Microbiological Water Quality in the Distribution System and Premise Plumbing: Legionnaires' Disease

Jennifer L. Clancy, Ph.D., M.S. Law
Corona Environmental Consulting, LLC
Chief Scientist

Presented to the Small Systems TAC Pennsylvania DEP

26 May 2015

Thank you to Serena diMagno and the TAC Board for inviting me here today to talk about *Legionella* and Legionnaires' disease (LD)

Todays' Talk

- My background and experience with *Legionella* and LD
- Conclusions
- History of waterborne disease (WBD) and waterborne disease outbreaks (WBDOs)
- Opportunistic pathogens and premise plumbing
- Way forward in preventing LD
- Organizations involved in addressing LD
- Conclusions (again)

My Background

- Education
  - B.S. Microbiology, 1975, Cornell University, Ithaca, NY
  - M.S. Microbiology and Biochemistry, 1980, University of Vermont, Burlington, VT
  - Ph.D. Microbiology and Immunology, 1988, McGill University, Montreal, Canada
  - M.S. Environmental Law, 1992, Vermont Law School, South Royalton, VT
- Director of Water Quality at Erie County Water Authority, Buffalo
- Consultant for >25 years to water utilities, manufacturers, USEPA, States, and regulatory agencies (Canada, UK, Australia)
- WaterRF Research Innovation Award (2012)
- AWWA A.P. Black Research Award (2014) for excellence in water supply research.

History of LD and how I got involved

- Bellevue Stratford Hotel, Philadelphia, July 1976
  - 182 cases, 29 deaths from ???
- *Legionella pneumophila* ID'd as cause of outbreak, Jan 1977
- Development of CYE agar for *Legionella* culture (1979)
- BCYE agar (1981)
- Molecular tools available now

- UVM, College of Medicine, Dept. of Pulmonary Med., Jan. 1980
  - Studying the pathology of LD
  - Develop an animal model of LD
    - Bonus - 2 outbreaks in summer 1980 in Burlington, VT

- Environmental WQ consulting, 1988
- Analyzing water and other env samples for *Legionella*
- WBDO investigations of LD
- Litigation support

This is unusual, but let’s start with the conclusions, fill in the details, and circle back.

Conclusions

- *Legionella* is the most well known of a group of organisms known as opportunistic pathogens (OPs)
- Common environmental microbe
- *Legionella* can be found in treated drinking water (DW) that meets all federal and state standards
- Legionnaires' disease is the #1 WBD in the US
- LD results from WQ degradation in building water systems in the premise plumbing (PP)

Conclusions

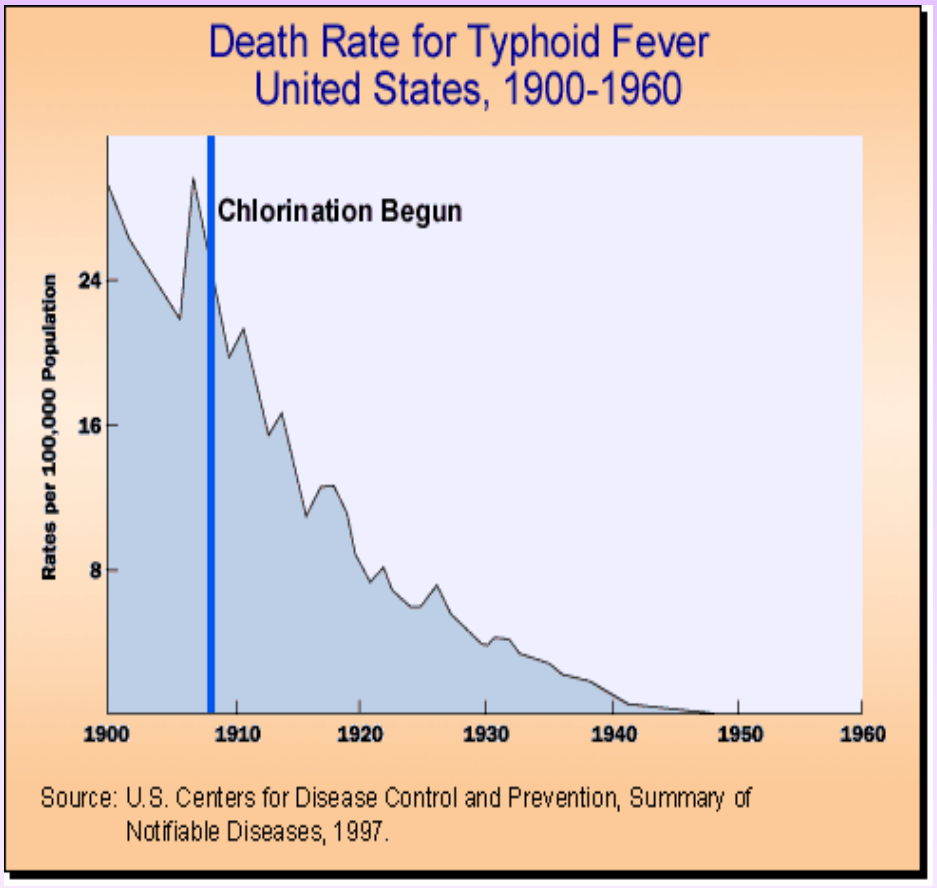
- LD is the result of a ‘perfect storm’
  - Low levels in treated DW
  - *Legionella* grow to high levels in PP
  - The bacteria are released into the air in microscopic droplets
  - Susceptible hosts breathe in the droplets
  - Host immune response is unable to prevent infection
    - Pontiac fever (mild flu-like illness, not fatal)
    - LD (pneumonia, may lead to death)

