The Unintended Consequences of Indoor Water Efficiency

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2024 EMERGING WATER TECHNOLOGY SYMPOSIUM

We've made great strides on Indoor Water Efficiency!

Water Consumption by Water-Using Plumbing Products and Appliances (1980 to 2023)

Water-using Fixture or Appliance	1980s Water Use (typical)	1990 Requirement (maximum)	EPAct 1992 Maximum	Baseline Model Plumbing Codes (maximum)	Green Code Maximums (i.e., Calgreen)	% Reduction in typical water use since 1980s
Residential Bathroom Lavatory Faucet	3.5+ gpm	2.5 gpm	2.2 gpm	2.2 gpm	1.2 gpm	66%
Kitchen Faucet	3.5+ gpm	2.5 gpm	2.2 gpm	2.2 gpm	1.8 gpm*	49%
Showerhead	3.5+ gpm	3.5 gpm	2.5 gpm	2.5 gpm	1.8 gpm	49%
Residential ("private") Toilet	5.0+ gpf	3.5 gpf	1.6 gpf	1.6 gpf	1.28 gpf	74%
Commercial ("public") Toilet	5.0+ gpf	3.5 gpf	1.6 gpf	1.6 gpf	1.28 gpf	74%
Urinal	1.5 to 3.0+ gpf	1.5 to 3.0+ gpf	1.0 gpf	1.0 gpf	0.125 gpf	96%
Commercial Lavatory Faucet	3.5+ gpm	2.5 gpm	2.2 gpm	0.5 gpm	0.5 gpm	86%
Food Service Pre-Rinse Spray Valve	5.0+ gpm	No requirement	1.6 gpm *(EPAct 2005)*	No requirement	1.28 gpm	74%
Residential Clothes Washing Machine	51 gallons per load	No requirement	26 gallons per load *(2012 std)*	No requirement	14 gallons per load *(Energy Star)*	73%
Residential Dishwasher	14 gallons per cycle	No requirement	6.5 gallons per cycle *(2012 std)*	No requirement	3.5 gallons per cycle *(Energy Star)*	75%

*Kitchen faucets with a manual override to temporarily increase flow to 2.2 gpm max must default back to 1.8 gpm when manual override is released.

Source: Modified from The Drainline Transport of Solid Wastes Buildings, by the Plumbing Efficiency Research Coalition (PERC), 2012. Chart updated by John Koeller and Peter DeMarco, 2018 and 2023.

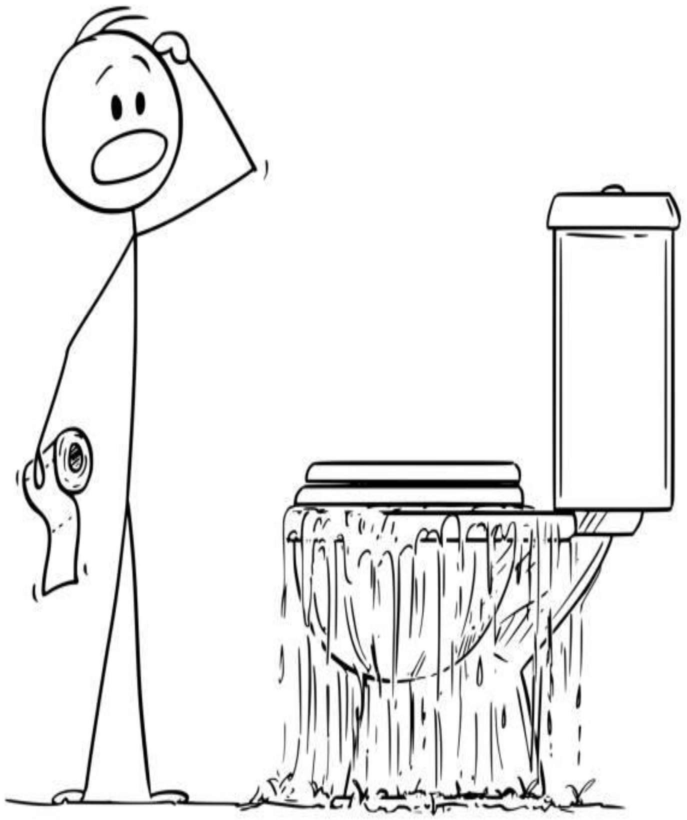
However, the Tipping Points are Real!

