Drinking Water Quality Variations in Green Residential Plumbing and Disasters

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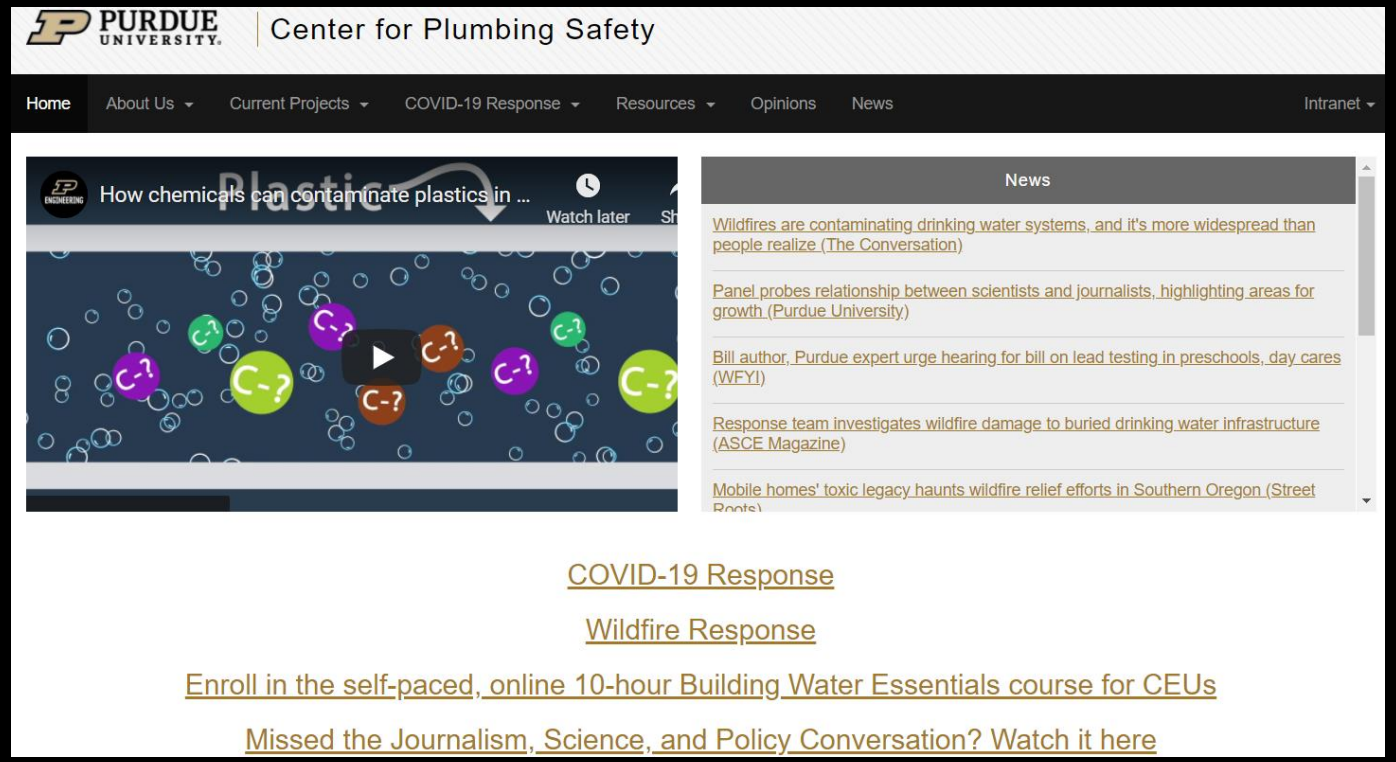
More information here…



www.PlumbingSafety.org

- ✓ Wildfire response
  - Info sheets
  - Videos
  - Studies
  - Links to FEMA materials
- ✓ COVID-19 response
  - Info sheets
  - Videos
  - Studies
  - Links to CDC resources
- ✓ Other resources
  - Project summaries
  - Scientific opinions
  - Reports & presentations
  - External plumbing docs

Water Quality Basics

Constant contaminant situations

Source water (hardness, heavy metals, algal products, PFAS, sulfur, etc.)

Added to water for treatment (chlorine, fluoride, etc.)