Conclusions

- LD is preventable (US CDC)
- Effects of DW treatment cannot control *Legionella* because the bacteria reproduce in PP
- Control of *Legionella* and LD happens in the building, not in the DW distribution system (DS)
- National effort ongoing on many fronts to address this issue of PP WQ with the goal of controlling LD

Changing Character of US WBDOs

- Early1900s - majority WBDOs due to typhoid fever.
- Bacterial WBDOs controlled with chlorination (1908)
- 2006 - typhoid cases 0.1 per 100,000 people (only 353 cases) with ~ 75% in international travelers.



Mike McGuire, The Chlorine Revolution (2013)

Changing Character of US WBDOs

- Early 1960s *Giardia* was discovered as an agent of WBD
- WBDs transmitted by viruses, including GWs
- In the 1980s-1990s, *Cryptosporidium* was the most frequent cause of WBDOs
  - 400,000 cases and >100 *Crypto* deaths in Milwaukee, 32 deaths in Las Vegas
- **Common source was fecal contamination of water supplies**
- **The focus of DW treatment was to control <u>fecal pathogens</u>**

Surface Water Treatment Rules (1980s on)

- SWTR - to prevent waterborne diseases caused by viruses, *Legionella*, and *Giardia lamblia* using filtration and disinfection
- IESWTR – control of turbidity
- Long Term 2 Enhanced Surface Water Treatment Rule (LT2) - focus on control of *Cryptosporidium* after Milwaukee outbreak in 1993 & others
  - Used toolbox approach: control of turbidity, source water protection, additional treatment for utilities at risk from Crypto (LT2 monitoring program)

But what happens after treatment?

- Water quality, both chemical and microbiological, changes as water moves from treatment into the DS and into homes and buildings of customers
  - Biofilms in DS pipes, tanks, surfaces
  - Stagnation, dead ends
  - Loss of disinfectant residual
  - Ingress of microbes in main breaks, cross connections, and low pressure incidents
    - Characterized by increases in HPCs and/or TC

Pathogens vs Opportunistic Pathogens

- Fecal pathogens (*Crypto, Giardia*, enteric viruses, *Salmonella*) focus of DW treatment
  - Removal/inactivation reduces their numbers
  - They cannot amplify after treatment because
    - They require a animal host in which to reproduce
    - Cannot regrow in water
  - TC used as indicator that WQ changes may have occurred during or after treatment

