendations should also address the safety of premise plumbing operators, decontamination of water-using appliances and water features, and disposal of flushed water.

Table 2.2
Flushing procedures used in prior contamination events or suspected events

Location, Year	Contaminant	In-home flushing procedure
Nibley, UT, 2015	Diesel fuel	Cold water 35 min, hot water 30 min, run appliances, continue until odor gone
Glendive, MT, 2015	Crude oil	Cold water 20 min, hot water 15 min
Washington DC, 2014	Not known, likely none	Begin at the sink on the lowest floor and run each cold water tap 10 min, flush cold water from upper level sinks 5 min, refrigerator water dispenser 5 min
Toledo, OH, 2014	Microcystins	Hot water 15 min, cold water 15 min, appliances 5 min
Charleston, WV, 2014	Crude MCHM, stripped PPH	Utility: Hot water 15 min, cold water 5 min, appliances 5 min Health department: Hot water 13 min per faucet, starting in kitchen. 2 min all hot water faucets. Cold water 4 min per faucet, 1 min all cold water faucets. Attempt to discharge to ground surface instead of septic tank
Stratford, ON, Canada, 2005	Car wash cleaning agent containing 2-Butoxyethanol	Cold water 5 min
Charlotte, NC, 1997	Fire suppressant (AFFF)	Hot water 10 min, cold water 10 min
Los Angeles, CA, 1994	Macrojet concentrate	Flush both cold and hot water
Hope Mills NC, 1986	Pesticides (heptachlor, chlordane)	Flush to drain lines and water heaters
Macon, GA, 1984	Creosote	Flush plumbing for 30 min

Source: Casteloes et al. 2015

TRANSPORT OF CONTAMINANTS THROUGH PLUMBING

Several key studies describe the behavior of contaminants in distribution system and premise plumbing and the efficacy of flushing for decontamination. Those studies are summarized below. In general, the transport of contaminants in premise plumbing is not well characterized. In particular, Szabo and Minamyer (2014a, 2014b, 2014c) conducted literature reviews to determine the persistence of biological, radiological, and chemical contaminants in distribution system infrastructure and to evaluate approaches for decontamination. Although distribution system infrastructure differs from that of premise plumbing, the findings of Szabo and Minamyer provide an indication of the effectiveness of flushing and are informative about premise plumbing. Findings about decontamination from the three studies by Szabo and Minamyer are summarized in Table 2.3. Contaminants for which there was limited information are omitted from the table. In general, the efficacy of flushing is highly dependent on water quality and, in some cases, can be improved through addition of dispersing agents or adjusting pH.

Table 2.3
Summary of decontamination findings

Contaminant type	Contaminant	Decontamination findings
Chemical	Arsenic	In pilot studies, for pH below 9, flushing removed 40-60% of arsenic adhered to coupon surfaces and biofilm; arsenic appears to desorb from pipe scale over time; increasing pH above 9 might improve arsenic removal
	Mercury	Studies report mixed results for flushing decontamination of pipes with mercury. Removal appears dependent on pH, but does not involve oxidation.
	Diesel fuel	Studies indicate that flushing has limited effectiveness in removing diesel fuel from cement-mortar coupons, but that addition of dispersants improved removal significantly; a single cited study showed that after accidental Diesel fuel contamination of a household plumbing, diesel fuel concentration was reduced below the taste and odor threshold after two days of flushing and use of water for sanitation.
	Chlordane	In pipe loop and bench scale studies chlordane adsorbed strongly to cement, ductile iron and plastic pipe surfaces, but that flushing might be an effective decontamination approach.
	Sodium fluoroacetate	Decontamination (flushing) was ineffective for decontamination of concrete.
Radiological	Cobalt	Free chlorine can oxidize cobalt, resulting in Co(III) which is insoluble in water. Removal/decontamination could require strong acids.
	Strontium	Low pH flushing is potentially effective for decontamination of adhere strontium.
Biological	Bacterial spores	Flushing was ineffective at removing adhered spores.
	Vegetative bacteria and viruses	Decontamination appears to require both flushing and chemical disinfection.

Source: Data from Szabo and Minamyer, 2014a; 2014b; 2014c

Treado et al. (2009) conducted bench scale, screening, pipe loop, water heater and full-scale studies of contaminant behavior in premise plumbing. Full scale tests were conducted in an experimental apparatus emulating a five-story building. Tests were conducted with chemical contaminants (phorate, toluene, gasoline and diesel fuel, strychnine, cyanide salts, mercuric chloride) and biological contaminants (spores, vegetative bacteria, and ricin). In screening tests, all of the chemical contaminants were found to sorb to all of the pipe materials tested (iron, PVC, and rubber). In full-scale tests, diesel fuel, strychnine, and *Bacillus thuringiensis* (BT) spores all sorbed to both copper and PVC pipe and were flushed only partially or not at all with water.

Based on findings from their experimental studies and modeling work, Treado et al. (2009) suggested key decontamination methods by category of contaminant (Table 2.4). Similar to Szabo

and Minamyer, Treado et al. found that decontamination of some contaminants required cleaners, oxidizers, and other adjustments to water quality.

Table 2.4
General decontamination procedures by contaminant type for premise plumbing

Contaminant category	Example	Key decontamination methods
Soluble chemicals	Strychnine, cyanide	For pipes and tanks – Continuous flushing with water, water buffered with chlorine, or water mixed with cleaner
Immiscible chemicals with specific gravity less than one	Diesel fuel, gasoline	For pipes - Continuous flushing with water, water buffered with chlorine, or water mixed with cleaner For tanks - Flush through drain valve at bottom of tank or water spigot
Immiscible chemicals with specific gravity greater than one	Phorate	Continuous flushing with water, water buffered with chlorine, or water mixed with cleaner For tanks - Drain through drain valve at bottom of tank, and fill with cleaning solution. Repeat as needed
Sediments or particles	Foreign particles	For pipes - Continuous flushing with water, drain from cleanouts where available For tanks - Drain and flush from bottom
Bacteria	*E. coli* O157:H7	For pipes and tanks - Flood system with water and disinfectant and let stand, followed by short flush. Repeat as needed
Spores	*Bacillus anthracis*	For pipes and tanks - Flood system with germinant solution and let stand to allow spores to germinate, followed by short flush
Toxins	Ricin	For pipes and tanks - Continuous flushing with water, water buffered with chlorine, or water mixed with cleaner

Source: Treado et al. 2009

In 2017, several new studies were published that described the susceptibility of metal and plastic service lines and plumbing materials to chemical contamination and the ability to decontaminate these materials by flushing and surfactants. Huang et al. 2017a and 2017b found that the short-term exposure of plastic and metal plumbing pipes to a dilute crude oil solution leached chemicals from PEX pipes for 30 days, cPVC pipes for 15 days, and copper pipes for 3 days. Also found was that total organic carbon levels were not effective in monitoring pipe decontamination. Casteloes et al. (2017) also reported that flushing did not affect the removal of BTEX from crude oil contaminated copper and PEX pipes after a single flush. Surfactant interactions with pipes and gasket materials were also evaluated. Some surfactants caused physical and mechanical damage, including swelling and extraction of materials from the

plastics, while other surfactants had no noticeable effect. No difference in BTEX removal for PEX and copper pipes was found for the surfactant tested. Szabo et al. 2017 found that flushing at 15 gpm could reduce benzene concentration for crude oil contaminated iron pipe after 1.5 hr of flushing. For copper plumbing, multiple rounds of flushing were required to reduce hydrocarbon levels and appliances seemed to be more difficult to decontaminate. Huang et al. 2017c although found that a biobased sorbent was capable of removing heavy metals deposited on plastic pipe surface during a short stagnation period.

FLUSHING FOR OTHER WATER QUALITY CONCERNS

Although the focus of the current project is flushing to address contaminants introduced into premise plumbing during acute contamination events, flushing can also be used to address water quality degradation in premise plumbing. Water quality degradation in premise plumbing includes increases in lead and copper concentrations due to corrosion, increases in DBP concentrations, and proliferation of opportunistic pathogens. All three of these water quality concerns are related to water stagnation in pipes and can be mitigated to some degree through routine flushing. The use of flushing to address lead and copper water quality problems is the best studied of these problems and described briefly below. Formation of DBPs and implications for flushing has not been studied as thoroughly and is briefly mentioned in this chapter. Growth of opportunistic pathogens in premise plumbing and the impact of flushing on exposures to pathogenic organisms is complex and outside the scope of this project and is not reviewed in this section.

In order to reduce consumer lead exposure, the EPA recommends flushing taps for 30 seconds to 2 minutes if the water has not been used for several hours (EPA, 2016). Analyses of lead and copper in drinking water in U.S. schools (Gilbert and Calabrese, 1991; Maas and Patch, 1990; Murphy, 1993; Triantafyllidou et al. 2014); Washington, D.C. (Edwards, 2014), West Virginia (Whelton et al. 2015), Slovenian schools (Bitenc, 2013), Germany (Fertmann et al. 2004) and Brazil (Grigoletto et al. 2012) have all confirmed expectations that flushing consumer taps is one strategy that can be employed to significantly reduce lead and copper exposure. However, in some cases lead levels can be considerably higher in flushed samples compared to the first liter flowing from the tap (i.e., “first draw”) (Clark et al. 2014; Del Toral et al. 2013; Edwards and Dudi, 2004; Gilbert and Calabrese, 1991; Masters and Edwards, 2015)

The EPA’s flushing recommendation is based on the assumption that the first-draw normally contains the highest amount of lead and that lead levels decrease with flushing. However, the concentration of lead in drinking water and the effectiveness of flushing strategies depends on site-specific factors such as the type of plumbing material (Broo et al. 1997; Edwards et al. 2001; Ferguson et al. 2011; Grace et al. 2012; Rajaratnam et al. 2002; Schock and Sandvig, 2009; Turek et al. 2011), length of the service line (Caredew, 2006; Cartier et al. 2011; Kuch and Wagner, 1983), disturbances (Boyd et al. 2004; Cartier et al. 2012; Del Toral et al. 2013; Sandvig et al. 2008; Triantafyllidou et al. 2014), the type of lead scale (Clark et al. 2014; Triantafyllidou et al. 2015) and consumer water use patterns (Arnold and Edwards, 2012; Del Toral et al. 2013). As such, more studies are needed to evaluate minimum flushing times, magnitude of flushing velocities required for particulate removal and limitations on household pipe velocities (Brown and Cornwell, 2015).

Recent studies have documented significant DBP formation in premise plumbing and in hot water plumbing in particular (Chowdhury et al. 2011; Dion-Fortier et al. 2009; Liu and Reckhow, 2014). DBP formation in premise plumbing is a result of both higher water temperatures

in premises (leading higher DBP formation reaction rates) and water stagnation in pipes and tanks (longer contact time between disinfectants and DBP precursors). Production of different DBP species in premise plumbing appears to differ, with trihalomethanes production much higher than that of haloacetic acids and other DBP species (Chowdhury et al. 2011; Dion-Fortier et al. 2009). Unlike lead water quality problems, there is an unambiguous reduction in DBPs associated with routine flushing after periods of no water use.

CHAPTER 3
EXPERT WORKSHOP

INTRODUCTION

An experts workshop to establish flushing guidance and assess related water community communication needs was conducted in Washington, DC on August 18-19 and its agenda is presented in Table 3.1.

Table 3.1
Experts workshop agenda

Day 1		
12:00 - 1:00	Lunch	
1:00 - 1:15	Introductions & Statement of Purpose	Bartrand
1:15 - 3:15	Breakout: What contaminants should be flushed and how do flushing strategies differ by contaminant? Breakout session will produce a matrix of contaminants or groups of contaminants with recommendations on (1) whether flushing the contaminants is the best strategy, (2) what health and safety considerations are required during flushing (3) does the contaminant or contaminant group require special strategy for effective flushing? And (4) what information about the contaminants could/should be communicated to premise plumbing operators and water customers?	Whelton
	Breakout: What events will prompt flushing? Breakout session will produce a list of events that could lead to flushing advisories. For each event, the breakout group will identify the types of contaminants that could be associated with the event, the extent of the event and the target groups that could be advised to flush their premise plumbing.	Bartrand
3:15 - 3:35	Break	
3:35 - 4:05	Plenary Session – Present Breakout Results and Group Discussion	
4:05 - 5:05	Classification of premise plumbing systems. Participants will develop a classification of premise plumbing configurations that groups types of systems that can be flushed similarly. The factors that dictate how flushing should be done (e.g., building type [single family residential, multi-family residential, school, hospital etc.], premise plumbing materials) will be identified as a first step in the classification process. The experts will also assess whether separate communications and outreach strategies are required for operators of different classes of premise plumbing systems.	Whelton, Bartrand
5:05 - 5:15	Summary of Day 1 and Introduction to Day 2	Bartrand

Day 2

Time	Workshop	Facilitator
8:00 – 8:30	Breakfast	
8:30 – 10:15	Develop Effective Flushing Strategies (Break-Outs). Each breakout group will be given a list of contaminants and propose flushing strategies for the contaminants. The strategy will state whether flushing is the best approach and practical instructions on how flushing should be conducted for each broad classification of premise plumbing.	Whelton, Ragain
10:15 – 10:30	Break	
10:30 – 10:50	Plenary Session – Breakout groups present results and group discussion	Bartrand
10:50 – 12:00	Communications Discussion. Participants will identify the communication messages and strategies to facilitate utility flushing advisories. Tools can include those for outreach to premise plumbing operators, public health agencies, other public agencies, and the drinking water community.	Ragain
12:00 – 1:00	Closing: How Workshop Results will be Used	Bartrand

DATA AND ANALYSIS AND SIGNIFICANT FINDINGS

An experts workshop was convened with the goal to (i) develop premise plumbing flushing processes; (ii) develop draft flushing guidance for specific incidents; (iii) establish the priority communication needs related to premise plumbing flushing; and (iv) establish critical knowledge gaps and research needs. The two-day workshop included representatives from government agencies, utilities, academia, and advocacy organizations.

What Contaminants Should the Community Be Prepared to Flush?

Although any contaminant could require flushing from premise plumbing, some contaminants are more likely to be problems within premise plumbing than others. Identifying the list of more likely contaminants that should be flushed makes development of strategies tractable and will result in more practical, useful communication strategies. A breakout group was tasked with identifying the events most likely to result in advising water customers to flush their premise plumbing and the contaminants associated with those events. In keeping with the scope of this project, the group was asked to focus on contaminants introduced into the distribution system from external sources and not contaminants that are generated during distribution system and premise plumbing operation (lead, disinfection byproducts, opportunistic pathogens).

It is helpful to classify precipitating events as systemic (large spills and events that impact entire water treatment and distribution networks) or localized (events that impact only a portion of a distribution system). Key events identified during the breakout session are presented in Table 3.2. The experts agreed that the majority of incidents likely to trigger premise flushing are associated with cross connections. Cross connections are locations in distribution systems where

there are connections between the potable water supply and non-potable water. Contamination can occur at cross connections when pressure in the potable water supply falls and non-potable water is drawn into the potable water (backsiphonage) and when pressure in the non-potable water side of the connection is greater than pressure in the potable water (backpressure) (EPA, 2001).