Leaching from storage and transport materials (heavy metals, organics, biofilm food)

Grow in biofilm (*L. pnemophila, M. avium, N. fowleri, P. aeruginosa, etc.*)

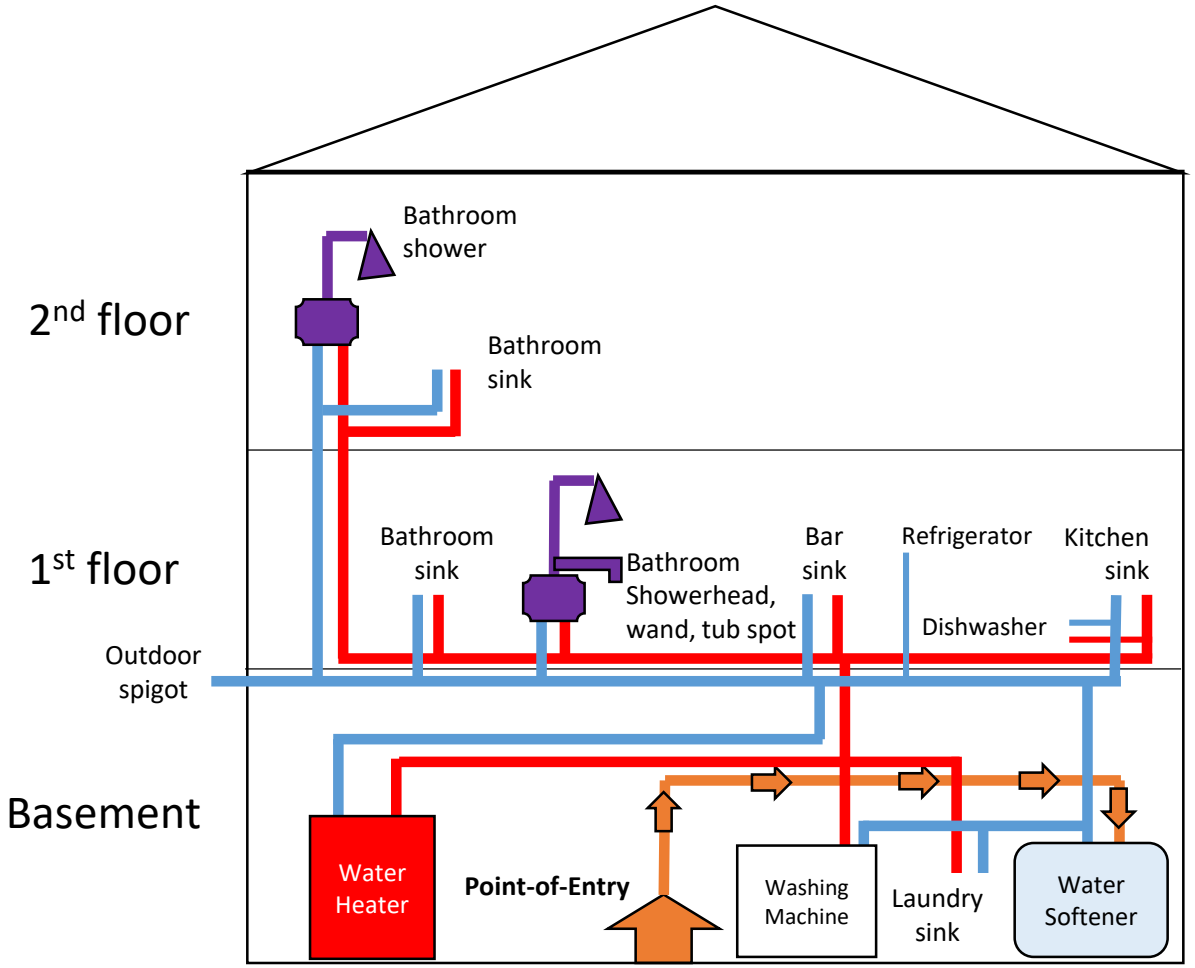
Transient contaminant situations

Scale/sediment release (i.e., colored / particulate water)