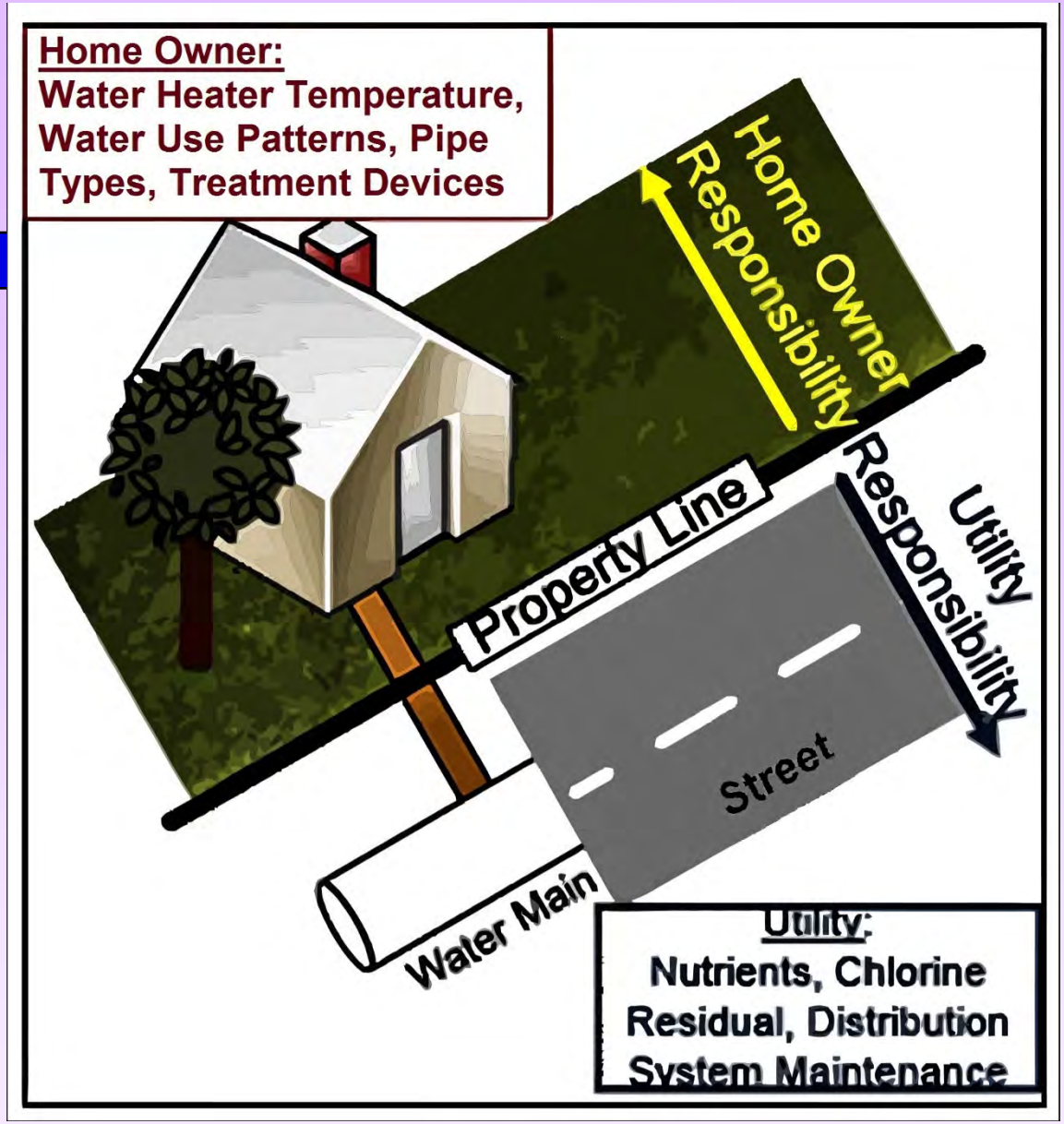
Opportunistic Drinking Water Pathogens

- Different from typical DW pathogens
- Not fecal in origin
- Occur naturally in the water/soil environment
- Do not rely on human or animal host to reproduce
- Can survive DW treatment and multiply in DW DS biofilms
- Special niche is found in premise plumbing
- Sometimes called emerging pathogens

Why are Emerging Drinking Water Pathogens Emerging Now?