Table 3.2
Events that could trigger a premise plumbing flushing advisory

Event type	Event	Examples or description
Systemic	Treatment chemical overfeeds	Overfeed of potassium permanganate used to control zebra mussels at an intake
	Spills (above intakes)	Crude oil spill from railcars at a stream crossing; industrial chemical spill from upstream above ground storage tank
	Releases from non-point sources	Harmful algal blooms; *Cryptosporidium* runoff during rain events
	Radiological releases	Intentional releases or widespread airborne releases after nuclear power accidents such as the Fukushima power plant
	Floods	Ingress following power failures and loss of distribution system pressure
	Private well contamination	Improper introduction of contaminant into the well during cleaning, backsiphonage from cross connections
Localized	Main breaks	Contaminants can enter the distribution system at the break location or due to pressure loss resulting from the break
	Cross contamination	Non-potable water pushed/drawn into the distribution system due to backsiphonage or backpressure
	Fire fighting	Firefighting contaminants entrained into distribution system and premises due to backflow or firefighting water use reduces distribution system pressure and causes backsiphonage at cross connections
	Hydrant flushing	Contaminants liberated due to scour and scale disturbance
	Deliberate contamination	Deliberate introduction of contaminants that are highly-toxic, resistant to treatment or intended to alarm water users

While many contaminants can enter premises following the events listed in Table 3.2, those events are most typically associated with a smaller set of contaminants. The smaller set of contaminants of greatest concern was identified based on experts' assessments and based on past experience. The resulting contaminant list is presented in Table 3.3. The contaminants of greatest concern vary widely in their toxicity, volatility, solubility, and specific gravity. Experts noted that, in an actual emergency response, the contaminant of greatest concern is the unknown contaminant. Given the range of potential contaminant properties it would be impossible to provide specific flushing guidance for an unknown contaminant. It was also noted that public perception that their premise is contaminated (although no contaminant might actually be present) is an important issue that needs to be addressed and communicated to consumers.

Table 3.3
Contaminants associated with events likely to trigger flushing

Precipitating Event	Likely Contaminants
Upstream spill	Petrochemicals
	Industrial contaminants stored in tanks
Non-point release	Algal toxins
	Cryptosporidium oocysts
	Agricultural chemicals
	Pesticides
Drinking water treatment chemicals	Aluminum sulfate
	Orthophosphate
	Potassium permanganate
	Chlorine overdose
	Sodium nitrite
Cross contamination	Non-potable water
	Sewage, biological contaminants
	Heating, Ventilation and Air Conditioning (HVAC) system contaminants (biocides from cooling towers, sodium nitrite for corrosion control)
	Sodium hydroxide from boiler systems
	Glycol
	Foams from firefighting
Radiological contaminants	Cesium; Iodine; Strontium; Plutonium
Contaminants originating in distribution system pipes	Particles/dirt/sand (mobilized during flushing/scour)
	Discolored water
	Particulate lead
	Reaction products from contaminants reacting with biofilms, pipe walls and distribution system components
Contaminants associated with multiple events or non-specific source	Trichloroethylene (TCE)
	Solvents
	Organophosphates
	Molybdenum

Contaminant Properties and Their Impact on Flushing Strategies

For decades, water utilities have responded to the accidental release of chemicals by flushing distribution systems, adjusting disinfectant levels and/or issuing boil orders. However, several recent high-profile events have demonstrated that flushing might have to be tailored to specific contaminants and that there is no established methodology for developing contaminant and site-specific flushing guidance (Casteloes et al. 2015). The latter point is illustrated by the issuance of multiple, conflicting flushing guidance following several recent events.

In parallel with the breakout session tasked with identifying contaminants likely to be flushed, a second breakout group evaluated contaminant properties that impact whether and how a particular contaminant or class of contaminant should be flushed. It was noted that, in addition to contaminant physicochemical properties, public perception plays a role in how, or even whether premise plumbing operators flush. There was a general perception among the experts that the public is particularly sensitive to potable water aesthetics (color, clarity and taste and odor) and

that water customers are likely to flush without specific guidance or direction if water aesthetic quality is poor. Other classes of contaminants (beyond those that are primarily related to aesthetic concerns) will differ widely in the urgency that customers feel to flush them and customers will vary widely in their response to advisories to flush for a particular contaminant. Findings of the breakout group are presented in Table 3.4. Specific flushing guidance might be required for combinations of the categories presented in the table. For example, a soluble, odorless contaminant associated with negative health effects after inhalation exposure would require different guidance than a soluble, odorless contaminant with no significant health impacts. In addition to considering categories of contaminants, the breakout group attempted to connect the contaminant to the entity or entities issuing a flushing guidance and to the impact of the guidance on premise plumbing operators and owners. In general, collaborative issuance of guidance by the utility and responding government health agencies is advised. Collaboration prevents multiple and mixed messages and increases the resources available for establishing and delivering effective guidance. Even after clear and consistent messaging, some premise plumbing operators may not flush. Following the 2014 chemical spill in West Virginia some residents waited more than three weeks to follow premise plumbing flushing instructions. This reality should be considered in the development and execution of flushing programs.

Table 3.4
Contaminant properties that dictate how flushing should be conducted

Category	Description
Health effects (consumer using water and flusher)	Acute v. chronic, carcinogen, mutagen, teratogen – or unknown
Flushing routes of exposure: Safety and public health consideration	Inhalation (both volatilized contaminants and aerosols), dermal
Contaminant class	Metals, VOCs, SVOCs, pesticides, treatment process chemicals, cyanotoxins
Physiochemical properties	Water solubility, Henry's Law Constant, Log K_{ow} solid-liquid partitioning coefficient
Aesthetic attributes	Taste and odor
Environmental conditions	Temperature, pH
Material interactions	Described in the premise plumbing configurations section of this report
Key flushing recommendations	Based on the above information
Exposure risks when flushing	Based on the above information
Who issues guidance?	Collaborative: local Health Department & water utility; state Health Department & water utility; Federal agency & utility
Who will flush?	Assure the highest probability of compliance that flushing is done right

Historically, there has been little information about site-specific and contaminant-specific guidance for flushing in order to decontaminate distribution systems. The need to fill these knowledge gaps was highlighted by the experts who were particularly concerned about the need for reliable flushing guidelines in order to protect public health and water infrastructure. Because of the unique fate and transport characteristics of each potential contaminant, more specific

flushing procedures are needed. For example, some contaminants can persist for long periods of time, autodecompose, absorb to pipe materials, and/or degrade plumbing. Contaminants may also differ in terms of health effects and toxicity. The experts suggested several ways of categorizing contaminants based on their properties and the impact these properties would have on flushing procedures. These classifications included acute vs. chronic, aesthetic vs. public health concern, the time required to flush out the contaminant, the ability of the contaminant to sorb to pipe surfaces, and the ability of the contaminant to volatilize.

It is likely that chemicals with similar properties can be removed from the distribution system using similar flushing procedure. As such, the experts determined that a decision tree should be developed as a guideline for flushing contaminants based on their properties. As a starting point, the decision tree divides broadly based on their chemical characteristics as shown in Figure 3.1. The chemical properties that are most likely to influence the flushing times include specific gravity, viscosity, and the octanol-water partition coefficient (K_{ow}). The specific gravity is the ratio of the density of a substance compared to the density of water. Contaminants with a specific gravity greater than 1 are likely to require longer flushing times. Substances that are also resistance to flow (as measured by viscosity) will also require longer flushing times. The ability of substances to sorb to pipe surface (measured by K_{ow}) as well as the type of pipe material play a critical role in determine the procedure and time needed to remove the contaminant. Depending on the contaminant, additional precautions may need to be taken when performing the flushing procedure. In cases where dermal or inhalation hazards exist ventilation and personal protective equipment will be necessary.

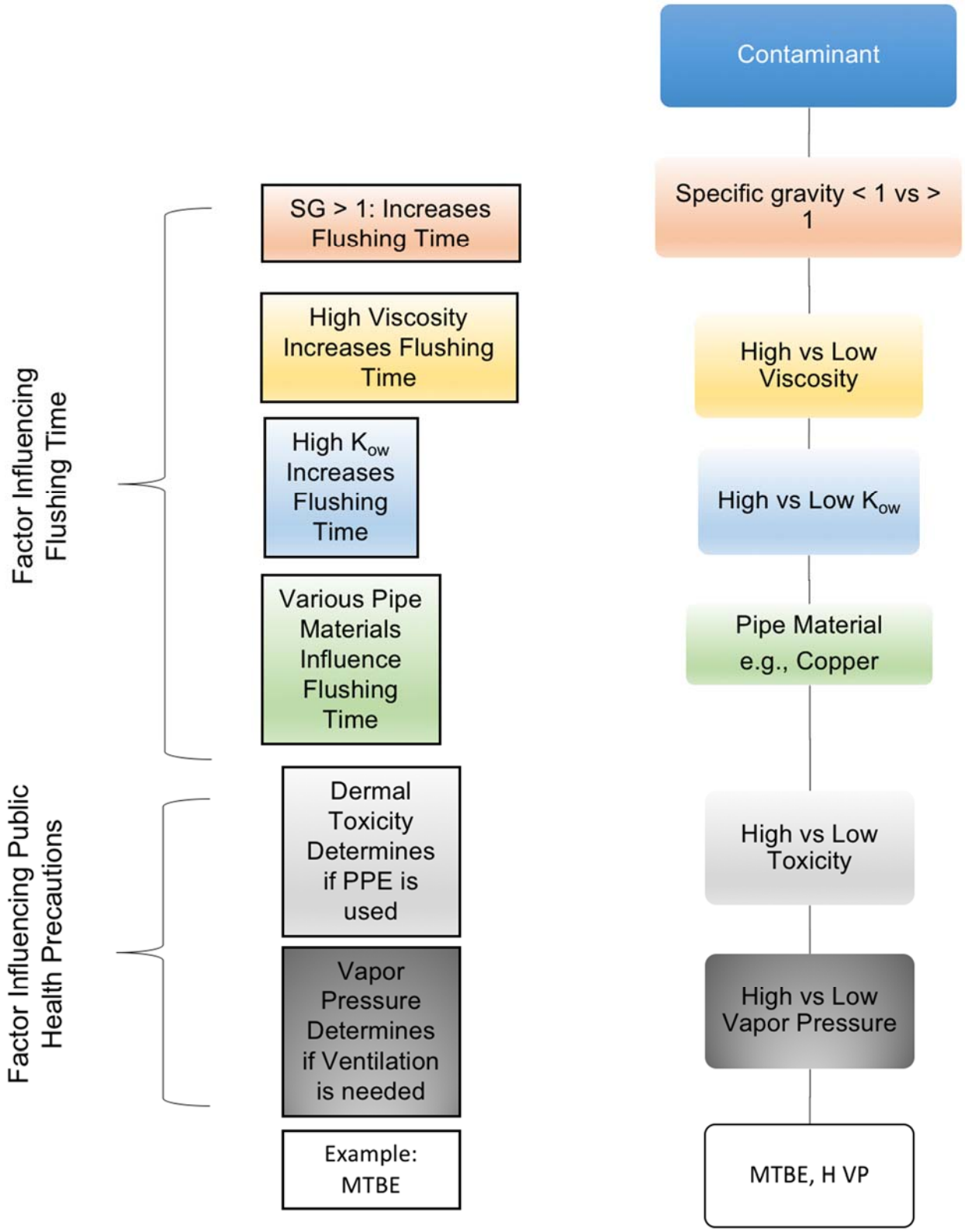
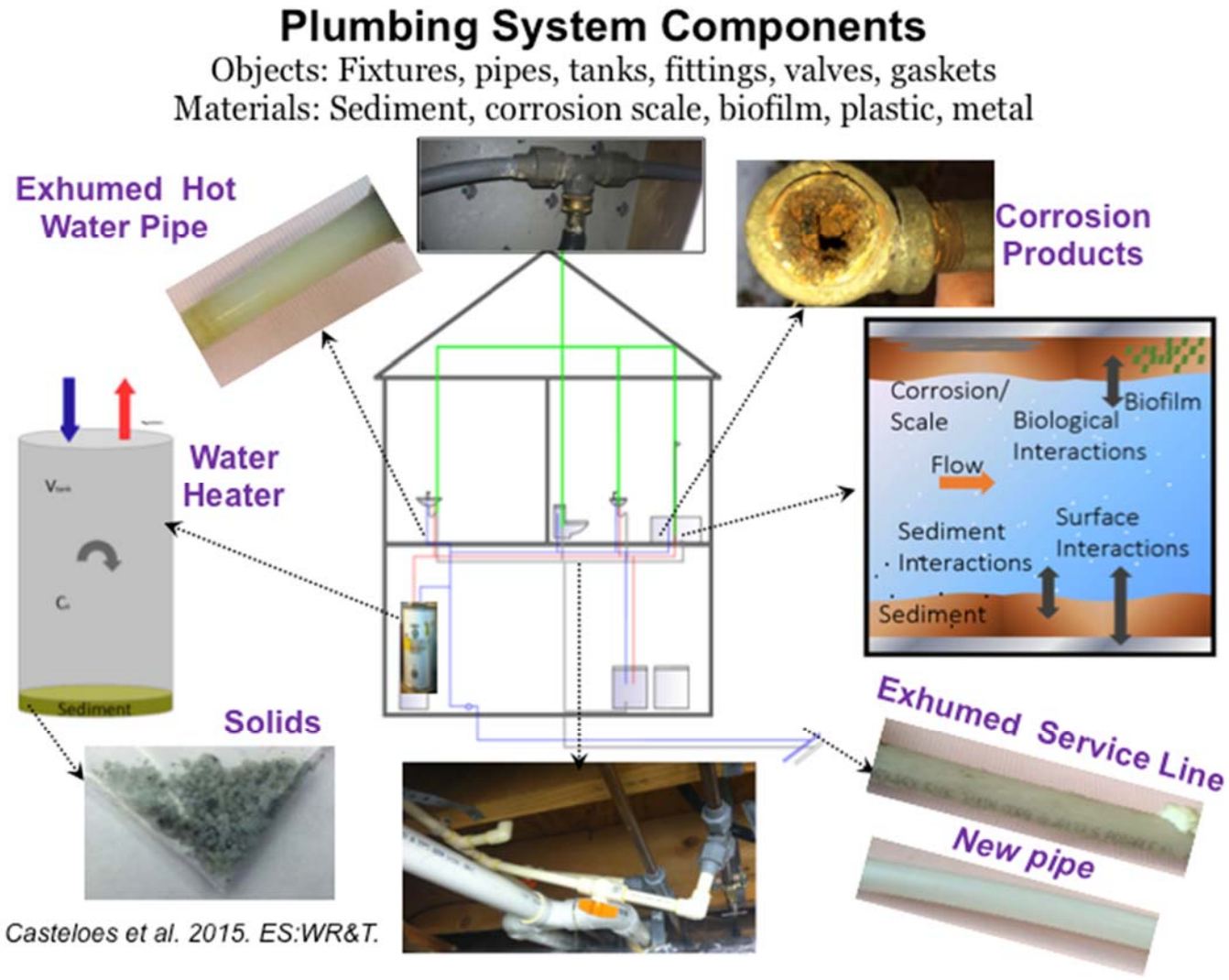


Figure 3.1 Example decision tree that will be used to determine distribution system flushing guidelines

PREMISE PLUMBING CONFIGURATIONS

Along with the identities and properties of contaminants for flushing from premise plumbing, the configuration of the systems themselves is the final critical determinant of flushing strategy. In plenum, the experts reviewed the components of premise plumbing and identified premise plumbing classes that could require specific flushing strategies and considerations. The premise plumbing configuration session was introduced by project PI Dr. Andrew Whelton, who provided an overview of the components of a residential premise plumbing. As shown in Figure 3.2, even a relatively simple residential plumbing system is comprised of numerous components and each of those components interacts differently with water resting in or passing through it.