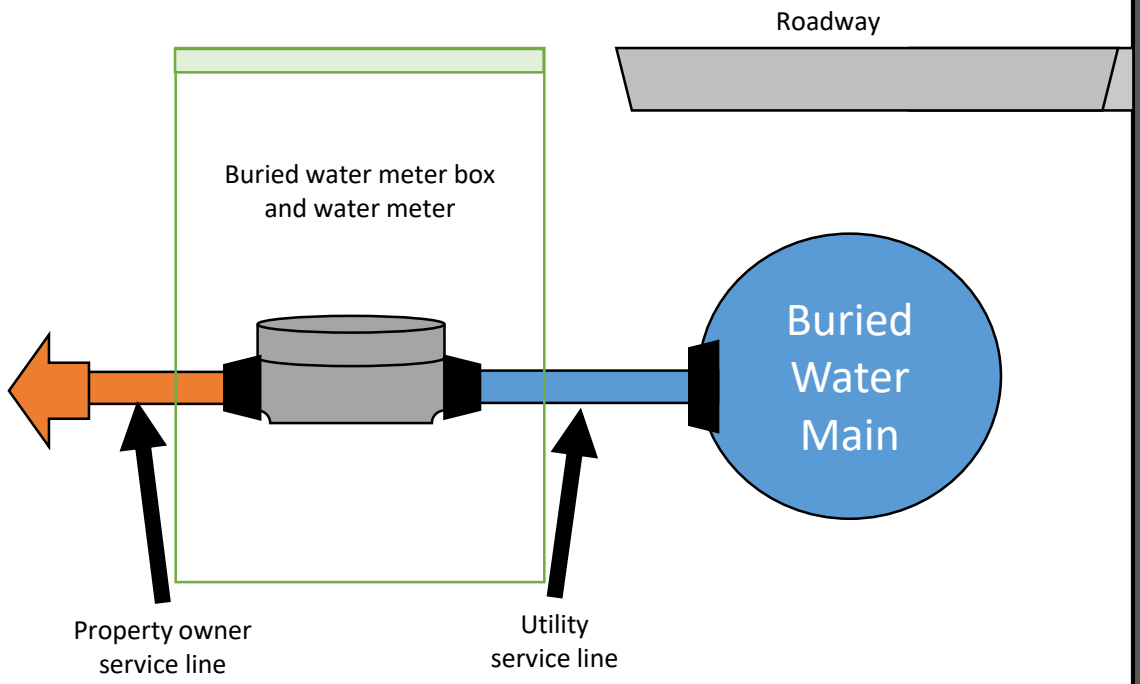
Biofilm and pathogen release

Disasters, accidents, cross connections (spills, fires, floods, backflows, etc.)

Single family home trunk and branch design with a centralized water heater (Manifold designs are much different)



Cold and hot water flow through separate pipes
Some locations are downstream from others, but branch off into separate pipes
Trunk and branch vs. manifold designs

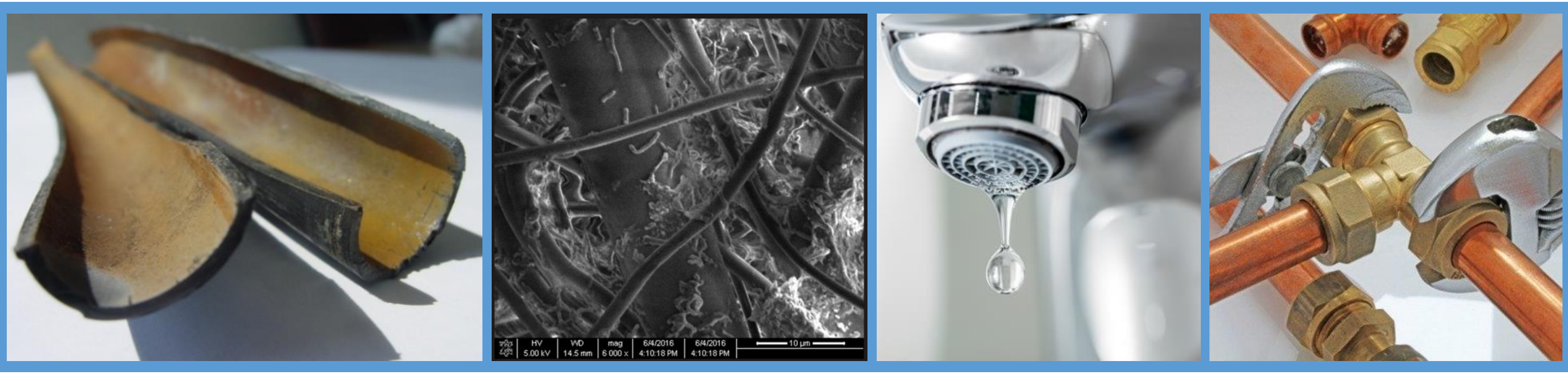


How old is your water before reaching the faucet?

$$\frac{\text{Volume of water stored in pipes}}{\text{Flowrate of water exiting the faucet}}$$

…our water systems are not designed to handle lower use

Right Sizing Tomorrow's Water Systems for Efficiency, Sustainability, & Public Health (2016-Pres)



Andrew Whelton, Jade Mitchell, Joan Rose, Juneseok Lee, Pouyan Nejadhashemi, Erin Dreelin, Tiong Gim Aw, Amisha Shah, Matt Syal, Maryam Salehi

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MICHIGAN STATE UNIVERSITY
SJSU SAN JOSÉ STATE UNIVERSITY
MANHATTAN COLLEGE
Tulane University
THE UNIVERSITY OF MEMPHIS

Goal and Objectives

To better understand and predict water quality and health risks posed by declining water usage and low flows

1. **Improve the public's understanding of decreased flow** and establish a range of theoretical premise plumbing flow demands from the scientific literature and expert elicitation with our strategic partners

2. **Elucidate the factors and their interactions that affect drinking water quality** through fate and transport simulation models for residential and commercial buildings

3. **Create a risk-based decision support tool** to help guide decision makers through the identification of premise plumbing characteristics, operations and maintenance practices that minimize health risks to building inhabitants.