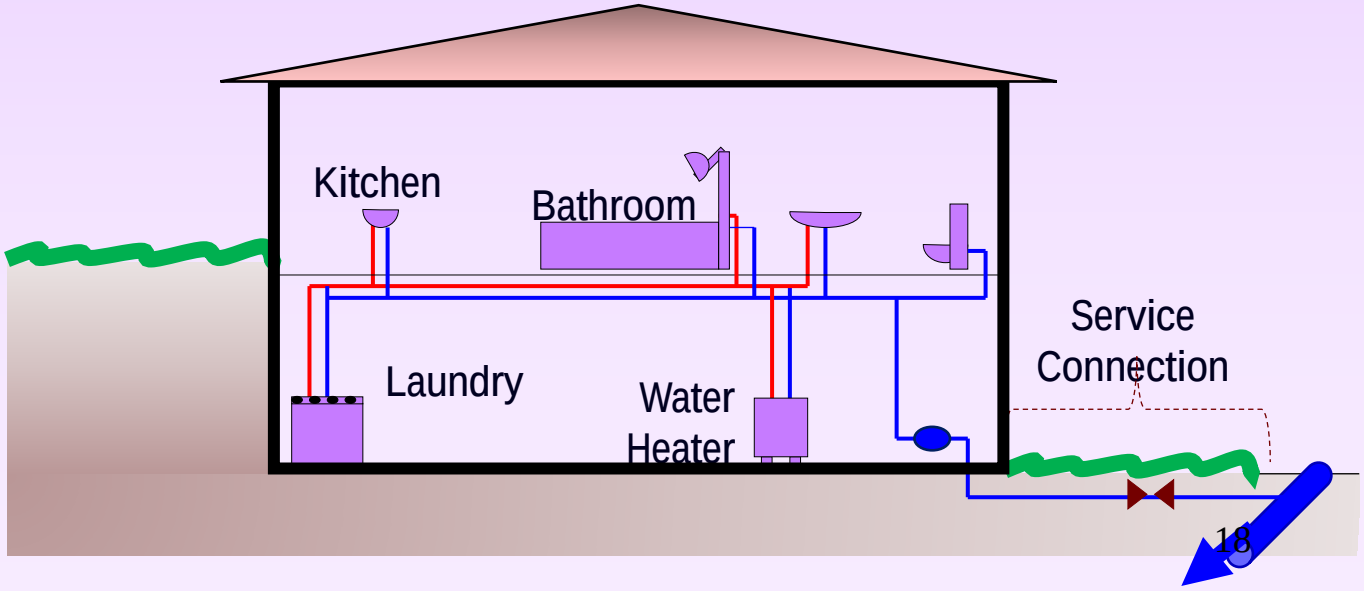
- "Microbiology of the built environment"
  - Premise plumbing is an example
- Engineered environments provide special conditions
  - Select for these organisms
  - Establish and proliferate (amplify)
  - Dispersion into aerosols
- Opportunistic pathogens – *Legionella* and others
- OPPPs

Premise plumbing – point from the service connection line from the public distribution system to private supply – schools, hospitals, hotels, businesses, private dwellings



Premise Plumbing

- Water supplier is no longer legally responsible for WQ in the pipes
  - exception in US is the Lead and Copper Rule.
- WQ responsibility becomes that of the building owner – individual, business, property manager.



Why is Premise Plumbing Unique?

- PP has all of the same WQ issues as the DW DS

  ONLY TO A FAR GREATER EXTENT

- Lack of knowledgeable professionals to recognize, prevent or mitigate WQ problems
- Lack of regulation of WQ after it enters a building
- Addressed by the National Academy of Sciences (2006) in a report on water supply DS risks

Factors that Make Premise Plumbing Unique (NAS, 2006)

- High SA to V ratio
- Materials
- Water age
- Extreme temperatures
- Low to no disinfectant residual
- Bacterial regrowth
- High variable velocities
- Proximity to service lines
- Cross connections
- Aerosol exposure

Legionnaires' Disease

- *Legionella pneumophila* common in tap water
- Causes LD when amplified in building water
- Contracted through inhalation of aerosols
  - **Water is safe to drink but not to breathe**
- US CDC reports 8,000 to 18,000 people are hospitalized with Legionnaires' disease each year
  - Perhaps 10 X cases unrecognized
- Pneumonia but can become systemic
- 5 to 30% fatality rate
- $434,000,000 cost to treat in US yearly
- 217% increase over 10 years in reported cases

#1 waterborne disease in the US and is preventable

Legionella

- Can grow at elevated temperatures and survive and multiply in hot water heaters (25-42°C, [77-108°F]).
  - Incubators for *Legionella*
- Becomes established in premise plumbing biofilms and is difficult to eradicate
- Colonize pipes, tanks, faucets, showerheads, etc.
- Outbreaks linked to all types of water features (pools, spas, showers, hot tubs, AC, ice makers, potting soils, windshield washer)

How can we prevent Legionnaires' Disease?