System components such as water heaters have hydraulics that promote settling and can have significant sediment deposits, which interact with and detain contaminants passing through the premise plumbing. Further, water heaters and other large-volume devices are subject to non-ideal hydraulics (short-circuiting, stratification) that should be considered during flushing. The material and condition of surfaces contacting water for each component influence the fate of contaminants in premise plumbing. Surface materials most frequently employed in premise plumbing are listed in Table 3.5. It was noted that the various plastics used in premise plumbing can react in widely different ways with contaminants and that care should be taken not assume all plastics perform similarly together.



Source: Casteloes et al. 2015.

Figure 3.2 Residential premise plumbing components

Table 3.5
Commonly used premise plumbing materials

Component	Plastics	Other Materials
Piping	Polyvinylchloride (PVC) High-density polyethylene (HDPE) Crosslinked polyethylene (PEX) Polypropylene (PP) Chlorinated PVC (cPVC)	Copper Galvanized iron Concrete Lead Lead-lined steel Black steel Brass
Pipe Coatings	Epoxy (EP) Polyurethane (PU) Polyurea (PEUU)	
Faucets, Valves, & Fittings	Synthetic rubber (O-rings) PVC	Lead Stainless steel Brass Copper Aluminum
Gaskets	Ethylene-propylene-diene monomer (EPDM) [S,P] Butyl rubber (BR) Natural butyl rubber (NBR) Styrene-butadiene rubber (SBR) Neoprene	
Water Heater	Polysulfone (PSU) dip tubes	Steel Glass Ceramic interior linings Magnesium or aluminum sacrificial anode rod

Source: Casteloes et al. 2015

Typical components and dimensions of residential premise plumbing were estimated as (Casteloes et al. 2015):

- 140 ft hot and cold water pipe
- ¼" to ¾" diameter pipe size
- Water heater volume: 20-80 gal (but 1-120+ gal also)
- Recirculating loops
- Low-flow devices
- Point of Use (POU)/Point of Entry (POE) devices

Low flow devices are important to consider during flushing for two reasons. First, low flow devices restrict water flow and thus result in lower flow rates in a given time than conventional (non-low-flow) fixtures. Second, low-flow devices can include materials that interact with contaminants. Water heaters are diverse and can be "on demand" (i.e., no appreciable volume),

small (e.g., water heaters installed in mobile homes) or very large (more than 120 gallons). In most large buildings, hot water is delivered to taps in recirculating loops. Effective flushing of those loops requires consideration of both loop volume and configuration. Flushing of the entire loop might be done best using the most distal tap, but each tap on the loop is connected to the loop and there is a stagnant water volume between the faucet and loop that could require flushing, in addition to the loop itself.

After the introduction to residential premise plumbing and components, experts were asked to identify plumbing system components that could require flushing and building types that could require special flushing strategies. Components of both residences and large buildings identified in the session are presented in Table 3.6. Experts noted that general guidelines for flushing appliances are probably not practical and that appliances' operating instructions are the best source for information on flushing appliances.

Table 3.6
Premise plumbing components

Category	Components
Basic system components	Pipes, gaskets, fittings, faucets, showerheads
	Water heaters (on demand or with tanks)
Appliances	Refrigerators (with water dispensers)
	Washing machines
	Dishwashers
	Ice machines
	Humidifiers
	Coffee machines
	Dental devices (e.g., Waterpiks)
	Drinking water fountains
Other system components that do not deliver potable water	HVAC systems
	Make-up water for steam boilers (steam vents to living space)
	Fire sprinkler systems
	Outdoor/garden sprinkler systems
	Water features
	Cooling towers
	Misters
	Swimming pools and hot tubs and spas
Water treatment devices	Filters
	Softeners
Other	Recirculation pumps
	Water recovery

In considering the classification of buildings that have to be flushed differently, the experts noted that how a plumbing system in a particular building is flushed depends on

- The type of structure,
- Occupancy, and
- The operation of the system connected to the premise plumbing (whether it is a community or a transient system).

The types of buildings the experts identified as requiring specific flushing guidance are listed in Table 3.7. In discussions at the end of the session, experts suggested that rather than type of building, one can look at the components of a particular system to determine the flushing strategy. For example, general rules for flushing components such as pipes, tanks and faucets can be provided in lieu of guidelines for entire premise plumbing. For larger systems, one expert suggested activities like HACCP could be done to allow complex system managers and operators to prepare for flushing. HACCP and similar programs analyze systems as a whole and as individual components.

Table 3.7
Buildings with unique premise plumbing designs

Category	Subcategories and considerations
Residences	Single family
	Multifamily
	All sizes (row homes to mansions)
	Different service line lengths
Hotels	Large
	Small
Commercial buildings	Malls
	Office buildings
	Restaurants and food services
	Industrial facilities
Schools	Preschools, primary and secondary schools
	Universities (residence halls, food services and other interconnected buildings with specific flushing requirements)
Medical facilities	Hospitals
	Nursing homes
	Dialysis units
Correctional facilities	

FLUSHING STRATEGY DEVELOPMENT

On the second day of the workshop, participants were divided into two groups and both groups were asked to develop flushing guidance for two scenarios (same two scenarios for both groups). Beyond simply developing the guidance, the exercise was intended to allow the experts to identify critical data and knowledge gaps preventing development of flushing guidance. The breakout groups were asked to assume the role of a utility or public health agency in the position of issuing an advisory and providing guidance with only the knowledge currently in hand. This scenario currently faces all utilities and health agencies opting to conduct flushing.

The scenarios are presented in Table 3.8. The first scenario involved a nontoxic concentration of potassium permanganate and the second involved a more complex contaminant – diesel fuel. Diesel fuel is both toxic (via multiple exposure routes) and volatile and could potentially interact with plumbing components. Responses of the two breakout groups to the two scenarios are presented separately below.

Table 3.8
Flushing scenarios for flushing strategy development session

Scenario	Description
1 – a soluble, non-sorbing, non-volatile contaminant with no significant health effects	Customers complain that pink water is coming from their taps. After investigation, the utility determines there was a potassium permanganate overfeed at a plant. A do not use (DNU) order is issued. During the DNU order toilet flushing, clothes laundering and firefighting are allowed/advised. On the morning of the third day after the DNU started, the public health department and utility determine that residual potassium permanganate has been flushed from the distribution system and issue an advisory that all premises flush their premise plumbing.
2 – a volatile contaminant with significant potential health effects	During cleaning, a fuel oil delivery truck introduces 50 gallons of diesel fuel into a drinking water distribution system at a cross connection. Using hydraulic models, the utility is able to determine the possible extent of distribution system contamination and issues a DNU order to the impacted customers. Firefighting and toilet flushing are allowed. After two days the DNU order is lifted, but a do not consume order remains in place. Customers are advised to flush their premise plumbing.

Results from Breakout Group 1

Scenario 1: Flushing to Remove Potassium Permanganate Contaminated Water

The experts assumed that potassium permanganate was a conservative pollutant that was not reactive with pipe surfaces. This assumption was needed to simplify the scenario, but there is evidence permanganate (an oxidant) reacts with organics, biofilms, and metals. It was also assumed that the contaminant only presented an aesthetic concern similar to iron red water complaints. The recommended flushing guidance is outlined below.

- Initial 5 min flush, or until clear
  - Once through the house
  - Cold then hot
  - Start at the lowest level and work your way up
  - Flush water heater slowly
- Run the ice machine two or more cycles
- Filters – remove and replace
- Run washing machine one cycle

Experts recommended that staged flushing be performed by first flushing the tap closest to the point of entry to the home in order to avoid spreading the contaminant throughout the building. The closest tap would be flushed until the water was clear followed by flushing of distal taps until the water is clear. After the staged flushing, whole house filters should be replaced. The final decontamination step would involve running the washing machine for one cycle to avoid discoloration of the laundry.

It was suggested that when the utility and public health department issued the DNU advisory, it could have also recommended that premise plumbing owners and operators turn off ice makers and take other counter measures to protect appliances and equipment. The group also noted that the contaminant was not expected to have any significant impact on wastewater collection and treatment systems and that the DNU advisory also be accompanied by a notification that it was safe to wash contaminated water into sanitary sewers.

Scenario 2: Flushing to Remove Diesel Fuel

Since diesel fuel is a mixture of complex chemicals and is likely to adsorb to plumbing component surfaces, a longer flushing time would likely be required compared to potassium permanganate. The experts developed recommendations for flushing diesel fuel based on similar past events. It was recommended that staged flushing be performed by flushing the cold tap closest to the point of entry to the home for a minimum of 35 minutes followed by flushing hot water taps for 30 minutes. Distal taps in the home would then be flushed in a similar fashion. Since the fuel contains volatile compounds the house should be properly ventilated during the flushing procedure. After flushing, water samples would be collected to confirm that contaminated water had been removed from plumbing components.

Steps suggested for the diesel scenario are presented below. Those steps include specific recommendations for flushing residences and additional considerations related to the overall utility and health department response to the diesel fuel spill.

- Flush cold from lower to upper
- Flush water heater (though specific guidance could not be developed during the session)
- Use a visual indicator
- Change filters – whole house or point of use
- Although the DNU order was lifted, a do not consume order should be maintained until targeted testing inside houses shows safe for use. The determination of “safe for use” should be based on utility-based sampling plan (voluntary by occupant)
- Messaging on do not use vs do no consumer can be nuanced – public question of “is it safe.” This issue is addressed in the Drinking Water Advisory Toolkit
- Need to give clear testing guidance for others doing testing
- Reabsorption is possible and should be considered in the flushing strategy and follow-on responses
- Multiple premise plumbing flushing cycles may be required: flush-wait-flush if contaminants desorb from plumbing components into the newly replaced clean drinking water
- There should be a list of certified plumbers who could do the work for those who cannot. Alternatively, the response could use other groups such as firefighters, who would be cleared to conduct the flushing.
- Residences are relatively simple – need to address more difficult situations such as hospitals, dialysis, nursing homes, etc. (keep up-to-date list of critical customers)
- Medical equipment in residences needs special assessment

Numerous research needs and data gaps relative to the diesel spill were identified by the breakout group and are listed below.

- Medical facilities – how to address a more inclusive service population in guidance
- What does it take to turn over the water in a facility under perfect conditions (no absorption etc.) –hydraulic understanding of representative systems
- Rates of absorption in pipes for various materials and differing pipe
- Rebound risk after flushing
- Need for flushing other than distribution systems
- On issuing drinking water advisory or guidance, who has the legal authority to issue flushing guidance, on par with a drinking water advisory – avoid mixed messages and related problems
- Organics
- Health impacts of inhalation exposure and through other routes of exposure
- Relationship with regulation of discharges under an emergency condition
- GIS tool to offer site specific guidance based on building characteristics – use big data for inputs

Results from Breakout Group 2

Scenario 1: Flushing to Remove Potassium Permanganate

The second breakout group began analysis of the first scenario by making assumptions, including: the contaminant posed no significant health threat; the primary problem posed by the contaminant is aesthetic (pink or brown color); and that the concentration of the contaminant does not impact either flushing or health effects. Because the contaminant is readily visible, this scenario presents an opportunity to engage customers as part of the solution. For example, customers could be given tools such as color charts that would allow them to assess impacts on the water and to assess the effective of their flushing activities.

The breakout group summarized the flushing objective as turning over water in the premise plumbing. Steps in turning over the water were:

- Open up cold water faucet on lowest level without removing aerators
- Run until water is clear or for a specified time (calculations and methods for determining the time are presented below.
- Flush water heaters (no specific guidance was developed).

Breakout group 2 devoted significant effort to developing methodologies for determining flushing time. It was observed that knowing the bases for recommended flushing times benefits development of guidance and facilitates communication with premise plumbing owners and agencies concerned with flushing. A conservative estimate of time required for flushing residences uses the following assumptions:

- Faucet flow of 0.8 gal/min (assumes an aerator is installed on the faucet)
- Service lines have 5/8-inch diameter and the typical length of service lines can be estimated by the local utility based on the housing stock and typical configuration. For

example, row homes in urban settings typically have shorter service lines than suburban homes.
- Flow in the service lines is roughly plug flow (i.e., there is not significant backmixing and water flows through the pipe as a coherent slug).

Under these assumptions, the time required to flush the service line is $t = \left(\pi \frac{d^2}{4} L_{SC}\right) / 0.8\,\text{gal/min}$ where L_{SC} is a conservative estimate of the length of the service connection and d is the service connection pipe diameter. The numerator in the equation for time to flush is the volume of water in the service connection. Similar calculations can be made for time to turn over water at the most distant faucet in the premise plumbing. The breakout group assessed that estimating the required flushing time in this way provided a conservative estimate of required flushing time because it relies on a low flow rate typical of a low flow faucet and because it is based on a conservative estimate of service line length. For the potassium permanganate scenario, customers can provide an additional check on the suggested flushing time by flushing the longer of the required time until the water appears clear.

The breakout group's recommended sequence for flushing houses typical of Washington DC was:

- Run each cold faucet for 2 minutes or until clear:
- Proceed from low faucets to high faucets (assuming the lowest faucet is likely to be the faucet nearest the service connection)
- Flush all faucets, including shower/bath faucets
- Flush the water heater tank.
- Flush appliances – run the washing machine through one cycle (rinse cycle).

The group did not develop specific guidance on water heater flushing. Although emptying the tank provides the best contaminant removal, emptying provides logistical and safety obstacles to some system operators/home owners and alternative approaches such as flushing out lines for a specified duration should be considered for flushing guidance. It was also noted that water heaters can be large and that "fresh" and "old" water mix in the water heater. The latter observation means that very long water heater flushing times are required to lower contaminant concentrations to very low levels (e.g., reduction of contaminant concentration to 1% of the original concentration).

COMMUNICATION

The next workshop session was intended to frame communications about flushing, to present communication tools and strategies already available to utilities and to elicit utilities' flushing communication needs that have not yet been met. The session was chaired by project PI Lisa Ragain, who provided an introduction to the session.

The introductory remarks began with a discussion of language and terminology. The end goal of an advisory is to encourage a group of people to take a specific action. The likelihood that the action is taken is improved by

- Using terms as used in the vernacular (and not with the very specific uses of the drinking water community) and
- Relating the action that is being advised to a tangible and understandable benefit.

The term flushing is confusing to homeowners and premise plumbing operators. It is most often associated with toilet flushing and should be replaced with an easier to interpret/distinguish term such as water turn-over, water refresh, running the tap or other phrases that reflect the goal of exchanging water in the premise plumbing. The phrase “premise plumbing” itself is problematic and not entirely understood, even in the drinking water community. Historically, compliance with drinking water advisories has been uneven. Some customers view advisories with suspicion, resulting in non-compliance. Others could view advisories as unimportant and result in noncompliance. Still others will reinterpret and modify guidance materials. For example, some customers could run faucets for far longer periods than suggested in an advisory. Compliance could be improved if the broader goals of flushing advisories were stated in ways that are more compelling to customers. For some, a message that they are protecting their health is a compelling reason to flush. For others, protecting their premise plumbing investment promotes compliance.

An expert noted that flushing can become complicated and that messages about flushing might require layering. The session facilitator agreed with this assessment and suggested that a toolbox approach might be the best way to provide utilities faced with issuing flushing guidance with the layers of information required for a specific scenario. It was suggested that a toolbox or a set of messages and guidances could be posted on a national website and accessible to utilities. At present, there are no organizations maintaining such a website. If such a website were created, its credibility would be enhanced if it were backed by the public agencies likely to be involved in a spill response and a flushing advisory.