"How low can we (safely) go?"

- New consumption values and flow rates are being considered at WaterSense™ and at State government levels

The unintended consequences are serious!

1. **Sanitary System consequences**:
   - Reductions to toilets puts drainline efficacy at risk resulting in chronic blockages and toilet overflows
2. **Water Supply System consequences:**
   - Reductions in faucet, showerhead flow rates increase hot water delivery times, often negating efficiencies
   - Also increases residency time in plumbing systems increasing exposure to OPPPS and lead



Let's see what the research says…….

Unintended Consequences - Sanitary Systems

The Implications of Reduced Flows in Building Drains

Plumbing Efficiency Research Coalition

PLUMBING MANUFACTURERS INTERNATIONAL

Alliance for Water Efficiency

IAPMO

ICC INTERNATIONAL CODE COUNCIL

PHCC PLUMBING-HEATING-COOLING CONTRACTORS ASSOCIATION

ASPE American Society of Plumbing Engineers

Download the full PERC Reports at Plumbingefficiencyresearchcoalition.org

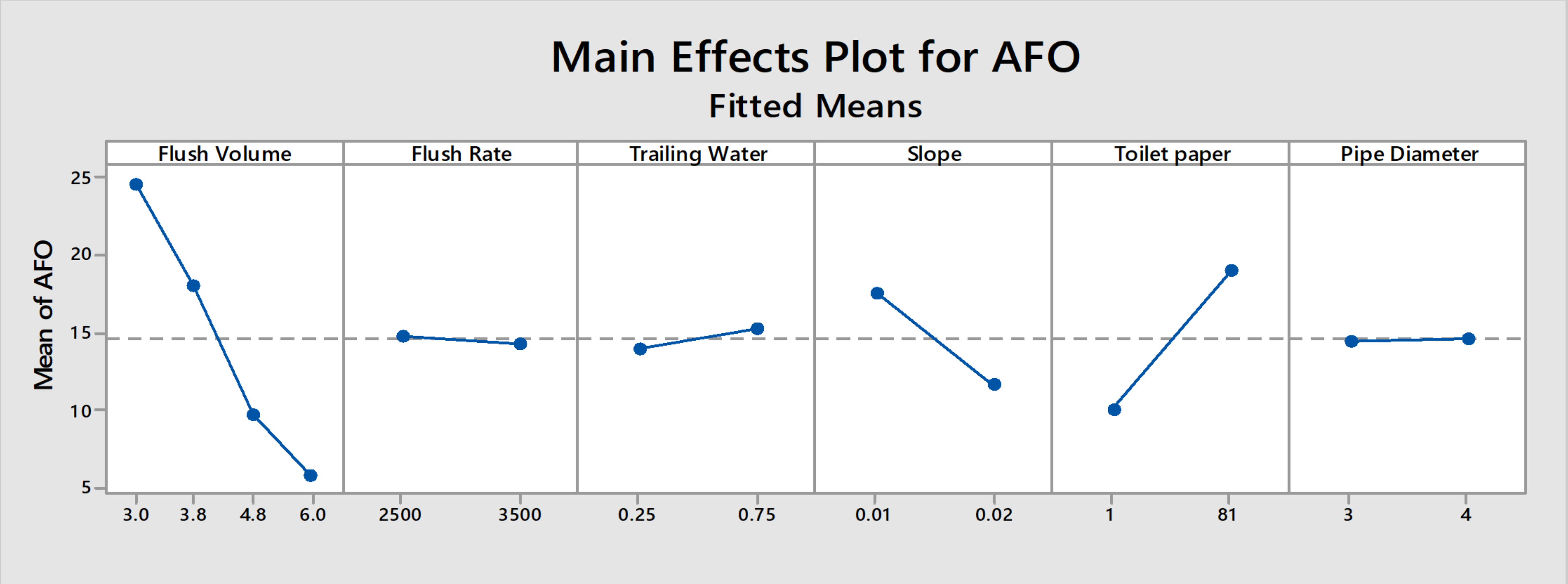
The PERC Study Findings

Conducted in 2014 - 2016

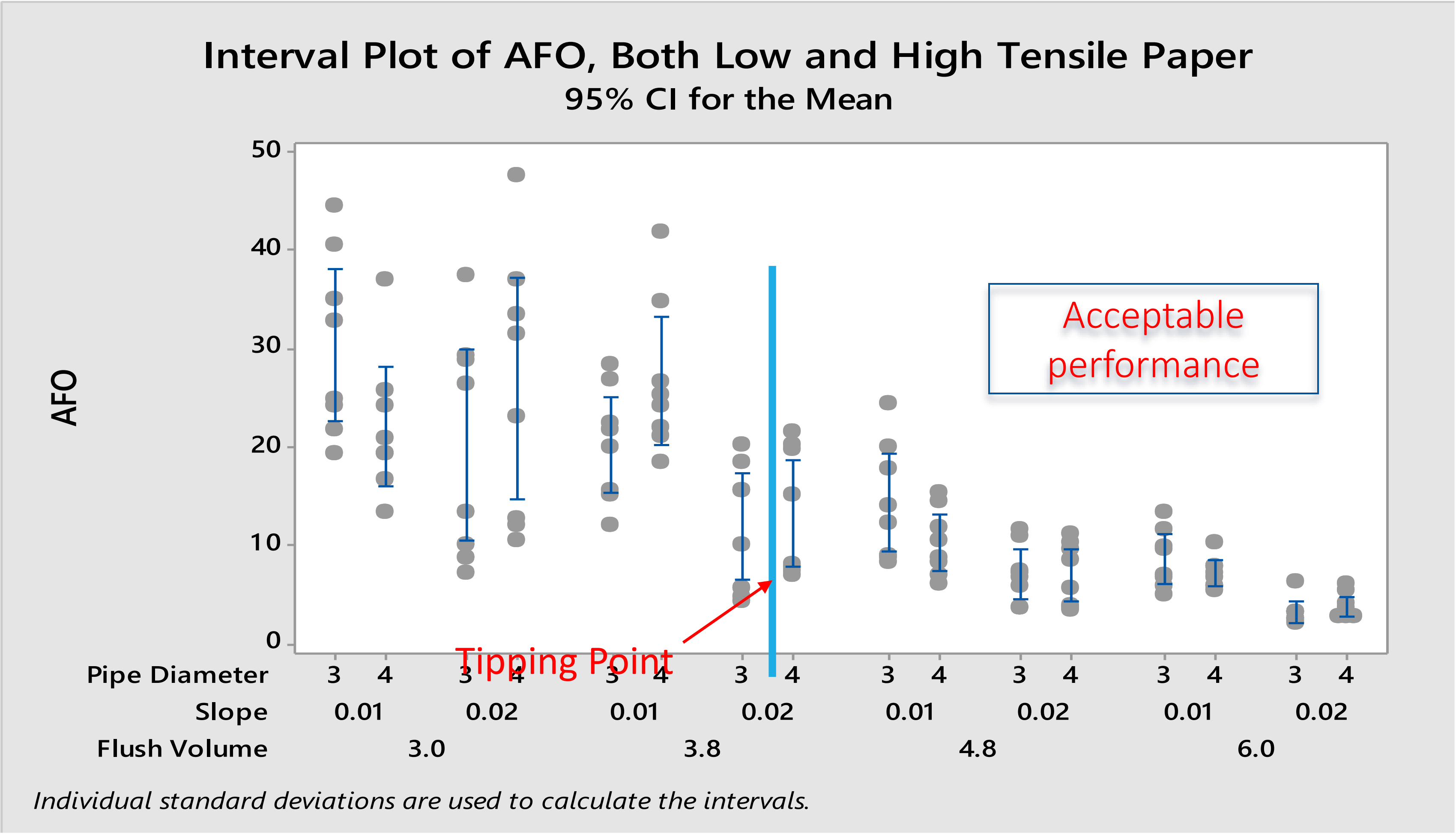
- Designed multi-variable drainline transport experiment investigating: flow reductions, changes in slope, toilet design attributes and the various toilet paper brands
- Focused on commercial building drainlines not having other long duration flows that support drainline transport