We know how *Legionella* works

- Live in soil and water and are not eradicated by DW treatment
- Grow in biofilms in pipes in building water systems
- Enter building water systems from the water supply, main breaks/repairs, cross connections
- Become established in building water systems because the conditions are perfect for their growth
- Warm to hot water, fluctuating temperatures, low use, loss of residual
- Grow to high levels and then are disseminated in aerosols
- Breathed in high numbers by susceptible individuals – disease or death can result

How can we prevent Legionnaires' Disease?

We know how to control *Legionella* in building water systems

- Keep the cold water cold (below 20°C, 68°F) and the hot water hot (60°C, 140°F) – watch out for scalding
- Keep the water moving, avoid stagnation
- Maintain plumbing fixtures, clean hot water tanks
- Understand the building water system and how to manage it effectively
- Actively manage building water quality

But it is hard to disinfect a system with an established infestation

Who is Working on This Issue?

- World Health Organization
- ASHRAE
- Cooling Technology Institute
- National Sanitation Foundation
- Water Research Foundation
- National Academy of Sciences
- American Academy of Microbiology
- AWWA
- USEPA
- CDC

World Health Organization (WHO)

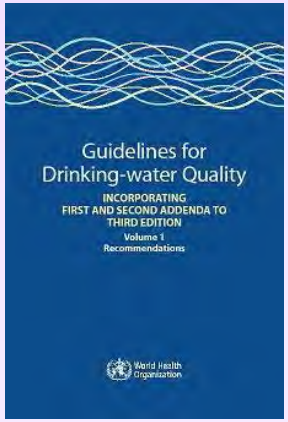
Hazard Analysis and Critical Control Points

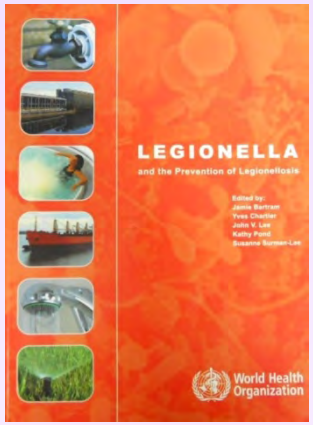
1994 – Havelaar, et al.- first proposed the use of HACCP for water quality management

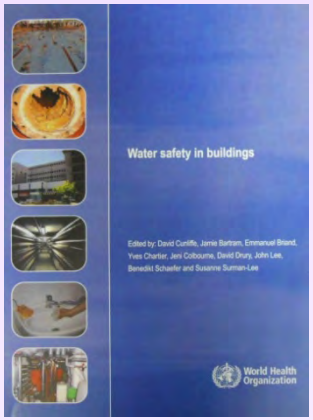
2004 – *Guidelines for Drinking-water Quality*

2007 – *Legionella and the Prevention of Legionellosis*

2011 – *Water Safety in Buildings*







26

HACCP *for* Building Water Systems

27

American Society of Heating Refrigeration and Air-conditioning Engineers (ASHRAE)

ASHRAE Guideline 12-2000
Minimizing the Risk of Legionellosis Associated with Building Water Systems

Working on revision called Standard 188, Prevention of Legionellosis Associated with Building Water Systems

ASHRAE Guidelines

- For control of *Legionella* in building water systems
  - Stored and distributed below 20°C (68°F)
  - Hot above 60°C (140°F)
  - Recirculated with minimum of 51°C (124°F)
  - 29°C (120°F) storage where practical
  - Thermal disinfection 160-170°F (71-77°C)

Cooling Technology Institute

- Cooling towers well established as sources of LD
- 2008 - Legionellosis Guideline: Best Practices for Control of *Legionella*
- Currently updating guideline