KNOWLEDGE GAPS AND RESEARCH PRIORITIES

In the final workshop session, experts were invited to identify knowledge gaps and research activities related to flushing. Unlike the rest of the workshop, experts were invited to consider all applications of flushing – inclusive of flushing to mitigate disinfection byproducts (DBPs), lead, and opportunistic premise plumbing pathogens. Research activities identified during the session are presented in Figure 3.3.

Improved understanding of premise plumbing systems

- Premise flushing model development, verification, and validation – determine what it takes to turn over water in a system; including commercial building.
- Assess the economics of flushing large occupancy and commercial buildings; determine the impacts of discontinued water flow on continuity of government and hospitals.
- Build large building flushing guidance upon findings for residences.

Develop flushing guidance

- Develop a model of nested conditions that lead to a flushing strategy – decision tree leading to strategy tied to action steps. Note that actions drive messages and actions are determined by contaminant properties/behavior.
- Develop classifications of contaminants that can be flushed similarly.
- Develop a model to estimate indoor air exposures due to flushing activity.

Improved understanding of the fate of contaminants in premise plumbing systems

- Pick a small number of contaminants; prioritize based on past incidents; determine how the selected contaminants behave in a pipe and on water fixture. Contaminants can be chosen because they are representative of a group (volatile, toxic, reactive, etc.).
- Conduct laboratory experiments evaluating the impact of flushing on concentration in premise plumbing (e.g., materials that sorb to premise plumbing components).
- Evaluate the impact of chemical properties on flushing efficacy; conduct studies to allow comparison with well-studied chemicals.
- Conduct short-term, high impact experiments, e.g., flushing studies of crude oil using pilot systems.
- Establish funding source and relationships for rapid response flushing studies.
- Conduct pilot and field studies for flushing strategy efficacy; pilot is only representative of the pilot site configuration. Rapid turn-around capability to understand basic efficacy of a flushing strategy.
- Link utilities to pilot facilities in national labs or research institutes for quick turn-around studies.

Evaluate the impact and effectiveness of flushing messaging and strategies

- Conduct a systematic evaluation of how messages resonated with consumers.
- Conduct a post-flushing retrospective analyses using flow data to determine customer response to flushing guidance; also analyze distribution pressure data to determine impacts of flushing on supply.

Enhance capacity for conducting flushing programs

- Develop a “strike team” for helping local utilities respond to emergencies.
- Integration of premise flushing as a viable public health intervention and through comparative analysis with current public health response toolbox (CDC, National Association of County and City Health Officials response guidance).
- Assess behavioral attributes of communities predictive of premise flushing efficacy during a drinking water contamination event.
- Develop models supporting public health and water utility collaborative approach to successful premise flushing during a drinking water contamination event.

Figure 3.3 Research needs to fill gaps and develop capacity for improved flushing guidance and application

CHAPTER 4
FLUSHING GUIDANCE

FLUSHING SINGLE-FAMILY HOUSEHOLD PREMISE PLUMBING

When contaminants are suspected to have entered the premise plumbing, the following procedure can be used by residents of single-family residences to flush their plumbing system. This guidance is designed to hydraulically turn over the water in a home and is appropriate for use for a contaminant that does not pose acute or long-term health risks to the people conducting flushing or living in the residence during and after flushing. Depending on the type of contaminant (nonreactive, volatile organic compounds, semi-volatile organic compounds, or sorbing compounds), additional protective measures or different flushing sequences, approaches or times may be needed to adequately flush the premise plumbing.

Experts at the WRF workshop acknowledged that studies have not been conducted to provide a foundation for specific guidance for flushing for all of the possible contaminant-plumbing material combinations and all the possible plumbing system layouts. Yet utilities must frequently issue flushing advisories and provide guidance. To address the need for a basic response to premise plumbing contamination, we have developed flushing guidance for the simplest possible scenario – turnover of water in a single-family residence (SFR) premise plumbing contaminated with a non-volatile, soluble, low toxicity contaminant. The resulting flushing guidance provides the minimum requirements for premise plumbing flushing. More complex scenarios (e.g., a volatile contaminant that poses a health hazard to the person flushing or to household residents) can be treated as special cases of the simple scenario and additional safety factors or precautions can be added to the guidance for a specific contaminant. Also, the rules and procedures underlying the SFR flushing guidance can be scaled for application to premise plumbing in larger building or that are otherwise more complex than SFR systems.

The following guidance for flushing a simple contaminant from a SFR premise plumbing is based on our best engineering judgment (informed by comments and recommendations from the workshop) and a review of past practices. As such more research is needed to develop evidence based guidelines.

Assumptions

- Contaminant(s) is nonreactive, non-sorbing, does not volatilize
- Flow rate = 0.8 gpm (EPA mandated minimum flow for low-flow faucets, Green and Maddaus, 2010); No point-of-use house or faucet filters are present anywhere in the building.
- Pipe diameter = 1 inches
- Length of service line = 150 ft (1.5 times greater than the average service line length in the US, NSF and ANSI, 2013)
- Total number of cold water faucets inside the residence = 4
- Total number of hot water faucets inside the residence = 4
- Concentration of contamination in distribution main = zero, non-detectable
- Flow in the pipes is plug flow (i.e., the contaminant is carried along with the water and there is very little mixing in the pipes)

- Target concentration after flushing = 1-log reduction (i.e., the flushing reduces the contaminant concentration in the water heater by 90%)
- Water heater tank volume = 80 gallons

Guidance

- Cold water plumbing should be thoroughly flushed before the hot water plumbing is flushed or used in any way. Avoid running water through endpoint devices (e.g., dish washers, clothes washers, POU devices, refrigerators, and ice machines) until the cold water plumbing has been thoroughly flushed. If the house has a point-of-entry filter, isolate the unit from the water system before beginning the flush protocol. If point-of-use filters being used, ensure that the filter is being bypassed.
- Begin by running the cold water faucet closest to the point of entry. Progressively, from closest to point of entry to furthest, open all the other cold water fixtures and allow the water to run for at least 20 minutes. Starting from the tap closest to the point of entry should avoid spreading the contaminant throughout the building plumbing. Remove and clean all aerators where possible.
- In bathrooms, begin by flushing toilets at least once. If a bathtub has bath tap and shower head, direct flow through the bath tap.
- Flush all external spigots for at least 10 minutes.
- After flushing all cold taps, re-direct bathtub tap flow to shower head, if applicable. These steps should remove contaminated water from the service line and cold water premise plumbing.
- Once the cold water pipes have been flushed, run the hot water tap closest to the hot water heater and proceed to simultaneously open all hot water fixtures. For the hot water flush, if a bathtub has bath tap and shower head, direct flow through the shower head first. Allow the water to run for at least 75 minutes and then turn off the faucets. This should drain the contaminated water from the heater and refill the tank with fresh water. Direct shower head flow to bathtub tap, if applicable. These steps should be effective at removing contaminants from the water heater. However, for information on draining and cleaning the water heater please consult the manufacturer.
- After flushing hot water pipes and the water heater, run empty dishwasher and washing machine and once on rinse cycle only.
- Replace all water filters (e.g., whole-house filter, refrigerator filter etc.) and empty ice from ice maker bin; run ice maker and discard 2 additional batches of ice.

Additional Considerations

- During the flushing, if a perceptive drop in pressure is evidenced by a decrease in flow, then flush each line and close the tap before opening the next tap.
- For multifamily homes, the same flushing procedure should be used. However, for larger buildings with distinct pressure zones, each pressure zone should be flushed separately using the protocol outlined above.

Justification

Determination of Faucet Flushing Time

The minimum flushing time is determined by the time required to transport clean water from the distribution main to faucets in the building. Assuming four faucets in the building, a flow rate of 0.8 gpm for each faucet, a service line length of 150 ft, and a pipe diameter of 1 inch, the minimum flushing time can be calculated as follows (Burlingame et al. 2012):

$$Flushing\ time = \frac{7.48\ gal}{1\ ft^3} \times \frac{3.142\ \times\ (\frac{Service\ line\ diamater\ (ft)}{2})^2 \times\ Length\ (ft)}{Number\ of\ faucet\ \times\ Flow\ rate\ (gpm)}$$

$$Flushing\ time = \frac{7.48\ gal}{1\ ft^3} \times \frac{3.142\ \times\ (\frac{1/12\ ft}{2})^2 \times\ 150\ (ft)}{4\ \times\ 0.8\ gpm}$$

$$Flushing\ time = 2\ minutes$$

The minimum flushing time to clear the service line would be 2 minutes. Since contaminant properties, building materials and plumbing configurations can vary widely, a safety factor of 10 and 5 was used for indoor faucets and outside spigots respectively. Therefore, a flushing time of 20 minutes and 10 minutes was recommended for indoor faucets and outside spigots, respectively.

The same procedure described above can be used for developing flushing guidance for commercial and multifamily buildings.

Determination of Water Heater Flushing Time

Assuming that the water heater hydraulics are similar to a continuously stirred tank reactor, the minimum flushing time required to reduce the concentration of a given contaminant by 90% can be calculated as follows (Casteloes et al. 2015):

$$\frac{C}{C_0} = e^{-\frac{nQ}{V}t}$$

where:

C = Final concentration
C_0 = Initial concentration in the tank
n = Number of faucets
Q = Flow rate = 0.8 gpm; including aerator restricted flow
V = Tank volume = 80 gallons
t = Flushing time, minutes

$$t = \frac{Vln|0.1|}{nQ}$$

$$t = \frac{V\ \times\ ln|0.1|}{nQ} = \frac{80\ \times\ ln|0.1|}{4\ \times\ 0.8} = 58\ minutes$$

The minimum flushing time for an 80-gallon tank was estimated to be 58 minutes. A safety factor of 1.3 was applied which accounts for the volume of water sitting in hot water pipes and the water tank. Therefore, a flushing time of 75 minutes was recommended.

Expert Panel Flushing Guidance

The following is draft language of the step-by-step procedures that customers can use to flush their premise plumbing applying the flushing times and strategies developed in this section.

Flushing Cold Water Taps

- Begin by running the cold water faucet closest to where water enters the house. Starting from the point closest to where water enters the house, open all the other cold water taps sequentially and allow the water to run for 20 minutes.
- Next, flush toilets at least once. If a bathtub has a spout and showerhead, direct flow through the spout.
- Flush all outside spigots for 10 minutes.
- After flushing all cold taps, direct the flow from the bathtub spout to the showerhead, if applicable.

Flushing Hot Water Taps and Water Heater

- Run the hot water tap closest to the hot water heater and proceed to open all hot water taps.
- If a bathtub has a spout and shower head, direct flow through the shower head first.
- Allow the water to run for at least 75 minutes and then turn off the faucets.
- If applicable, direct shower head flow to bathtub tap for 2 minutes.

Flushing Appliances

- Run empty dishwasher and washing machine once on rinse cycle.
- Replace all water filters (e.g., whole-house filter, refrigerator filter etc.) and empty ice from ice maker bin; run ice maker and discard 2 additional batches of ice.

CHAPTER 5
COMMUNICATIONS STRATEGY

INTRODUCTION

Water utilities and regulatory agencies play an important role in ensuring that safe, reliable drinking water is delivered to the public and that the public knows how to maintain high water quality in their premise plumbing systems. Premise plumbing flushing is an important instance in which the public needs to act to ensure safe water. Unexpected events can introduce contaminants into drinking water distribution systems and those contaminants can be drawn into the premise plumbing. In many cases, flushing (opening taps and turning over water in premise plumbing and fixtures and appliances) is an effective strategy for reducing contaminant concentrations below levels of concern. In this section of the report, a communications strategy for guiding the public through premise plumbing flushing is presented.

As noted in Chapter 3, flushing premise plumbing is deceptively complex and guidances issued in the wake of previous contamination event responses have differed widely both in content and in communications strategies. Even as more data need to be gathered on premise plumbing operation and maintenance, flushing water pipes in homes and commercial/institutional buildings after contamination events remains a highly used strategy for averting and mediating the health hazards that can accompany a contamination event. While this project would focus on decontaminating plumbing after a contamination incident, it also is necessary to understand principles for good drinking water communications concerning contamination so consumers get accurate and understandable advice and instructions on what they can do to protect their premise plumbing and their own health.

This section is designed as a stand-alone product. The primary references used to develop the structure and content of the flushing communications strategy were the Centers for Disease Control and Prevention Drinking Water Advisory Communications Toolbox (CDC, 2013a) and "A Field Guide to Designing a Health Communications Strategy" (O'Sullivan et al. 2003).

SUMMARY OF STRATEGY

This strategy is guidance to public information specialists at water providers and public health agencies. It includes an overview, a situation analysis, a critical review of past flushing guidances, and suggested communications channels and message tools for various audiences. The objective of the strategy is threefold:

- to educate the public – homeowners and owners of commercial and institutional buildings – about the need for and steps involved with the guidance devised in the Experts Workshop for washing "old" water that might contain contaminants out of the premise plumbing and replacing it with fresh water that is more likely to be contaminant-free,
- to convince them to adopt this guidance, and
- to provide them resources that will help them answer questions and support adopting the flushing guidance.

To meet these objectives a communications strategy should employ a layered or surrounding approach, in which the target audience gets messages that build upon each other via print, broadcast, radio, social media, and person-to-person tools whose content is in concise and understandable language.

This plan does not contain budget or implementation sections as it is assumed each individual provider and agency will make decisions on those topics according to its own needs and resources.

SITUATION ANALYSIS

Purpose

While this project focused on decontaminating plumbing after a contamination event, it also is necessary to understand the principles for good drinking water communications during and after contamination events or for flushing other than in response to contamination. Drinking water-related communications with the public falls into three categories:

- Emergency
- Routine/Regular
- Maintenance and awareness
- Emergency flushing communications includes flushing guidance issued following contamination events, main breaks and other conditions that cause a sudden degradation in water quality in distribution systems.

Routine flushing communications include guidance on flushing in concert with mains flushing, guidance on maintaining water-using appliances and water heaters, and general advice on flushing to address chronic water quality problems such as disinfection byproduct formation in premise plumbing and loss of disinfectant residual during periods of stagnation. Maintenance and awareness communications can reinforce the message that the premise plumbing is a building owner's responsibility and that water quality can degrade in premise plumbing.

Currently, customers receive insufficient and hard-to-understand communications on basic flushing procedures. What they do get often was created and sent to them in the heat and haze of a crisis and may be hard to understand. Further, in past events there has been little or no follow-up to gauge the effectiveness of flushing communications. This section offers a basic communications strategy that utilities can adapt to educate consumers about flushing premise plumbing and suggestions on how to evaluate the efficacy of information sent to and collected from utilities.

Issues Addressed

The 2014 Elk River, West Virginia, MCHM spill illustrated the potential for widespread exposure to a hazardous contaminant via premise plumbing. It also illustrated the need for clear and consistent communication to the public. After the Elk River crisis, toxicologists determined that the health impact on the public of MCHM was likely minimal (though that finding is still disputed). During the crisis, however, government agencies and others issued conflicting information about the potential health impacts, but also how to flush premise plumbing. Conflicting information can increase difficulty in enlisting the public's trust and cooperation during remediation efforts.

The public health issue involved in flushing premise plumbing is illness associated with exposure to contaminated water. Those contaminants could be associated with increased risk of gastrointestinal illness, respiratory illness, reproductive problems, neurological disorders, and other medical conditions. The CDC emphasizes the importance of considering susceptible populations when identifying hazards after a contamination event, noting that "Infants, young children, pregnant women, the elderly, and people whose immune systems are compromised because of AIDS, chemotherapy, or transplant medications, may be especially susceptible to illness from some contaminants." For example, specific flushing guidance could be especially important for kidney dialysis units if cyanotoxin concentration in treated water exceeds or even approaches current health advisory levels.