The PERC Study Findings

“The Main Effects Plot shown below is a visual characterization of the results from the PERC Phase 2 Designed Experiment. The more vertical the line, the more significant the variable. This indicates that while all the volume reductions are clearly significant, the most significant reduction (in drainline transport performance) occurred between the 4.8 Lpf / 1.28 gpf and the 3.8 Lpf / 1.0 gpf levels.”



Finding The "Tipping Point"



The tipping point lies within the 1.0 gpf data set.
PERC does not recommend 1.0 gpf in long drains.

Supplemental Testing (PERC 2.1) Results

Deliverable 1: Impact of Dual Flush discharges on DLT vs. Single Flush

Comparing Single Flush to "Full" Dual Flush Value

- **78.8%** reduction in DLT performance when comparing 1.6 / 1.0 gpf dual flush to 1.6 gpf single flush
- **59.4%** reduction in DLT performance when comparing 1.28 / 0.8 gpf dual flush to 1.28 gpf single flush
- **Result:** *Reductions in Flush Volume, even when there is no solid waste other than toilet paper included with the reduced Flush Volume discharge, negatively impacts drainline performance*

Supplemental Testing (PERC 2.1) Results

Deliverable 2: Impact of slope deviations on DLT

- Test apparatus modified to make 1 pipe section (10 ft.) perfectly flat (no slope)
- Overall, DTL performance was reduced by 41.7% with the worst results occurring at the lower Flush Volumes
- Interestingly, the biggest reduction in performance occurred between the 1.28 gpf and 1.0 gpf Flush Volumes, providing additional confirmation of the tipping point identified in Phase 2.0

How Toilets Are Tested and Certified

Keep in mind… Maximum flush volumes are indeed maximums

- When a toilet is tested and found to flush over the max volume, even by a small amount, the test is considered a failure.
- Manufacturers must aim for a volume under the max flush volume (typically 0.05 - 0.10 gpf) to ensure compliance.
- Thus, a max flush volume of 1.1 gpf will result in most toilets flushing between 1.0 and 1.05 gpf.

Unintended Consequences - Water Supply Systems

At the water distribution system level - longer water delivery times from point of treatment to delivery at buildings - with less or no residual disinfectant

- Hydrant flushing is a common utility response to improving water quality

At the plumbing system level - longer dwell times in plumbing systems

- Amplifies opportunistic pathogen grown in Domestic Hot Water Systems and longer lead leachate
- Increases exposure to metals including lead
- Increases hot water delivery times and water waste due to heat loss - where's the benefit?