National Sanitation Foundation

- Addressing building WQ in two ways
  - Developed and teach a course on HACCP for building water systems
  - STANDARD NSF/BSR 444 *Prevention of injury and disease associated with building water systems*
    - The purpose of this Standard is to specify minimum practices for the prevention of injury and disease associated with building water systems. (HACCP or water safety plan)

Water Research Foundation (WaterRF)

- Project 4379 - *State of the Science and Research Needs for Opportunistic Pathogens in Premise Plumbing* - report outlining issues with OPPPs)and the critical research gaps.
- Project 4383 - *Green Building Design: Water Quality and Utility Management Considerations*.
  - competing factors with maintenance of high WQ at odds with energy use.
- Project 4572 - *Flushing Guidance for Consumer Premise Plumbing and Service Lines to Avoid or Address a Drinking Water Advisory*.
- WaterRF has put premise plumbing issues as a new focus area
  - 4006 – *Research Plan for Management of Emerging Pathogens in Distribution systems and Premise Plumbing*

American Academy of Microbiology

- Convened expert workgroup in 2012
- Report 2013
  - Microbes in Pipes: The Microbiology of Water Distribution Systems

AWWA

- Development of Guidance for Communicating *Legionella* Control to those that can take action
- Originated with AWWA but expanded to include utilities, public health professionals (county, state, federal), regulators, WaterRF, EPA, CDC, WQ scientists and engineers
- Education to those responsible for building WQ

Workshop Participants

Atlanta
July 22, 2014

Matthew Arduino	CDC
Michael Beach	CDC
Gary Burlingame	Philadelphia Water
Joe Carpenter	CDC
Jennifer Clancy	Corona Environmental
Cesar Cordero	EPA
Lisa Daniels	PDEP
David Dyjack	NACCHO
Elaine Floyd	Alaska DEC
Julie Gargano	CDC
Laurel Garrison	CDC
Jessica Godreau	NCDNR
Grace Jang	WaterRF
Greg Kail	AWWA
Mark LeChevallier	American Water
Claressa Lucas	CDC
Marilyn Marshall	Corona Environmental
Dennis Porter	Greenville Water (SC)
Lisa Ragain	Aqua Vitae
Stig Regli	EPA
Alan Roberson	AWWA
Sam Rucinski	AWWA
Steve Via	AWWA

AWWA

- Disinfection Residual Strategy Panel (2015)
  - National workgroup on disinfectant residuals in DW DSs
  - Reviewing science and knowledge gaps re: residuals and disinfection
  - Developing strategy for informing regulatory decisions on residual determination

USEPA

- Working with CDC and the Association of State Drinking Water Administrators (ASDWA)
  - developed a comprehensive guidance document to assist States in understanding the treatment technologies available for use in secondary treatment for large buildings
- EPA held a webinar on this topic on May 28th
- Expect document in 2015

US CDC

Legionellosis (and other plumbing-associated infections) is preventable.

- Since 2000, advised facility managers involved in building WQ to apply HACCP principles.
  - *"Since 2000, there has not been a reoccurrence in any facility that followed this recommendation."*

Claressa Lucas, Ph.D.

Microbiologist

ELITE Program Coordinator

Conclusions

- *Legionella* is the most well known of a group of organisms known as opportunistic pathogens (OPs)
- Common environmental microbe
- *Legionella* can be found in treated DW that meets all federal and State standards
- Legionnaires' disease (LD) is the #1 WBD in the US
- LD results from WQ degradation in building water systems in the premise plumbing (PP)

Conclusions

- LD is the result of a ‘perfect storm’
  - *Legionella* grow to high levels in PP
  - The bacteria are released into the air in microscopic droplets
  - Susceptible hosts breathe in the droplets
  - Host immune response is unable to prevent infection
    - Pontiac fever (mild flu like illness, not fatal)
    - LD (pneumonia, may lead to death)

Conclusions

- LD is preventable
- Effects of DW treatment cannot control *Legionella* because the bacteria reproduce in PP
- Control of *Legionella* and LD happens in the building, not in the DW DS
- National effort ongoing on many fronts to address this issue of PP WQ

Thank you for your attention.

Questions/comments welcomed