The Most Monitored Home in America

West Lafayette, Indiana
Less than 100 yards from Purdue
3 Bedroom, 1.5 baths
Water saving fixtures
Trunk-and-Branch design
PEX piping
Renovated in 2014

Thermocouples throughout piping, 1x /sec
Indoor air temperature, 1x /sec
Flowrates at every fixture, 1x /sec
Energy use per device, 1x /sec

www.ReNEWWHouse.com

October 2017-October 2018

30,000+ individual water quality measurements completed - does not include flow monitoring, pressure monitoring, or qPCR

2.64 billion online plumbing related measurements

>223,000 labor hours

PURDUE UNIVERSITY | Tulane University | SJSU San José State University | Manhattan College | Michigan State University | The University of Memphis

TAPPED INTO PLUMBING

Issue September 2018

Reflecting on Year 2

By Andrew Whelton, PhD
Purdue University

Greetings !

Two years ago the US Environmental Protection Agency provided our team a grant to address a National Priority problem: Drinking Water Safety in Building Plumbing. Since then, we have accomplished a lot working with our 32 Partners. We have been testing drinking water safety in homes, schools, and other buildings and also conducting pilot and bench-scale tests. In 2019 you can learn more about this study and it's results through our website www.PlumbingSafety.org, meetings, and webinars.

It is mind-blowing to think about the sheer scope of what we are working on. This project would not have been possible without the tremendously talented cadre of students, postdoctoral associates, staff, and faculty in Indiana, Louisiana, New York, Michigan, and Tennessee. A special thanks is extended to our project partners shown on the next page! Here's a taste of what we've done:

- More than 300 million plumbing related measurements have been conducted at a single home alone. More than 15,000 drinking water quality sampling results have been obtained for that same building—and testing is not yet complete.
- Researchers have identified new exposure thresholds for some emerging disease causing organisms sometimes found in building drinking water.
- Students, postdoctoral associates, and staff have run thousands (possibly tens of thousands) of laboratory tests to better understand how plumbing can affect drinking water in plumbing rigs and at real buildings.
- Our team members have shared results with the public health and utility sectors along with regulators in California, Indiana, Louisiana, Nevada, Oregon, and Washington, DC.

Stay tuned and check our website for coming results. 2019 is going to be an amazing year. And, we hope you join us on this journey of discovery.

HEALTHY HOMES

By Andrew Whelton, PhD, Purdue University

While more than 136 million homes exist in the US, validated models for predicting water safety in homes are lacking. Through this project, we are addressing that problem head-on. Almost 1 year into our intensive drinking water testing study at a single-family home, we have an amazing series of discoveries. More than 300 million online water measurements and 15,000 water sample results have been collected—so far. Results will begin to be released in 2018 and 2019.

SCHOOLS AND OTHER LARGE BUILDINGS

By Tiong Gim Aw, PhD, Tulane University

For large buildings like schools, "Are chemical and microbiological characteristics of water the same during low water use Summer months compared to when school is back in session?" Our drinking water study of large buildings is addressing this question.

PLUMBING AT SCALE

Our state-of-the-art Plumbing Testing & Evaluation (T&E) Facility is up and running thanks to amazing and herculean efforts by students and staff. We now can test at-scale different plumbing components and designs. Online water quality monitoring, temperatures, flows, water heaters, pipes, faucets, home treatment equipment, chemistry and microbiology, and more. In 2019 we expect to initiate tests to better answer questions generated from our testing from real buildings. We are also on the lookout for collaborators. If you would like to work with us, have ideas, or wish to help, please contact us.