The importance of a communications strategy to help the public manage drinking water related health risks was shown in a recent study of compliance with boil-water advisories (Vedachalam et al. 2016). In that study, a meta-analysis of 11 boil-water advisory reports showed that boil-water advisory effectiveness strongly depends on implicit public understanding and compliance. Compliance in boiling drinking water was high, but compliance with other aspects of boil-water guidance was low. Further, the study pointed out the importance of follow-up of guidance provided to the public to determine compliance and to ascertain whether communications strategies and tools were effective.

A non-health concern related to flushing premise plumbing is public confidence in water providers and public health agencies. Water customers are likely to be apprehensive when told a contaminant might have entered their building through the water supply. That apprehension could be exacerbated if conflicting information is posted on social media channels or other non-mediated information sources. In past contamination events, conflicting information and apprehension led to distrust of the water provider. This loss of confidence is particularly troubling given that a loss of trust in the water provider could result in reduced compliance with flushing guidance that the water provider issues.

Context

In extreme circumstances, addressing contamination premise plumbing likely would require large-scale remediation by the government or some party other than the premise plumbing system. However, an easy, do-it-yourself practice that consumers can use to try to mitigate ill effects or avert them is to flush the premise plumbing (pipes, water treatment devices, water tanks and water-using appliances) in homes and commercial/institutional buildings. The backdrop to the creation of this flushing guidance includes recent oil spills, the chemical spill in West Virginia, and a scare in Toledo from cyanotoxins, which are produced by microorganisms in polluted, warm water. Consumers' ability to flush their own premise plumbing is undercut by insufficient or unreadable instructions on what to do. Communications must be understandable to multiple audiences and stakeholders, including the public, scientists, and public health officials.

Information Gaps

The CDC Drinking Water Advisory Communications Toolbox (CDC, 2013a) is the best source for evaluations of drinking water communications. As such, we used the principles and findings of the research from the *Toolbox* as the model for this project. Another model drawn upon for the communications strategy is *A Field Guide to Designing a Health Communications Strategy* from Johns Hopkins Bloomberg School of Public Health/Center for Communications

Programs (O'Sullivan et al. 2003). The evaluation of the project and the recommendations in this report are further supplemented by research and evidence-based practice of water systems in the National Capitol Region (Arlington County; Alexandria, VA; DC Water; Fairfax Water; Prince William County Service Authority; Rockville, MD; Washington Aqueduct; and WSSC in coordination with the Metropolitan Washington Council of Governments [COG]). Beyond the *Toolbox*'s advisory guidelines, few broad communications strategies exist for giving consumers understandable information about when, how, and why they should flush water pipes in their homes and in commercial and institutional buildings. Also lacking is a long-term plan to communicate with consumers about where they like to get their information, what information they need or would like to get, whether information they have received has been understandable, and if they acted upon it.

COMMUNICATIONS STRATEGY

Objectives

The primary objectives of this communications strategy are to assist water provider and government agency communication specialists and staff to:

- Create tools that inform key audiences about the premise plumbing guidance based on the Experts Workshop on Flushing Guidance for Consumer Premise Plumbing and Service Lines to Avoid or Address a Drinking Water Advisory held in 2015 (see Chapter 3)
- Create understandable and concise tools for each audience on how to flush your home/office building/institution plumbing
- Disseminate this information effectively and promptly when a contamination event has occurred
- Send follow-up information to reinforce the messages
- Provide a mechanism for customers to ask questions or get additional help.

Audiences

Table 5.1 shows five likely audiences for messages. Different sites and circumstances might have different audiences, different flushing strategies and different levels of understanding of the operation of premise plumbing.

Table 5.1
Audiences for different sites and circumstances where flushing could be recommended

Audiences	Type	Example	Notes
Customers			
Residential	Single Family	Houses, townhouses	
	Multi Family	Apartments, duplexes	
Building Managers	Commercial/Business	Office buildings, restaurants	
	Institutional	Medical facilities, universities, schools	
	Residential	Apartment complexes, assisted living	
Non-Public Health Public & Elected Officials			Preferred customer information source
	Director of Public Works/Utilities		
	Chief Administrative Officers (CAOs)	County/City Managers	
	County Councils/Mayors		
	Fire Chief/Fire Marshall		
Public Health Officials			
	County/City/State		
	Medical Officer/Health Official		
	Environmental Health	Inspectors Sanitarians	
	Community Health		
	Occupational Health		
Plumbing and building professionals			
	Plumbers		
	Inspectors		
	HVAC		

It is common practice in the drinking water community to refer to "communications to the public." However, there is no single "public" for any given event. Differentiating audiences for different types of events is critical to encouraging customers to take the appropriate action – and to identifying populations who may be more susceptible to the ill effects of contaminated water. Differentiating audiences is even more critical for communications on flushing premise plumbing since the different audiences have different responsibilities and sensitivities. Factors that differentiate audiences include:

- Geographic
- Age
- Marital status
- Income
- Educational level
- Primary language

Once the differences are determined, best approaches in creating and disseminating information might become clearer, for example, writing advisories in Spanish and placing them in Spanish-language newspapers or on websites.

Strategic Approach and Rationale

The approach is oriented to empowering the customer. It will do so by layering multiple messages and communications channels to convince residential, business, and institutional customers that employing the new guidance for flushing is good for their health and easy to do and to educate them about this guidance. The reasons for this approach are as follows:

1. Water can become contaminated and pose a health risk.
2. Consumers often think that only measures taken by their water utility can help clean or maintain cleanliness of the water pipe systems in their homes or commercial/institutional buildings.
3. In the event of a contamination, it is important to reopen schools, restaurants, etc., as soon as possible.

Message Formulation

The four communications points message content is likely to address are (1) information on why the customer is being asked to flush their premise plumbing, (2) the importance of refreshing the water in their premise plumbing; (3) how to flush their drinking water pipes of contaminants; and (4) contact information for customers who have questions or feedback. Additional content will depend upon the event that prompted flushing, what audience is being addressed, what information you want them to absorb, and what action you want them to take. The following important considerations, which reflect the main challenges in communicating about flushing premise plumbing systems, must be taken into account (Roy et al. 2015):

- The reading level and health literacy of the audience
- Language complexity and the use of technical jargon in advisories
- Informational design and graphics

- Clarity in addressing recommendations
- Public distrust of tap water based on prior contamination events and media reports about them.

Messages must not only impart information, but also address challenges associated following a premise plumbing guidance. To that end – and to heighten the likelihood of customers embracing the flushing guidance – the points below should be part of messaging:

- Premise plumbing flushing is easy to do, costs almost nothing and requires no special tools, physical strength, or knowledge beyond the flushing guidance. It does not involve sewage.
- Maintaining plumbing in residences and commercial buildings/institutions is the responsibility of the owner of the building – not the water provider.
- After receiving an advisory informing them that a contamination event has occurred, customers should replace existing water in their pipes with new water using the guidance suggested by the water provider.

Readability

Water advisories that utilities sent to customers allow for a review of current practices. They also offer lessons for the newly created guidance in this report by learning from examples and making messages as understandable as possible for customers based on the research. Eight guidelines for flushing premise plumbing were collected from U.S. and Canadian utilities and public health agencies. Six of the eight guidelines are presented in Appendix A. The readability of these guidances was evaluated using the Flesch-Kincaid readability tests, which have been used extensively in the education field to assess how understandable the materials are. The tests consist of two inversely related components: the Flesch reading ease (Equation 5.1) and the Flesch-Kincaid grade level (Equation 5.2) (Kincaid et al. 1975).

$$Flesch\ reading\ ease = 206.835 - 1.015\frac{(Total\ words)}{(Total\ sentences)} - 84.6\frac{(Total\ syllables)}{(Total\ words)} \quad [5.1]$$

$$Flesch - Kincaid\ grade\ level = 0.39\frac{(Total\ words)}{(Total\ sentences)} + 11.8\frac{(Total\ syllables)}{(Total\ words)} - 15.59 \quad [5.2]$$

Table 5.2 gives examples of publications and their reading ease as assessed through the average words in a sentence. Research has found that the average American reads at a 7th to 8th grade level (Kutner et al. 2006); the National Institutes of Health recommended in 2013 that public health communications materials be written at a 6th to 7th grade level. The readability of the evaluated guidances ranged from 41.2 to 70.9 with a grade level between 6.6 and 12 (Table 5.3). The flushing guidance developed based on expert panel input (see Chapter 4) was reformatted to ensure that the grade level and readability were within the ranges recommended for public health communications. Overall, key elements that improve the ease of understanding advisories include checklists, bullet points and graphics for each step.

Table 5.2
Analysis of readability of flushing materials

Style	Flesch reading ease	Average words/sentence	Magazine type	Example	Estimated school grade completed
Very easy	90-100	8 or less	Comics	Harry Potter and the Sorcerer's Stone, Chapter 2	4th
Easy	80-90	11	Pulp fiction		5th
Fairly easy	70-80	14	Slick fiction		6th
Standard	60-70	17	Digests	Readers' Digest	7th-8th
Fairly difficult	50-60	21	Quality	US Department of Defense documents	Some high school
Difficult	30-50	25	Academic	Harvard Law Review	High school/some college
Very Difficult	0-30	29 or more	Scientific		College

Source: Adapted from Roy et al. 2015

Table 5.3
Water system flushing advice evaluation

Water System	Event	Date	Reading Ease	Grade Level
Expert Panel Guidelines	General advice	EPA	68.5	7.1
Middleton, WI	Discolored water	N/A	54	9.6
Walkersville, MD	Boil water advisory	January 2008	43.8	12
Prince Albert, Saskatchewan	Boil water advisory	March 2012	54	9.8
Charleston, WV*	MCHM chemical spill	January 2014	54	9.6
Toledo-Lucas County, OH	Microcystin	August 2014	54.5	9.5
Washington, DC	Petroleum smell	December 2014	46.5	10.5
Syracuse City, UT	Boil water advisory	June 2015	41.2	10.6
Glendive, MT	Benzene	January 2015	70.9	6.6

* This flushing guidance is specific to West Virginia American Water, and other flushing procedures were issued by the State of West Virginia and a nonprofit organization (http://ftpcontent.worldnow.com/wowk/howtoflush.pdf).

Other principles of effective writing should be used to make advisories and instructions as clear and as lively as possible, particularly to the general public. Avoid jargon. Don't make customers guess at what you want them to do – express desired actions simply and respectfully. Do not sound like you are scolding the customer. Use the active rather than the passive voice.

Decide how you want to frame the content of your communications. Research shows two types of frames: a "gain-framed" approach (benefits of taking the action) and a "loss-framed" approach (the costs of failing to take the action; Rothman et al. 2006). "A compelling body of evidence Supports the thesis that gain-framed messages are more effective when promoting a prevention behavior while loss-framed messages are more effective when promoting a detection behavior such as getting a mammogram (Rothman et al. 1999).

Terminology

Word choice (not only jargon) can be a significant obstacle to audience comprehension of advisories and, therefore, of the adoption of the desired behavior change. To enhance the likelihood that people will use the flushing guidance, communication to them should be free of jargon and technical terms, and should make clear the tangible benefits they could realize if they flush their premise plumbing as suggested here.

The term *flushing* can be confusing to homeowners and to premise plumbing operators since it more often is associated with toilet flushing. Communications to the public should clearly state that *flushing* in this instance means turning on water in plumbing and in appliances that use water, and replacing existing water with fresh water. That wording should be understandable as long as it is clearly defined. Alternative wording – as long as it is clear such as "running the tap" – could be used as well.

The phrase *premise plumbing* is problematic because it is jargon and, even for those who might understand what premise plumbing means, questions persist about which part of the water system is considered premise plumbing. Alternatives could be *building plumbing systems* or, perhaps just *plumbing systems*. Again, a clear definition might be required, or put in a Frequently Asked Questions section of an advisory/message, making clear that building plumbing could include appliances that use water, such as washing machines or ice makers.

Channels and Tools

Each jurisdiction will have its own circumstances and, possibly, own research showing how their customers prefer to receive information. (Utilities that have not done such research could consider conducting focus groups/surveys on what communications channels their customers utilize and which they prefer as a primary information source.) Table 5.4 provides examples of generic messages to the general public and channels that utilities can use as a springboard for their own communications strategy. Different tools and channels likely will be used for different audiences.

Below are the questions that utilities and others should ask when selecting communications channels for advisories and other messages:

- What is the purpose of this specific message?
- Who is the audience?
- What is the level of urgency?
- What type of advisory is needed?
  - Broadcast
  - Electronic
  - Print media – newspapers, leaflets, door hangers, signs
  - Radio

- Person-to-person/word-of-mouth

Channels

Person-to-person/word-of-mouth can be a very effective channel for making customers aware of advisories and prompting action. Word-of-mouth is often the means by which most people learn of advisories, find information they trust and take action (CDC, 2013a). While it is effective, the caveat for this channel is that it is not the preferred means of communications for most people – public official notification is the preferred means of communications. This contrast of "most effective" vs. preferred requires a twofold communications strategy. A primary objective, then, is to promote and encourage word-of-mouth communications with accurate information. Secondary is to ensure public officials are communicating in broadcast and electronic media.

Table 5.4
Examples of communications channels/messages

Channel	Channels details	Notes
Broadcast	Local network and community-access channels	Example: public service announcement.
Internet	On utility's front page and payment page; email; social media	Clearly official advisory that refers to website with flushing instructions
Mobile phones	Text messages	Text message must be clearly official. Refer to website with instructions.
Print	Fit instructions in with routine utility/drinking water communications and/or as separate mailings.	Instructions could be accompanied by illustrations.
Person-to-person	Hold community meetings; pass out instructions; provide explanations; ask for questions.	Important for reaching epidemiologically susceptible populations; instructions should be accompanied by illustrations or photos

Communications to plumbing and business inspectors could include information on these topics:

- Backflow
- Inspections/reopening
- Connection to plumbing and HVAC professionals
- Understanding of pipes, housing stock, configurations

Communication Tools

It is assumed that water providers and public health agencies will craft their own messages/tools tailored to their own circumstances and needs. Appendix A presents flushing instructions issued to customers in response to past events, and Appendix B includes a list of possible questions for a Frequently Asked Questions feature and a post-flushing checklist of the steps customers should have taken.

DISCUSSION

This broad communications strategy is offered as a first step in a multi-step process, particularly in the event of a contamination emergency. The guidance and this strategy should be posted on multiple websites as a resource for the public, water providers and public health officials. The information in this communications strategy reflects the judgment of a large group of experts based on the best information available at this time and is meant to serve as an interim guidance and strategy. Ultimately, further research needs to be done to confirm best practices so that this guidance can be revised according to evidence-based findings.

Water providers and public health agencies also should consider conducting research to assess the local media landscape and their customers' relationship to it. The assessment should include asking whether customers have mobile phones and access to the Internet and television. Focus groups, which should be conducted among all of the audiences and stakeholders, could help ascertain which communications channels customers look to for initial and follow-up information. After advisories are sent in the wake of a contamination event, utilities should conduct an evaluation to determine whether information was read and action was taken.

MANAGEMENT CONSIDERATIONS

As noted earlier in this report, some aspects of a communications strategy have been left out since each water provider and public health agency has its own needs, resources, administrative procedures and, in many cases, its own communications specialist. Offered below are the management considerations that often are detailed in a communications strategy.