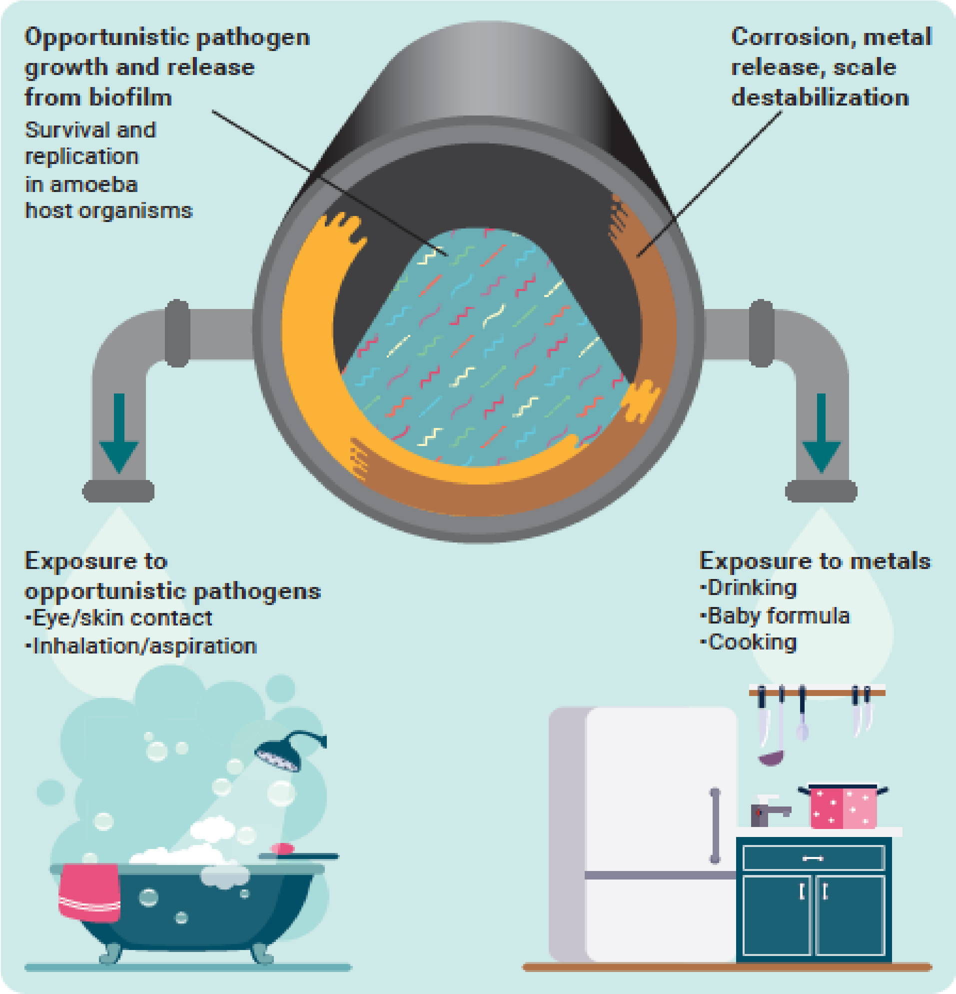


Figure 2. *Opportunistic pathogen and metal exposure*

Growth of Opportunistic Pathogens

Primary causes of waterborne disease in US

Legionella pneumophila

- 8K-18K cases/yr
- $430M/yr
- Cause of all 31 reported respiratory waterborne disease outbreaks 2007-10

Mycobacterium avium

- 100 cases/10^5 people >60yrs
- $425M/yr
- Only recently linked to drinking water