CONTACT US www.PlumbingSafety.org awhelton@purdue.edu

Partners, Supporters, and Participants

Whirlpool Corporation

GORDON & ROSENBLATT

Indiana State Department of Health

HRC

hbn Healthy Building Network

IDEM

Watershed, LLC

COMMUNITY ENGINEERING SERVICES, PLLC

U.S. Green Building Council LEED USGBC

The Nature Conservancy

Genesee County Health Department

citizens energy group

AVON COMMUNITY SCHOOL CORPORATION

NEHA National Environmental Health Association

DeKalb County Georgia

IRWA

IAPMO

NIST National Institute of Standards and Technology U.S. Department of Commerce

Science Interactive

Naval Hospital Jacksonville, Florida

ASPE American Society of Plumbing Engineers

InspectAPedia

Université Laval

Technion Israel Institute of Technology

University of Cincinnati

Go now and visit www.PlumbingSafety.org !!!

Industrial, Academic, and Government Partners

The study:

An investigation of spatial and temporal drinking water quality variation in green residential plumbing, 2019

Building and Environment

1. Water quality entering the building varied seasonally.
2. **For 10.3% time, water entering the building did not contain a detectable chlorine disinfectant residual.**
3. Inside the building, stagnation time varied seasonally and across fixtures. Water at the kitchen sink in the Summer had different characteristics than water in the Winter.
4. Water pH also consistently and significantly increased in the plumbing from 7.5 to 9.4, and TTHM levels increased up to 89%.
5. Great carbon variability was found inside the building for cold (0.4-61.0 mg/L) and hot water (0.5-4.7 mg/L).

https://doi.org/10.1016/j.buildenv.2019.106566

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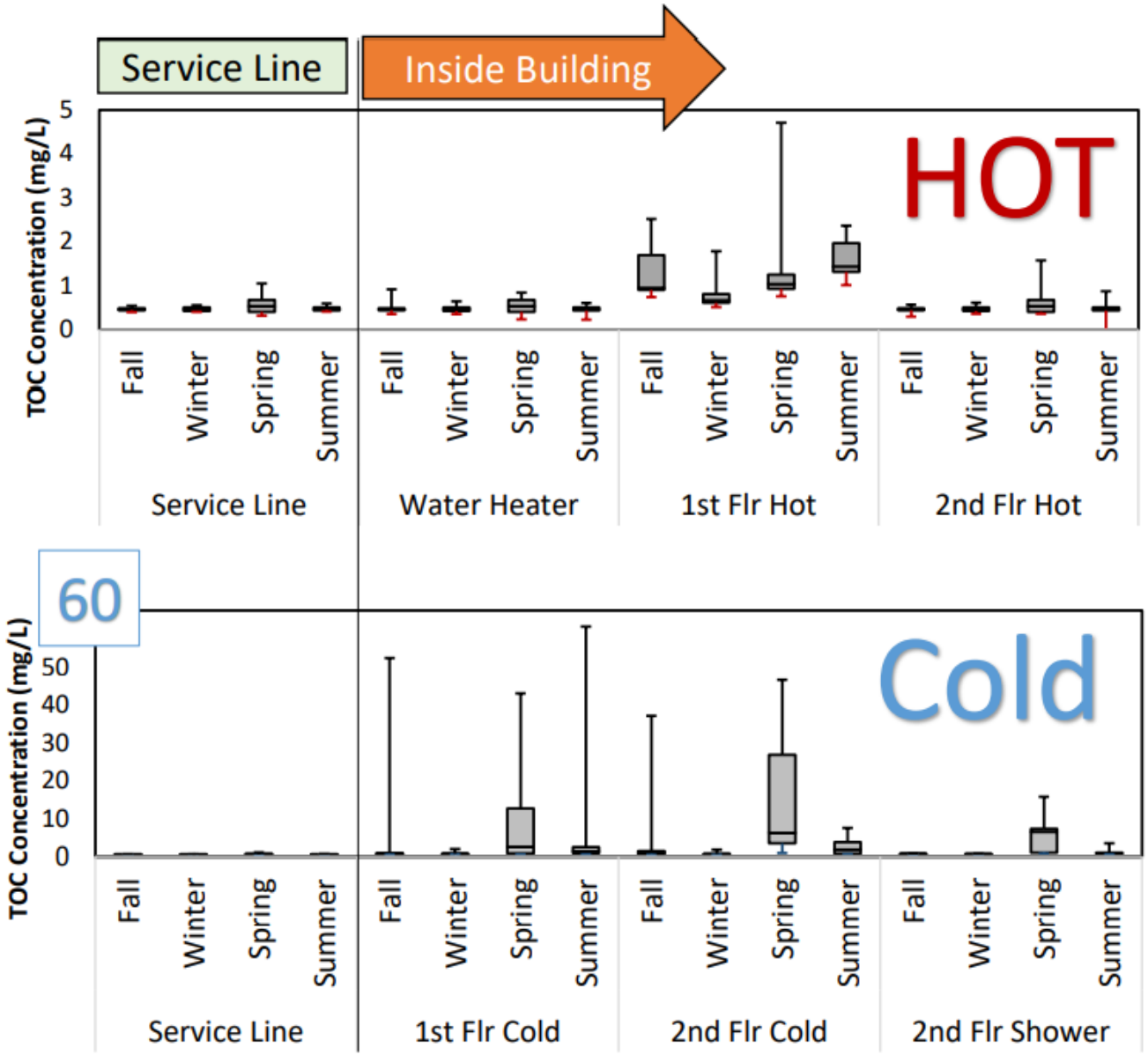
Single Family Home: Water at Service Line ≠ Water at the Tap