- Identify lead organization and partners who will collaborate with you.
- Define roles/responsibilities.
- Outline how partners will work together.
- Timeline.
- Budget.
- Plan for monitoring/evaluation activities.

APPENDIX A
GUIDANCES FROM PAST FLUSHING ACTIVITIES

FLUSHING PROTOCOLS EVALUATED FOR READABILITY

The following six protocols (Middleton, Prince Albert, Toledo-Lucas County, DC Water petroleum smell, Syracuse City, Glendive spill) are examples of some of the procedures that were evaluated for readability. In some cases, the reading level was above that recommended by public health experts. As such, we recommend that the draft guidance developed in Chapter 4 be used as a starting point for utilities.

Middleton Water

INFORMATION ABOUT DISCOLORED WATER

Occasionally Middleton Water receives consumer questions or complaints regarding the appearance of drinking water, specifically iron-tinted discolored water. There are two major sources that can cause water to be discolored –
1)…flow changes in the water mains caused by a main leak or an open fire-hydrant, or..
2)…the water pipes in your property, often from a failing hot water heater.

Why is the water discolored in my property?

Iron-tinted discolored water may occur because of sediment in the pipes or rust which has built up on the inside walls of older water mains. This sediment can be disturbed and subsequently suspended in the water due to an increase or change in water flow which may be caused by water main breaks, routine maintenance, flow direction change or the use and flushing of a nearby fire hydrant.

Failing hot water heaters in properties are also a source of discolored water. If the discoloration comes only when you run the hot water in your property, check the condition of your hot water heater. Discolored water from the cold water faucet usually signals an issue with the water mains in the street or the property's internal plumbing.

Discolored water can be a chronic problem in areas where there are older cast iron mains. Replacement, rehabilitation and cleaning of these older mains will provide relief - however such solutions are expensive and take time. It is important to call Middleton Water when you have a chronic problem, so we can try to provide a temporary solution until the main can be renovated.

Is discolored water dangerous?

No. Discolored water is not a health threat even though it is not very appealing to drink. Even very low levels of iron can color the water.

What should I do if I have discolored water?

Middleton Water recommends that you flush your water until you get clear water from the main. If it is still discolored after several minutes of flushing, you may need to wait a couple of hours until the sediment settles, and the water in the main clears. Then try flushing again. If it does not clear within a few hours, please call again. Middleton Water may need to flush the main.

When the water is discolored, it is recommended to not do laundry or run the hot water (to prevent sediment getting into your hot water tank). If it is necessary to do laundry, use stain remover or Tide detergent with the wash. Use of chlorine bleach is **NOT** recommended, as this could make the situatio worse. Do not dry clothing in your dryer.
Another option for washing the clothes again is a product called **Red B-Gone**.
DO NOT SMELL DIRECTLY….it is a strong chemical solution. Do not use with detergent. View this product description and directions at:

http://www.red-b-gone.com/instructions.html

http://www.proproducts.com/Libraries/MSDS/E_Red_B_Gone.sflb.ashx

The City will provide a 6oz. bottle upon request.

Filtering or treating the water may remedy chronic or persistent iron-tinted water problems; however Middleton Water does not endorse specific filtering devices. If you decide to use a filtration or treatment device in your home we recommend use of a National Science Foundation (NSF) listed device. In addition, we strongly recommend that the device be maintained according to the manufacturer's instructions. Failure to maintain this type of equipment properly may make treatment ineffective and may create the potential for contamination.

Source: Courtesy of the City of Middleton

Prince Albert Flushing Guidance

Procedure for Flushing Water Systems AFTER an Emergency Boil Water Order

The flushing and cleaning steps contained in this document should be completed by all users of the Prince Albert water system **AFTER** the emergency boil water order (EBWO) is lifted. The steps described are to ensure that your water service and home plumbing has been adequately flushed. If these steps are not completed, unsafe water may remain in a plumbing systems.

Read through this information and check off the things that apply to your home. Then follow the instructions for each item you check off. The instructions in this document are routine in nature and in most cases can be found in the owner's manual. If you find that you are unsure or require assistance, consider asking a friend, neighbour or relative. You can also contact a local plumber or contact one of the agencies below.

Further Information and Contacts:
Please watch and listen for further instructions from your water utility, the Prince Albert Parkland Health Region and the Ministry of Environment. Related information may be available on:

www.citypa.com
www.princealbertparklandhealth.com

You can also contact the following agencies for more information:

Water Treatment - Saskatchewan Ministry of Environment, PA	306-953-3369 or 306-953-2296
Household Plumbing - PAPHR, Public Health Inspection	306-765-6600
General Inquiries - City of Prince Albert	306-953-4900
Rural Water Users - Prince Albert Rural Water Utility	306-764-6200

Information in this document
This document identifies the steps every user served by the Prince Albert water supply and distribution system should take. Details on each step are available on the pages noted. Additional steps are required for rural users and properties that are not single-family homes (e.g.: apartment/condo buildings with shared water service).

Please read these instructions carefully. Individuals only have to complete those steps that are applicable to their plumbing system. All users served by the Prince Albert waterworks need to complete the following:

- Step 1: Flush the cold water plumbing in your building or home (see page 2)
- Step 2: Flush the hot water plumbing in your building or home (see page 2)
- Step 3: Ensure that the water softeners, water filters and other water treatment or conditioning equipment are safe to use (see page 3)
- Step 4: Flush and clean other water using appliances (see page 3)
- Step 5: Discard potentially contaminated food and water (see page 3)

Appendix A: Cleaning and flushing instructions for specific devices (pages 4-7)
Appendix B: Special instructions for owners and residents of buildings that are not single family homes (page 8)

Notes: If your are in doubt about the instructions, consider asking a friend, neighbour or relative for assistance, contact the manufacturer, or seek the services of a trained professional such as a plumber. Always follow equipment manufacturers flushing and disinfection instructions if available.

1

Procedure for Flushing Water Systems AFTER an Emergency Boil Water Order

Specific Instructions for All Users of the Prince Albert Water Supply

Before you begin, make sure you have the following items available:

- Owner's manual for any devices that will require flushing. If there is a difference between the advice in this document and the owner's manual, follow the owner's manual.
- Pliers and adjustable wrench
- Garden hose
- Fresh unscented bleach (bleach works less over time, scented product will leave tastes/odours)
- Wet-dry vacuum or sump pump *(for PA Rural Water Utility users only)*

NOTE: If in doubt seek the services of a trained professional such as a plumber.

Step 1: Flushing Cold Water System:

To ensure that each stage of the procedure is followed, please check off each action as it is finished.

- ❑ 1) If applicable, disconnect your water supply from the water softener and all other treatment devices prior to the start of flushing. *(See Step 3 (Page 3), or Appendix A (Pages 6-7) for water softeners or other treatment devices prior to reconnecting to the water supply)*
- ❑ 2) If possible, remove (i.e. unscrew) aerators on taps to ensure enough water flow through the tap.
- ❑ 3) Individually flush each cold water tap for 5 minutes.
- ❑ 4) When weather permits, outdoor taps should be flushed.

While completing cold water flushing, try to refrain from using water at other fixtures (such as turning on other taps) during the flushing procedure, as you may introduce particles into your piping. There may be high levels of chlorine in the water that can cause odours when you are flushing your water system. Levels of chlorine in the water delivered to you will be reduced after the Emergency Boil Water Order is removed.

Step 2: Flushing Hot Water System:

To ensure that each stage of the procedure is followed, please check off each action as it is finished.

Take Appropriate Safety Precautions – Hot water can cause serious burns! Be Careful!

Normal hot water temperatures (greater than 113F or 45C) are sufficient to kill the organisms of concern. People should not increase the temperature of their hot water tanks. Increasing the temperature of a hot water tank may result in serious scalding or thermal shock. (**Individuals in multi-unit dwellings with shared hot water should see Appendix B, Page 8).**

- ❑ 1) If you are unsure of your hot water tank temperature your tank should be flushed according to Appendix A1, Page 4, or
- ❑ 2) If you are confident your hot water tank temperature is greater than 113F or 45C, individually flush each hot water tap for 5 minutes.

While completing hot water flushing, try to refrain from using water at other fixtures during the flushing procedure, as you may introduce particles into your piping. Please see Appendix A (Page 4-5) for information regarding hot water tanks.

Procedure for Flushing Water Systems AFTER an Emergency Boil Water Order

Step 3: Water Filters, Softeners, Treatment Units or Conditioners:
To ensure that each stage of the procedure is followed, please check off each action as it is finished.

- ❑ Disposable-type filter cartridges should be discarded, including those in refrigerators and ice making units.
- ❑ If the unit is a media filter bed-type unit (e.g. sand filter): isolate unit from the household water system and consult manufacturer, supplier or qualified plumbing or water treatment professional on method to disinfect the unit (see Page 6).

Please see Appendix A (Sections A.2 to A.5, Page 5-7) for information for commercial ice makers, water softeners, reverse osmosis water treatment devices, and swimming pools.

Step 4: All Other Appliances
All appliances, large or small, that have been in contact with the drinking water supply should be flushed, disinfected with a mild bleach solution, and rinsed thoroughly. If applicable, all filters must be replaced prior to use.

A mild bleach solution can be made by mixing approximately 2 tablespoons of bleach per gallon of water or 10 ml of bleach per liter of water. Chlorine is a strong oxidant and the chlorine solution is higher than normal. Seek advice from the manufacturer or supplier of the appliance for further advice.

The following list of water-using appliances and devices is provided to assist in highlighting the post-EBWO actions that are required. Households and facilities that are using other water using appliances and devices not listed here should also ensure those are cleaned and disinfected, if possible. To ensure that each appliance or device is cleaned and disinfected, please check off each item as it is finished.

☐ Kitchen Coffee pots, coffee makers and machines	☐ Aerators (faucet screens)
☐ Fridge filters	☐ Other Medical devices that use water
☐ Fridge water dispenser (5 minute flush)	☐ Hot water tanks (see Appendix A.1 – pages 4-5)
☐ Brita filters (Discard/Replace Media)	☐ Hot tubs (empty and refill)
☐ Ice makers (discard 1st 3 batches of ice)	☐ Pre-stored water (i.e. watering cans)
☐ Water softeners (see Appendix A.3 – page 6)	☐ Water feature (empty and refill)
☐ Bathroom Water piks	☐ Other appliances _____

Step 5: Food Safety – if in doubt throw it out
Discard ice, juice made from concentrate, or other food products which may have used or been mixed with contaminated water.

This information was adapted from materials developed by:
- Cryptosporidium and Water: A Public Health Handbook. Atlanta, Georgia: Working Group on Waterborne Cryptosporidiosis.
- The Hunterdon, N.J. Department of Health,
- The District of Coldstream/Vernon Water Department, and
- The Minnesota Department of Health.

Appendix A—Cleaning & flushing instructions for specific devices

A.1 Hot Water Tank Procedure

Instant, or tankless hot water heaters, that do not have a tank do not require flushing.

1. Gas water heaters with a pilot light - set the gas valve to "Pilot" to prevent the burners from coming on while you are flushing it.
   Electric water heater - turn off the circuit breakers. With an electric water heater, if the water level drops below the heating elements and the thermostat turns the elements on, the heating elements will probably burn out quite rapidly.
   Gas water heater with a tank but no pilot light - turn off the circuit breaker for the hot water tank. Wait at least 30 minutes for the internal electrical components to cool down.
2. Connect a garden hose to the drain valve at the bottom of the tank. Make sure the outlet of the hose is in a safe area away from pets and children. It can be very hot and can scald quickly.
3. Close the shut off valve on the cold inlet to the water heater.
4. Open the drain valve at the bottom of the heater allowing the water to flow out through the garden hose. This may be under pressure- open slowly and make sure hose is securely in floor drain. If the sediment is clogging the drain valve then try closing the temperature/pressure relief valve and turn the cold inlet valve back on to "power flush" the sediment out.
5. Open the highest level hot water tap at a sink and leave open to vent draining hot water tank.
6. In some cases the sediment will have hardened into large chunks that can block the drain valve. If so, then wait until everything cools down, remove the garden hose from the drain valve, remove the valve if necessary, and use a long screw driver to break up the clog. This is a very messy procedure.
7. When the garden hose has finished draining, close the venting hot water tap on the highest level.
8. Open the cold water supply line to the hot water tank and let flush for 3 minutes. Be sure to make sure the garden hose is securely placed in floor drain as it will now be draining under pressure.
9. Close the drain valve at the bottom of the tank and remove the garden hose.
10. Open the highest level hot water faucet in your house, and let it run until no air bubbles come out. Close the tap when air is purged from hot water line.
11. Turn the heater back on, and with gas units re-light the pilot light if necessary.
12. Flush each hot water tap for five (5) minutes.

If in doubt consider asking a friend, neighbour or relative for assistance, contact the manufacturer, or seek the services of a trained professional such as a plumber.

A.2 Commercial Ice Maker Procedure

1. Flush the water line to the machine inlet:
    a) Close the valve on the water line behind the machine and
    b) Disconnect the water line from the machine inlet.
    c) Open the valve, run 5 gallons of water through the valve and dispose of the water.
    d) Close the valve.
    e) Reconnect the water line to the machine inlet.
    f) Open the Valve.
2. Flush the water lines in the machine.
3. Turn on the machine.
4. Make ice for 1 hour and dispose of the ice.
5. Clean and sanitize, following the manufacturer's instructions, all parts and surfaces that come in contact with water and ice.

A.3 Water Softener Procedure

Follow the manufacturer's instructions for disinfecting the particular unit you have. If the disinfection information is unavailable, the following steps can be used:

1. Ensure water supply valves are adjusted to "bypass" the water softener until chlorine is flushed from system.
2. Prepare a bleach solution by adding 4 tablespoons of new plain unscented bleach per cubic foot of softener resin to a couple liters (0.5 gallons) of water. Most residential softeners are 1-1.5 cubic feet of softener resin so 4 to 6 tablespoons of bleach would be required. (note: 30,000 grain softener = 1 cubic foot of softener resin.)
3. Pour bleach solution into the brine tank (through the float if possible)
4. Adjust water supply valves so appliance is 'on-line'.
5. Switch the softener to "manual regeneration".
6. Cycle the softener for 2 regenerations.
7. Adjust timer to the current time of day and resume normal online operation.

NOTE: If in doubt seek the services of a trained professional such as a plumber or a water softener supplier.

A.4 Reverse Osmosis (RO) Disinfection Procedure

1. Turn off the water supply to the RO unit and open the RO faucet to relieve pressure and drain the RO storage tank.
2. Remove and discard the pre- and postfilters and remove the RO membrane element. Clean and disinfect the filter sumps, the filter heads, and the RO membrane housing and end caps.
3. Fill the first pre-filter sump with water to within about 2 inches from the top and add 1 ounce (2 tablespoonfuls) of unscented laundry bleach (6 percent sodium hypochlorite or 5.7 percent available chlorine); carefully reassemble this first prefilter with the chlorine/water mixture but without its filter cartridge element in place.
4. Reassemble all the remaining housings without their membrane element and filter cartridge elements in place.
5. Open the water supply to the RO. Open the RO faucet and allow water to run until you can begin to smell the chlorine bleach. (If no chlorine bleach smell can be obtained, go back to bullet point three and increase the amount of laundry bleach added until a residual can be maintained throughout the system.)
6. Close the RO faucet and allow the storage tank to fill and then remain full for 25-30 minutes.
7. Open the RO faucet again and leave it open until the entire chlorine bleach smell is gone. Let the accumulated water in the RO storage tank drain completely.
8. Turn off the water supply to the RO. Close the RO faucet after all the pressure has been relieved and the water flow stops.
9. Install all new pre- and post-filters, using careful sanitary techniques so as to not re-contaminate the RO system.