Pseudomonas aeruginosa

- 11,000 HAIs from 1992-93
- No required reporting

Naegleria fowleri

- "Brain eating amoeba" – 2 recent high profile cases linked to drinking water

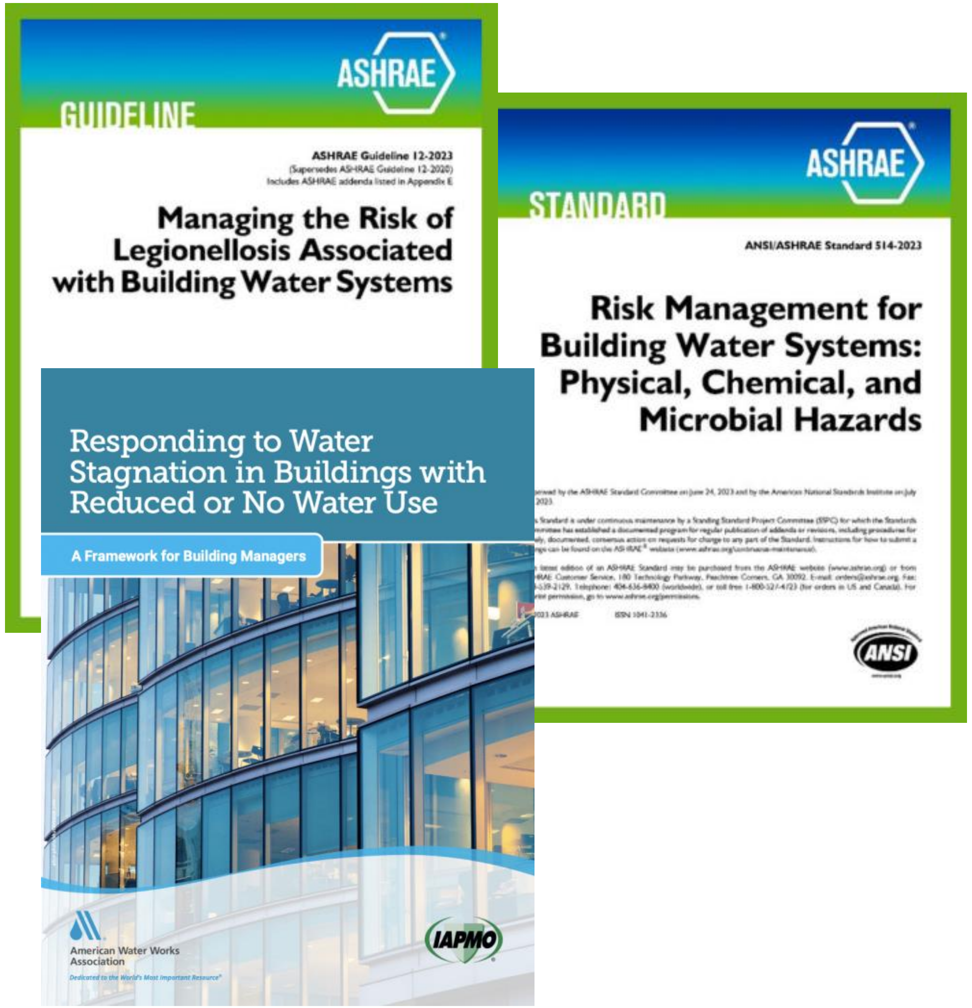
Slide courtesy of Professor Marc Edwards - Virginia Tech University

New Tools Available for Addressing Opportunistic Pathogens in Plumbing Systems

The codes & standards developing community has worked hard to address the growing concerns about pathogen growth in plumbing systems:

- After over ten years in development, ASHRAE 188 was published in 2015 and has been updated twice. Provides excellent risk management provisions for Legionella
- ASHRAE 514 provides similar risk management provisions for additional pathogens as well as physical and chemical hazards
- AWWA - IAPMO Guideline *: Responding to Water Stagnation in Buildings with Reduced or No Water Use* addresses water stagnation in buildings

However, cases of Legionella and other OPPPS related illnesses continue to grow and are correlated to reduced flows



Trends in Unintended Consequences

Increasing efficiency in codes and standards

- State regulators further reducing toilet flush volumes and plumbing flow rates (California is a good example)

Rising Costs of Utility Water Quality Maintenance

- Flushing needs to occur on a regular basis to move water through the distribution system and preserve the chlorine residual to the customer meter
- Increased system flushing wastes water and makes customers angry when they see water running down the street
- Constant water quality monitoring and increased flushing adds cost to the customer bill, often at a disproportionate rate to low income customers

A Practical Solution:
The IAPMO Water Demand Calculator

The Water Demand Calculator for new residential construction:

- Significantly reduces water aging
- Delivers hot water faster
- Generates quantifiable construction cost savings
- Reduces the carbon footprint of the structure
- Saves on water- and water heating-related energy utility bills for the entire life of the plumbing system
- Is a legal option within the Uniform Plumbing Code in all states

https://www.uniformcodes.org/water-demand-calculator/

Final Thoughts

1. There are clear benefits to water efficiency and reducing waste in our building plumbing systems.
2. But we need to tackle the problem from a whole building perspective and evaluate where efficiency can pose unintended consequences in stranded fixtures.
3. There are diminished returns for further reducing fixture flows in buildings, particularly if system flushing is wiping out the water savings from the extremely low flow rates.
4. Rising water utility bills to cover the increased water quality maintenance and flushing cost needs to be part of the regulatory codes and standards analysis.
5. Marc Edwards' work for the Water Research Foundation on pathogen growth in green buildings showcases the clear problems of diminished returns.

Thank You! Questions?

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