	Service Line	Cold Water Lines	Hot Water Lines	MCL[1] SDWR[2]
Water pH	7.65 –(7.73)– 7.81	7.43 –(8.17)– 9.24	7.35 –(8.18)– 9.01	6.5-8.5[2]
Total Chlorine (mg/L)	BDL –(0.7)– 1.6	BDL –(0.1)– 0.8	BDL –(0.3)– 1.7	State Dependent
Temperature (C)	11.5 –(18.0)– 23.8	19.1 –(22.1)– 27.4	17.2 –(22.3)– 27.9	N/A
TTHM (µg/L)	0.00 –(1.64)– 9.62	1.91 –(16.79)– 41.88	3.42 –(19.91)– 39.20	80[1]
TOC (mg/L)	0.32 –(0.41)– 1.05	0.40 –(3.92)– 46.7	0.49 –(0.94)– 4.71	N/A
Calcium (mg/L)	36.79 –(84.62)– 100.47	0.13 –(1.68)– 77.29	0.50 –(1.53)– 14.19	N/A
Iron (µg/L)	ND –(11.5)– 40.3	ND –(12.2)– 132	2.0 –(7.1)– 16.3	300[2]

Service line chlorine levels varied significantly during the day and throughout the week.



Typical TOC in water distribution systems
1-6 mg/L

TTHMs = pH, carbon, chlorine, temperature, stagnation time

[80 ug/L = MCL]

1. pH drastically increased, 7.5 to 9.4
2. Carbon came from utility water
3. Carbon leaching from new PEX pipe was pH and temperature dependent.
4. Carbon also present in biofilms
5. TTHMs increased in the building
   - < 4.8 ug/L entering building
   - Max 42 ug/L inside building (+89%)

❑ In-building TTHM levels were not predicted by 3 available models

2. Microbiology in a Water-Efficient Home: Stagnation, Seasonality, and Physiochemical Effects on Opportunistic Pathogen and Total Bacteria Proliferation, *Tiong Gim Aw, **Christian Ley**, et al.*