A.4 Reverse Osmosis Disinfection Procedure, continued

10. Reinstall the RO membrane element in its housing. Fill the membrane element housing with water and 1 milliliter (20 drops) of laundry bleach. Reassemble this membrane element, chlorinated water, and housing unit
11. *CAUTION: High levels of chlorine over an extended period of time can degrade polyamide thin film composite (TFC) RO membranes, although significant degradations should not occur in these specified few minutes of chlorine contact time. Please review the manufacturer's information for your device.
12. Immediately reopen the water supply to the RO system and reopen the RO faucet. Let water drip from the RO faucet until the chlorine bleach smell has dissipated.
13. Finally, close the RO faucet, let the storage tank completely refill, and discard the first full tank of water following the completion of this procedure.

NOTE: If in doubt seek the services of a trained professional such as a plumber or water treatment supplier.

A.5 Swimming Pools Procedure

1. Acid wash cartridge pool filters or change media on diatomaceous earth and sand filter units
2. Drain and refill or shock chlorinate
3. Public pools should contact the Prince Albert Parkland Health Region for more information.

NOTE: If in doubt seek the services of a trained professional such as a plumber or swimming pool professional.

Procedure for Flushing Water Systems AFTER an Emergency Boil Water Order

Appendix B—Special Instructions for owners and residents of buildings that are not single family homes

This includes: Hospitals, Clinics, Long-term Care Facilities, Nursing Homes, Assisted Living Facilities, Dental Offices, commercial establishments (e.g. restaurants, hotels, convenience stores)

General Instructions

- ❑ Complete the five steps listed for all users on Page 1.

Be sure to:

- ❑ Re-start and flush any water-using fixture or piece of equipment in accordance with the manufacturer's specifications. This may vary from fixture to fixture. Consult your facility's engineer and/or the manufacturer when re-starting the equipment.
- ❑ If a water-holding reservoir is present in a building or on a property, the building owner or operator should consult with their facility engineer or a plumber about draining and disinfecting the reservoir before flushing plumbing systems.

Homes on Septic System (generally applied to rural users)

- ❑ Before you begin flushing the plumbing system in homes on private sewage systems, you will need a hose and buckets to prevent drainage/overloading the systems.
- ❑ When flushing the plumbing system run all inside taps using a hose or bucket to avoid overloading the sewage system, directing water outside and away from sewage field (be sensitive to potential impact on neighbouring properties).

Special Instructions for Apartment buildings and other Multi-family Dwellings

- ❑ The communal hot water tank (and any other treatment systems such as water softeners) should be flushed by the owner or operator of the building. The individual residents should be notified to flush their hot water taps only after the tank(s) have been flushed.

Special Instructions for Rural Water Pipeline Utility Users:

The Prince Albert Rural Water Utility will be sending out a separate document for rural users. Rural users will have similar instruction (steps 1 – 5) but will need to **Clean and disinfect your Cistern/storage tank before flushing the water lines in order to not re-contaminate your piping and/or devices.**

Please contact the Prince Albert Rural Water Utility at 764-6200

If you have further questions specific to your home or facility, please seek the services of a trained professional such as a plumber.

8

Source: Courtesy of the Prince Albert Parkland Health Region

Toledo-Lucas County

Tips on when and how to flush water systems

BLADE STAFF

Toledo-Lucas County Health officials said the water is safe to use in the Toledo area and that if your water lines have been used since Friday, you do not need to flush your system.

If you have not used your water over the weekend, they recommend running the hot water taps first for about 15 minutes prior to using. Then run cold water taps for five minutes. Do this before flushing out any appliances.

They are stressing that it is very important to not flush appliances right away because it could overload the water system. If you do flush out appliances over the next few days, the health department has supplied the following recommendations.

■ **Ice makers:**

If you have an ice make in your refrigerator, first throw away all ice and then:

If you have a filter on your ice maker

Some refrigerators, with ice makers, also have filters on the small water line that feed the ice maker. If you have filters on your ice maker, you want to replace the filter AFTER flushing your refrigerator's ice maker. These filters require routine replacement. This would be a good time to replace the filter to ensure that the water line to the ice maker is completely flushed. Some refrigerators also provide filtered cold water. Check to make sure that you have replaced any filter AFTER flushing cold water supply. Then flush cold-water dispenser for five minutes.

After flushing these lines, let the ice maker container fill up completely and discard this ice and clean the container before replacing. If you have more than one refrigerator make sure you perform the same procedure on those units as well.

■ **Water filters**

Clean or change your water filters, or contact the filter manufacturer for more details.

Water supplies for pets

Pets need clean water too. Be sure to empty all water bowls, bottles, or other water supplies for your pet. Wash the pet bowl, bottle or other water supply. Then refill with tap water.

·Point of entry/point of use devices (this may not apply to everyone)

If you have a Point of Entry water treatment system such as a water softener or filter, which all of the home's water passes through before it enters the main plumbing system, you should consider the following general guidelines before completing your household plumbing flushing.

■ **Water Softeners:**

Household water softener, which uses a natural or synthetic resin material to exchange sodium for calcium and magnesium present in the water, should be manually regenerated before flushing your plumbing system. This will ensure that the softener resin has been backwashed and cleaned before flushing procedures begin. If you are unsure of how to manually initiate a regeneration cycle, refer to your softener owner's manual or call your equipment supplier for assistance.

■ **Sediment Filters:**

Household water filters usually fall into two basic categories:

1. Pressure filters, which can be backwashed to clean.

2. Cartridge filters, which have a replaceable element or cartridge.

If your home has a pressure filter that can be backwashed, you should initiate a manual backwash of the filter before proceeding with, and after completing, the flushing procedures. If you have a whole house cartridge filter system, you should replace the cartridges after completing the flushing procedures.

■ **Point of use filters/treatment:**

If you have or use Point of Use filters, which are typically attached to your kitchen faucet you should replace the filter before using the faucet-connected unit. These filters require periodic replacement anyway so this would be a good time to do this.

■ **Reverse Osmosis:**

Reverse Osmosis drinking water treatment often have pre-filters, which you may want to replace before flushing the RO System. However the actual Reverse Osmosis membrane module should not require replacement. If the manufacturer of the membrane suggests that you replace this part of the system you should ask them to give you the specific reasons why.

Source: The Blade (http://www.toledoblade.com/local/2014/08/04/Tips-on-when-and-how-to-flush-water-systems.html)

Washington DC Petroleum Smell

DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY | 5000 OVERLOOK AVENUE, SW | WASHINGTON, DC 20032

FREQUENTLY ASKED QUESTIONS AFTER NOT DRINK ADVISORY IS LIFTED
EFFECTIVE 12/19/2014

Why did DC Water issue a Do Not Drink Advisory?

- On December 17, 2014, DC Water received reports of a petroleum-type smell in the water and issued a Do Not Drink Advisory for a portion of NW Washington until testing confirms that the water is safe.

What did DC Water do to address the issue?

- DC Water worked closely with the Environmental Protection Agency, its partners in the District of Columbia, DC Department of Environment, Washington Aqueduct, and the Metropolitan Washington region to communicate with the public and quickly restore water service.
- DC Water crews flushed the pipes to push contaminants out of the system.
- Extensive testing was conducted to confirm drinking water safety.

What should I do now that the advisory is lifted?

- Throw out any food, drinks or ice that was prepared with tap water between December 17, 2014 and December 19, 2014, including infant formula.
- Flush cold water taps by following the instructions below:

Single-Family Homes:

- Begin at the sink on the lowest floor and run each cold water tap for 10 minutes.
- After 10 minutes, move to upper level sinks and run each cold water tap for 5 minutes.
- Flush your refrigerator's water dispenser for 5 minutes.
- Discard any ice that was made during the Do Not Drink advisory.
- For automatic ice makers, make and discard one cycle of ice.

Commercial and Multifamily Buildings:

- Follow same procedure as above AND
- Notify all tenants to run every cold water tap for 5 minutes.

Why should I flush my pipes and how will flushing ensure that the water is safe to drink?

- Flushing your taps moves water out of your house and brings in fresh, new water from the drinking water reservoirs. DC Water flushed the public water pipes in the affected area of the distribution system. Flushing the plumbing in homes and buildings will ensure that fresh water is flowing through the city's distribution system and the interior pipes.

Does my water filter need to be replaced?

- Refer to the manufacturer's instructions.

dcwater.com

If I drank the water during the Do Not Drink Advisory, will I get sick?

- The Do Not Drink Advisory was issued to minimize the risk associated with a potential contaminant in the distribution system.
- Health effects from chemical contaminants vary depending on the concentration of the substance and the length of the exposure time.
- Common symptoms of chemical exposure include skin irritation, nausea, headaches, dizziness, vomiting and respiratory irritation.
- If you experience unusual symptoms of illness, contact your medical provider immediately.

Why does my water smell/taste/look different?

- If you experience a petroleum smell or taste, contact the Command Center immediately at 202-612-3400.
- You may notice a stronger chlorine taste or smell due to extensive flushing in the pipe system.
- Chlorine levels meet the Environmental Protection Agency's water quality standards, and you can minimize the taste or smell by running your water for several minutes.
- It is normal to see some water discoloration (rust or brown color) due to the disturbance that occurs when water flows at a high rate through the pipes.
- If customers experience discolored water, they should run their cold water taps for 5 minutes. If the water does not clear, call the Drinking Water Division at 202-612-3440.

How can I be sure that I receive alerts or notifications when there is a water system emergency?

- Sign up to receive alerts on www.dcwater.com by creating a My DC Water login which will be connected to an account. You will have the option to receive alerts about changes in water service that are relevant for the address (outages, drinking water advisories).
- Make sure the phone number is correct in our records to receive the automated calls.
- Follow us on Twitter (@dcwater) or Facebook.
- Sign up for Capital Alerts to get notifications about District-wide emergencies at www.capitalalert.gov/.
- Request that we add your email to our media listserv so that get all DC Water press releases by sending an email request to externalaffairs@dcwater.com.

Additional Resources

DC Water Customer Service: 202-354-3600
DC Water 24-Hour Command Center: 202-612-3400
DC Water Drinking Water Division: 202-612-3440
www.dcwater.com/emergencies

Source: Courtesy of DC Water

Syracuse City Davis County Health Department

WATER FLUSHING INSTRUCTIONS FOR AFTER THE WATER IS DECLARED SAFE:

Please review the following flushing procedures for each applicable plumbing fixture or appliance.

- Faucets – 20 minutes cold
- Showers - 20 minutes cold
- Toilets – None required
- Washing Machines – None required
- Dish Washers – None required
- Outdoor Spigots – 5 minutes, disconnect hose first
- Refrigerator Water Dispenser – 5 minutes
- Faucet/Fridge Water Filters – Consider replacing filter per manufacturers recommendation
- In Line Water Filter - Consider replacing filter per manufacturer's recommendation
- Ice Makers – Dump all existing ice
- Water Heaters – Run hot water from all faucets until water runs cold. Second option is to drain water heater using spigot/release on the bottom of heater.
- Water Softeners – Cycle water softener per manufacturer's recommendation
- Reverse Osmosis Systems – Cycle through and consider replacing filters per manufacturer's recommendation
- Soft Drink Dispensers – Disconnect flavoring and cycle water through until replaced with fresh water, reconnect flavoring.

Source: Used with permission of Syracuse City, Utah

Glendive Poplar Pipe Flushing Guidance

Poplar Pipeline Response

Frequently Asked Questions for Flushing Your Water Pipes

Flushing

Do I need to run every faucet in my house? Do they need to be opened at the same time?

Yes, we need to do all of the faucets at the same time, in the following sequence:

Each household needs to open all of the cold taps on their water faucets and run them for 20 minutes. This will flush all of the inlet lines and make sure clean water is running into the house.

After that, close all of them and open all hot water taps on your water faucet and run for 15 minutes.

Will there be a harmful off-gas and should I ventilate while I run my water?

Benzene is highly volatile, meaning it evaporates into the air easily. You may notice an increased odor while the system is flushed. This should improve as the system is flushed. We recommend opening a window at each end of the house and turn on all vent fans while you are flushing the pipes. The amount of Benzene you will be exposed to during this process is below harmful levels, even though you may smell it. If you don't like the odor, leave the room while the ventilation is running and return when the odor dissipates. If the odor persists please report those instances to the hotline so that they can be logged and mapped. The hotline number is 888-959-8351

Do I need to run my outside spigots?

No, you don't need to run them now. If you haven't been running your spigots, there is no way for contamination to have gotten into the lines. If you are concerned, run your outside spigots in the spring for at least a minute prior to using them for drinking.

What should I do about service lines that were shut off prior to the spill?

They can be reopened and used as normal since all water in the distribution system is now safe for consumption. If they weren't used after Saturday morning, there is no way for contamination to have gotten into the lines.

How many times do I need to flush my pipes?

Flush them one time and resume normal use of your water.

What should I do about my toilets?

Because the water in the toilet is not for consumption, you do not need to do anything. If you are concerned, flush all toilets twice.

Do I need to scrub my sinks and bathtubs?

No, Benzene will not adhere to surfaces.

Water Heater

Do I need to drain my water heater completely?

It does not need to be drained completely, but you may if you want to. As the water heater empties during the flushing process, it simultaneously refills with clean water. The flushing procedure will remove all of the contaminants.

Has permanent damage been done to my water heater?

No. No heavy oil products have made it into the water distribution system. All contaminants readily dissolve in water and will be removed through the flushing process.

Do I need to replace my water heater?

No, see previous response.

RO Systems

Do I need to change the filter on my RO system?

Almost all RO systems include a carbon pre-filter. The carbon pre-filter should be replaced. All other filters can be replaced on their normal schedule.

How does this affect my water softener?

There will be no long term effects to water softener systems. After you complete your flushing, you should run a re-generation on your water softener. Your water softener automatically regenerates periodically. If you have questions about this, see your water softener installer.

Who will pay for the new filters if needed?

There will be a claims process in place in a few days and people can file a claim to recover the cost of the new filters.

Water

Who will pay for the cost of the water it takes to flush my system?

The approximate volume of water used for flushing for an average household will be 150-200 gallons. The cost of the water is about a dollar. Bridger is working with the city to rebate individual customers $5 on their water bill. This is the about five times the cost to the average residential customer. For users who pay water bills for multiple homes, such as trailer parks, the rebate will be $5 per connection. For heavier users, like the hospital or businesses, an appropriate amount will be rebated.

This entry was posted in FAQs on January 22, 2015 [http://poplarresponse.com/2015/01/22/frequently-asked-questions-for-flushing-your-water-pipes/] .

Source: Poplar Pipeline Response (http://poplarresponse.com/2015/01/22/frequently-asked-questions-for-flushing-your-water-pipes)

APPENDIX B
CHECKLIST AND FAQ SUGGESTIONS

CHECKLIST AFTER FLUSHING

- ☐ Have the cold water taps been flushed?
- ☐ Have hot water taps and/or water heaters been flushed?
- ☐ Has ice, juice made from concentrate, or other food that may have come in contact with contaminant been discarded?

Have the following appliances and devices been cleaned or disinfected?

☐ Kitchen coffee pots & coffee makers	☐ Aerator (faucet screens)
☐ Fridge filters	☐ Medical devices that use water
☐ Fridge dispensers (5 minute flush)	☐ Hot tubs (empty and refill)
☐ Brita filters (Discard/Replace filter)	☐ Water features (empty & refill)
☐ Water softeners	☐ Other appliances

SAMPLE FAQS

Flushing

Why should I flush my taps?
How should I flush my taps?
Do I need to flush my outside spigot?
Will there be harmful off-gas and should I ventilate while the tap in running?
Do I need to flush every appliance in my house/building that uses water? How do I do it?

Water Heater

Do I need to drain my water heater completely?
Do I need to replace my water heater?

Filters

Do I need to change the filter?
How does this affect my water softener?
Who will pay for the new filters if needed?

Aesthetics

Why is my water discolored/odorous?

Is discolored/odorous water dangerous?

Other Information

How can I be sure that I receive alerts or notifications when there is a water system emergency?
Who will pay for the cost of the water it takes to flush my system?

REFERENCES

Arnold, R.B., and Edwards, M. 2012. “Potential reversal and the effects of flow pattern on galvanic corrosion of lead.” *Environ. Sci. Technol.*, 46: 10941–10947.

Bitenc, K. 2013. Lead in drinking water in Slovenian kindergartens and schools. In *Proc. 16th International Conference on Heavy Metals in the Environment*. Rome, Italy.

Boyd, G., Shetty, P., Sander, A., and Pierson, G., 2004. “Pb in tap water following simulated partial lead pipe replacements.” *J. Environ. Eng.*, 130: 1188–1197.

Broo, A.E., Berghult, B., and Hedberg, T. 1997. “Copper corrosion in drinking water distribution systems — the influence of water quality.” *Corros. Sci.*, 39: 1119–1132.

Brown, R.A., and Cornwell, D.A. 2015. “High velocity household and service line flushing following LSL replacement.” *J. - Am. Water Works Assoc.*, 107. doi:10.5942/jawwa.2015.107.0012.

Burlingame, G., Wiggen, G., and Ogino, C. 2012. “Responding to contamination: Where do I sample?” *Opflow*, 38: 10–13.

Caredew, P.T. 2006. “Development of a convective diffusion model for lead pipe rigs operating in laminar flow.” *Water Res.*, 40: 2190–2200.

Cartier, C., Arnold Jr., R.B., Triantafyllidou, S., Prévost, M., Edwards, M., 2012. Effect of flow rate and lead/copper pipe sequence on lead release from service lines. Water Res. 46, 4142–4152.

Cartier, C., Laroche, L., Deshommes, E., Nour, S., Richard, G., Edwards, M., and Prévost, M. 2011. “Investigating dissolved lead at the tap using various sampling protocols.” *JAWWA*, 103: 55–67.

Casteloes, K.S., Brazeau, R.H., and Whelton, A.J. 2015. “Decontaminating chemically contaminated residential premise plumbing systems by flushing.” *Environ. Sci. Water Res. Technol*. DOI: 10.1039/C5EW00118H.

Casteloes, K.S., Mendis, G.P., Avins, H.K., Howarter, J.A., and Whelton, A.J. 2017. “The interaction of surfactants with plastic and copper plumbing materials during decontamination.” *J. Haz. Materials*. https://doi.org/10.1016/j.jhazmat.2016.11.067.

CDC (Centers for Disease Control and Prevention). 2013a. *Drinking Water Advisory Communication Toolbox.* Atlanta, GA: CDC.

CDC (Centers for Disease Control and Prevention). 2013b. “Surveillance for Waterborne Disease Outbreaks Associated with Drinking Water and Other Nonrecreational Water — United States, 2009–2010.” *MMWR Morb Mortal Wkly Rep*, 62: 714–720.

CDC (Centers for Disease Control and Prevention). 2015. “Surveillance for Waterborne Disease Outbreaks Associated with Drinking Water— United States, 2011–2012. *MMWR Morb Mortal Wkly Rep.*, 64 (31): 842-8.

Chowdhury, S., Rodriguez, M.J., Sadiq, R., and Serodes, J. 2011. “Modeling DBPs formation in drinking water in residential plumbing pipes and hot water tanks.” *Water Res.*, 45: 337–347.

Clark, B., Masters, S., and Edwards, M. 2014. “Profile sampling to characterize particulate lead risks in potable water.” *Environ. Sci. Technol.*, 48: 6836–6843.

Del Toral, M.A., Porter, A., and Schock, M.R. 2013. “Detection and evaluation of elevated lead release from service lines: A field study.” *Environ. Sci. Technol.*, 47: 9300–9307.

Dion-Fortier, A., Rodriguez, M.J., Sérodes, J., and Proulx, F. 2009. “Impact of water stagnation in residential cold and hot water plumbing on concentrations of trihalomethanes and haloacetic acids.” *Water Res.*, 43: 3057–3066.

Edwards, M. 2014. “Fetal death and reduced birth rates associated with exposure to lead-contaminated drinking water.” *Environ. Sci. Technol.*, 48: 739–749.

Edwards, M.A., Dudi, A. 2004. “Role of chlorine and chloramine in corrosion of lead-bearing plumbing materials.” *JAWWA*, 96: 69–81.

Edwards, M.A., Powers, K., Hidmi, L., and Schock, M.R. 2001. “The role of pipe ageing in copper corrosion by-product release.” *Water Sci. Technol. Water Supply*, 1: 25–32.

EPA (U.S. Environmental Protection Agency). 2016. “Basic information about lead in drinking water.” http://www.epa.gov/your-drinking-water/basic-information-about-lead-drinking-water#reducehome.

EPA (U.S. Environmental Protection Agency). 2012. *Removing biological and chemical contamination from a building’s plumbing system: Method development and testing*. Washington, DC: EPA.

EPA (U.S. Environmental Protection Agency). 2001. *Potential contamination due to cross-connections and backflow and the associated health risks.* Washington, DC: EPA.

Ferguson, J.F., von Franque, O., and Schock, M.R. 2011. “Corrosion of copper in potable water systems,” in *Internal Corrosion of Water Distribution Systems*. Denver, CO: American Water Works Association.

Fertmann, R., Hentschel, S., Dengler, D., Janssen, U., and Lommel, A. 2004. “Lead exposure by drinking water: An epidemiological study in Hamburg, Germany.” *Int. J. Hyg. Environ. Health*, 207: 235–244.

Gilbert, C.E., and Calabrese, E.J. 1991. *Regulating Drinking Water Quality*. CRC Press.

Grace, S., Lytle, D.A., and Goltz, M.N. 2012. “Control of new copper corrosion in high-alkalinity drinking water.” *JAWWA*, 104: 39–40.

Green, D., and Maddaus, W. 2010. *Water conservation for small and medium sized utilities*. Denver, CO: American Water Works Association.

Grigoletto, T.L.B., Fuzari, B.H.C., Andrade, A.R., Campos, M.L.A.M., Gerlach, R.F., and Tanus dos Santos, J.E. 2012. “Chemical and physical factors influencing lead and copper contamination.” *Quimica Nova*, 35: 1995–2001.

Hawes, J.K., Conkling, E.N., Casteloes, K., Brazeau, R.H., Salehi, M., and Whelton, A.J. 2017. “Predicting contaminated water removal from residential water heaters under various flushing scenarios.” *J. - Am Water Works Assoc.* https://doi.org/10.5942/jawwa.2017.109.0085.

Huang, X., Andry, S., Yapturi, J., Kelly, D., Ladner, D.A., and Whelton, A.J. 2017a. “Crude oil contamination of plastic and copper drinking water pipes.” *J. Haz. Materials.* https://doi.org/10.1016/j.jhazmat.2017.06.015.

Huang, X., Whelton, A.J., Andry, S., Yaputri, J., Kelly, D., and Ladner, D.A. 2017b. *Interaction of fracking and crude oil contaminants with water distribution pipes*. Denver, CO: Water Research Foundation.

Huang, X., Zhao, S., Abu-Omar, M., and Whelton, A.J. 2017c. “In-situ cleaning of heavy metal contaminated plastic water pipes using a biomass derived ligand.” *J Environ Chem Eng.* https://doi.org/10.1016/j.jece.2017.07.003.

Kincaid, J.P., Fishburne, J., Rogers, R.L., and Chissom, B.S. 1975. *Derivation of new readability formulas (automated readability index, fog count and flesch reading ease formula) for navy enlisted personnel*. Millington, TN: Naval Technical Training Command.

Kuch, A., and Wagner, I. 1983. "A mass transfer model to describe lead concentrations in drinking water." *Water Res.*, 17: 1303–1307.

Kutner, M., Greenburg, E., Jin, Y., and Paulsen, C. 2006. *The health literacy of America's adults: Results from the 2003 national assessment of adult literacy*. Washington, DC: U.S. Department of Education.

Liu, B., and Reckhow, D.A. 2014. "Disparity in disinfection byproducts concentration between hot and cold tap water." *Water Res.*, 70: 196–204.

Maas, R.P., and Patch, S.C. 1990. *Lead contamination of North Carolina domestic tapwater: Prevalence, risk factors and control measures.* Black Mountain, NC: UNC-Asheville Environmental Quality Institute.

Masters, S., and Edwards, M.A. 2015. "Increased lead in water associated with iron corrosion." *Environ. Eng. Sci*., 32: 361–369.

Moya, J., Howard-Reed, C., and Corsi, R.L. 1999. "Volatilization of chemicals from tap water to indoor air from contaminated water used for showering." *Environ. Sci. Technol.*, 33: 2321–2327.

Murphy, E.A. 1993. "Effectiveness of flushing on reducing lead and copper levels in school drinking water." *Environ. Health Perspect.*, 101: 240–241.

Nieuwenhuijsen, M., Paustenbach, D., and Duarte-Davidson, R. 2006. "New developments in exposure assessment: The impact on the practice of health risk assessment and epidemiological studies." *Environ. Int.*, 32: 996–1009.

NSF. 2014. *HAACP for building water systems.* http://www.nsf.org/services/by-industry/water-wastewater/haccp-building-water-systems/.

NSF and ANSI. 2013. *Drinking Water System Components – Health Effects.* Ann Arbor, MI: NSF International.

O'Sullivan, G.A., Yonkler, J.A., Morgan, W., and Merritt, A.P. 2003. *A field guide to designing a health communications strategy*. Baltimore, MD: Johns Hopkins Bloomberg School of Public Health/Center for Communications Programs.

Pruden, A., Edwards, M.A., and Falkinham, J.O., 3rd. 2013. *State of the science and research needs for opportunistic pathogens in premise plumbing*. Denver, CO: Water Research Foundation.

Rajaratnam, G., Winder, C., and An, M. 2002. "Metals in drinking water from new housing estates in the Sydney area." *Environ. Res.*, 89: 165–170.

Raucher, R., Raucher, K., Pratt, J., and Ragain, L. 2014. *Identifying the gaps in understanding the benefits and costs of boil water advisories*. Denver, CO: Water Research Foundation.

Rothman, A.J., Bartles, R.D., Wlaschin, J., and Salovey, P. 2006. "The strategic use of gain- and loss-framed messages to promote healthy behavior: How theory can inform practice." *Journal of Communication*, 56: S202–S220

Rothman, A.J., Martino, S.C., Bedell, B.T., Detweiller, J.B., and Salovey, P. 1999. "The systematic influence of gain- and loss-framed messages on interest in and use of different types of health behavior." *Pers. Soc. Psychol. Bull*., 25: 1355–1369.

Roy, S., Phetxumphou, K., Dietrich, A.M., Estabrooks, P.A., You, W., and Davy, B.M. 2015. "An evaluation of the readability of drinking water quality reports: A national assessment." *J. Water Health*, 1: 645–653.

Sandvig, A., Kwan, P., Kirmeyer, G., Maynard, B., Mast, R., Rhodes, R.T., Trussell, S., Cantor, A.F., and Prescott, A. 2008. *Contribution of service line and plumbing fixtures to lead and copper rule compliance issues*. Denver, CO: AwwaRF.

Schock, M., and Sandvig, A. 2009. "Long-term effects of orthophosphate treatment on copper concentration." *JAWWA*, 101: 71–82.

Szabo, J., and Minamyer, S. 2014a. "Decontamination of biological agents from drinking water infrastructure: A literature review and summary." *Recent Dev. Assess. Manag. Serious Health Threats*, 72: 124–128. doi:10.1016/j.envint.2014.01.031.

Szabo, J., and Minamyer, S. 2014b. "Decontamination of chemical agents from drinking water infrastructure: A literature review and summary." *Recent Dev. Assess. Manag. Serious Health Threats*, 72: 119–123. doi:10.1016/j.envint.2014.01.025.

Szabo, J., and Minamyer, S. 2014c. "Decontamination of radiological agents from drinking water infrastructure: A literature review and summary." *Recent Dev. Assess. Manag. Serious Health Threats*, 72: 129–132. doi:10.1016/j.envint.2014.01.025.

Szabo, J., Hall, J., Reese, S., Goodrich, J., Panguluri, S., Meiners, G., and Ernst, H. 2017. "Full scale drinking water system decontamination at the water security test bed." *J. - Am. Water Works Assoc*. https://doi.org/10.5942/jawwa.2017.109.0141.

Traedo, S., Kedzierski, M., Watson, S., Martys, N., Cole, K., 2009. Watson, S., Martys, N., and Cole, K. 2009. *Building plumbing system decontamination – first report on recommendations*. Gaithersburg, MD: NIST.

Triantafyllidou, S., Le, T., Gallagher, D., and Edwards, M. 2014. "Reduced risk estimations after remediation of lead (Pb) in drinking water at two US school districts." *Sci. Total Environ.*, 466-467, 1011–1021.

Triantafyllidou, S., Schock, M., DeSantis, M., and White, C. 2015. "Low contribution of PbO2-coated lead service lines to water lead contamination at the tap." *Environ. Sci. Technol.*, 49: 3746–3754.

Turek, N.F., Kasten, L., Lytle, D.A., and Goltz, M.N. 2011. "Impact of plumbing age on copper levels in drinking water." *J. Water Supply Res. Technol. – AQUA*, 60: 1–15.

Vedachalam, S., Spotte-Smith, K.T., and Riha, S.J. 2016. "A meta-analysis of public compliance to boil water advisories." *Water Res.*, 94: 136-145.

Whelton, A.J., McMillan, L., Connell, M., Kelley, K.M., Gill, J.P., White, K.D., Gupta, R., Dey, R., and Novy, C. 2015. "Residential tap water contamination following the Freedom Industries chemical spill: Perceptions, water quality, and health impacts." *Environ. Sci. Technol.*, 49: 813–823.

ABBREVIATIONS

BR	Butyl rubber
CDC	Centers for Disease Control and Prevention
cPVC	Chlorinated PVC
DBP	Disinfection byproduct
DNU	Do not use
DS	Distribution system
EP	Epoxy
EPA	United States Environmental Protection Agency
EPD	Ethylene-propylene-diene
HACCP	Hazard Analysis and Critical Control Points
HDPE	High density polyethylene
HVAC	Heating, Ventilation and Air Conditioning
MCHM	4-methylcyclohexanemethanol
NBR	Natural butyl rubber
PEUU	Polyurea
PEX	Crosslinked polyethylene
POE	Point of Entry
POU	Point of Use
PP	Polypropylene
PU	Polyurethane
PVC	Polyvinylchloride
SBR	Styrene-butadiene rubber
SFR	Single family residence
SVOCs	Synthetic volatile organic compound
VOC	Volatile organic compound

THE
Water
Research
FOUNDATION

1199 North Fairfax Street, Suite 900
Alexandria, VA 22314-1445
www.werf.org | werf@werf.org

6666 West Quincy Avenue
Denver, CO 80235-3098
www.waterrf.org | info@waterrf.org