Service line water quality varied by season

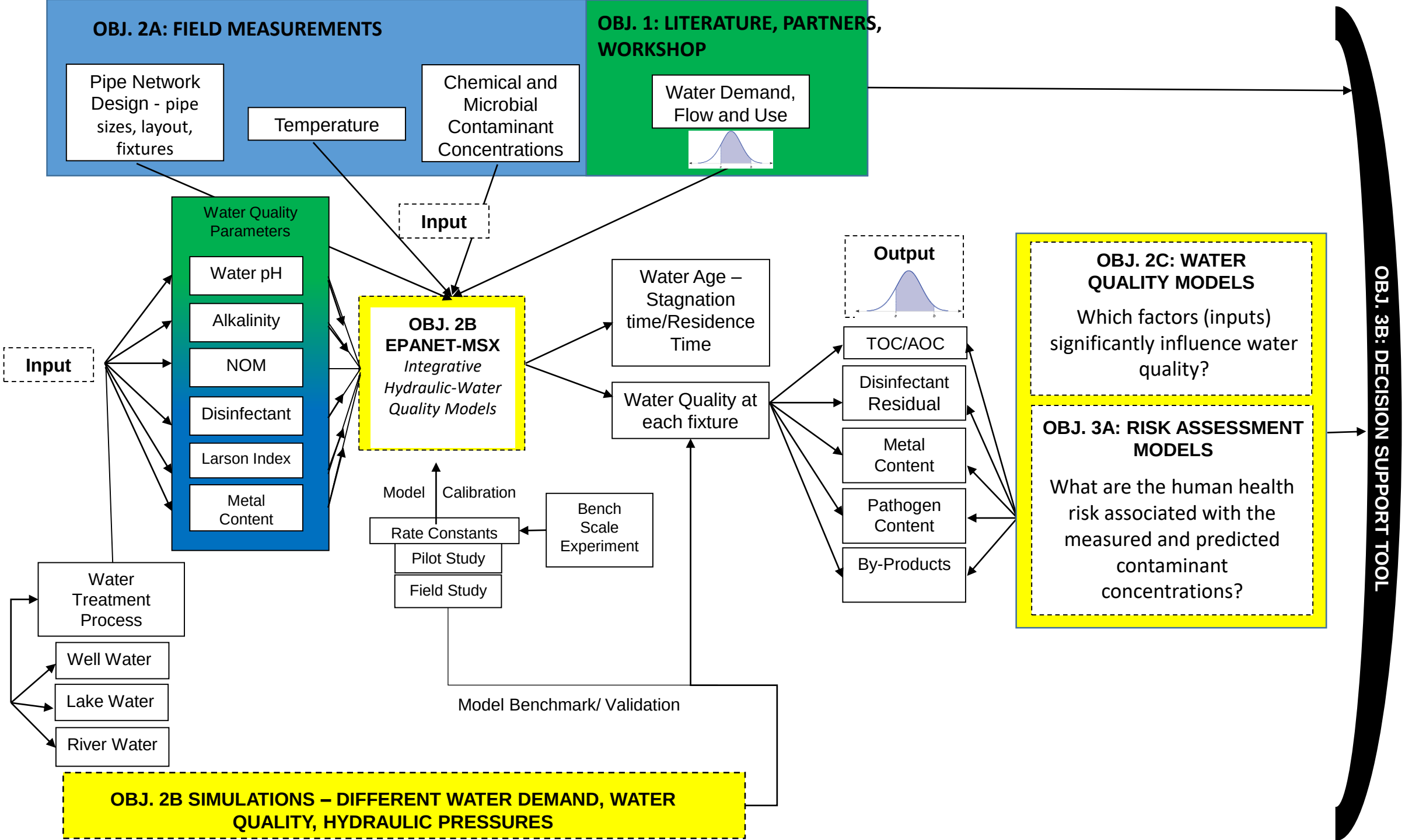
Season	Range		
	Chlorine*, (mg/L)	TOC (mg/L)	HPC** (CFU/100mL)
Fall (13)	0.2 – 0.8	0.40 – 0.54	22 – 23,600
Winter (17)	ND – 1.6	0.40 – 0.56	ND – 11,700
Spring (12)	0.1 – 2.1	0.32 – 1.05	4.3 – 21,666
Summer (16)	ND – 0.8	0.41 – 0.59	18.3 – 11,366

**Chlorine detection limit = 0.1 mg/L*
*** HPC detection limit = 20 CFU/100mL*

Opportunistic pathogen survey of residential water system using qPCR

Location	*Legionella spp.*, % samples positive			*Mycobacterium spp.*, % samples positive		
	Sum.	Fall	Winter	Sum.	Fall	Winter
Service Line	12.5	30.8	14.3	87.5	38.5	37.5
Water Heater	100	100	50	100	92.3	87.5
Kitchen cold	100	61.5	62.5	100	69.2	87.5
Kitchen hot	100	84.6	75	85.7	76.9	75
Bathroom cold	100	69.2	50	100	69.2	75.0
Bathroom hot	100	92.3	87.5	100	69.2	87.5
Shower	100	92.3	100	100	76.9	100

Number of sampling events: Summer n=16; Fall n=13; Winter n=8


OBJ. 2A: FIELD MEASUREMENTS
Pipe Network Design - pipe sizes, layout, fixtures
Temperature
Chemical and Microbial Contaminant Concentrations
OBJ. 1: LITERATURE, PARTNERS, WORKSHOP
Water Demand, Flow and Use
Input
Water Quality Parameters
Water pH
Alkalinity
NOM
Disinfectant
Larson Index
Metal Content
Input
OBJ. 2B EPANET-MSX Integrative Hydraulic-Water Quality Models
Water Age – Stagnation time/Residence Time
Water Quality at each fixture
Output
TOC/AOC
Disinfectant Residual
Metal Content
Pathogen Content
By-Products
OBJ. 2C: WATER QUALITY MODELS
Which factors (inputs) significantly influence water quality?
OBJ. 3A: RISK ASSESSMENT MODELS
What are the human health risk associated with the measured and predicted contaminant concentrations?
OBJ. 3B: DECISION SUPPORT TOOL
Model
Calibration
Rate Constants
Pilot Study
Field Study
Bench Scale Experiment
Water Treatment Process
Well Water
Lake Water
River Water
Model Benchmark/ Validation
OBJ. 2B SIMULATIONS – DIFFERENT WATER DEMAND, WATER QUALITY, HYDRAULIC PRESSURES

4 Seasons (Summer, Fall, Winter, Spring)	2 Systems (Hot, Cold)
4 Service Line Length (1' (As is), 25', 50', 100')	2 Free Chlorine at service line (As is, 2x)
2 Pressure boundary conditions (35/40psig (As is cold/hot), 80psig)	4 Conservation Scenarios (25%, 50%, 100%(As Is), 200%)

Manhattan College

Purdue University

Michigan State University

Funded by:

We need to be able to predict water quality at the fixture

↑ Service line **length** 1 ft → 50 ft, **Legionella spp.** GCN / L increased up to 1,000,000.

↑ Service line **length** 1 ft → 50 ft **Copper** concentration increased up to **4x**.

↑ **Pressure** from 35 psig → 80 psig, **Legionella spp**. GCN / L decreased up to 10,000x.

↑ **Pressure** from 35 psig → 80 psig, **Copper** concentration decreased up to 15x.

↓ **Water use** to 25% of normal condition, **HPC** levels increased 100x.

Courtesy of Prof. Juneseok Lee, Maria Palmegiani, and others ….

Residential Focus

- Residential municipal water changes over 1 yr - chemistry
- Residential municipal water changes over 1 yr - microbiology
- Residential municipal water – chemistry/microbiology model
- PEX pipe metal scale accumulation and removal - chemistry
- PEX pipe leaching, DBP generation - chemistry
- PEX pipe degradation - chemistry
- Residential municipal water – water heating
- Residential municipal water – Legionella prediction
- Residential rainwater changes over 4 months – chemistry/microbiology
- Lessons from wildfire caused water contamination
- Population post-disaster water safety attitudes
- Plastic pipe water contamination due to heating

Others

- Plumbing research needs
- Pathogen exposure modeling
- Institution municipal water changes over a semester - microbiology
- Office municipal water changes over weekends – chemistry / microbiology
- School municipal water changes over summer – chemistry / microbiology

PEX plumbing pipe is >60% of new residential construction

- PEX can leach a lot of organic chemicals into water (~50 mg/L)
- High leaching variability across and even within brands
- Leaching can cause water to smell like gasoline
- Some leached carbon is available for microbial growth
- Leaving pipe on shelf caused less leaching
- TOC or total organic carbon good surrogate indicator for leaching in the lab

Disasters continue to expose a deficiency of knowledge and this has profound impacts on health, safety, and economic prosperity

Maximum Benzene Level	Event/Location	Population Affected	System Name	Year
6	Echo Mountain Fire/Oregon	120	Whispering Pines Mobile Home Park	2020
11	Echo Mountain Fire/Oregon	362	Hiland WC - Echo Mountain	2020
1	Echo Mountain Fire/Oregon	760	Panther Creek Water District	2020
76	Almeda Fire/Oregon	6,850	City of Talent	2020
45	Lionshead Fire/Oregon	205	Detroit Water System	2020
2	CZU Lightning Complex Fire/California	1,650	Big Basin Water Company	2020
42	CZU Lightning Complex Fire/California	21,145	San Lorenzo Water District	2020
2,217	Camp Fire/California	26,032	Paradise Irrigation District	2018
38	Camp Fire/California	924	Del Oro Water Co.-Magalia	2018
8	Camp Fire/California	1,106	Del Oro Water Co.-Lime Saddle	2018
530	Camp Fire/California	11,324	Del Oro Water Co.-Paradise Pines	2018
40,000	Tubbs Fire/California	175,000	City of Santa Rosa	2017

Hazardous waste levels of benzene in drinking water. More VOCs, SVOCs above safe limits.

Sources: Smoke and plastics thermal degradation

Some plumbing plastics uptake chemicals and leach them back out making clean water unsafe

Our March 2020 Study: Lessons Learned from the 2017 Tubbs Fire and 2018 Camp Fire

AWWA WATER SCIENCE

Wildfire caused widespread drinking water distribution network contamination

Download FREE here:
https://doi.org/10.1002/aws2.1183

VOCs and SVOCs present, levels can exceed hazardous waste limits (40,000 ppb benzene, etc.)

Do Not Use water order should be issued

Protect homeowners and their plumbing

Thursday November 8, 2018 Camp Fire – A Different Scale

Executive Department
State of California

November 8, 2018

Proclamation of a State of Emergency

WHEREAS on November 8, 2018, the Camp Fire began burning in Butte County and continues to burn; and

WHEREAS this fire has destroyed homes and continues to threaten additional homes and other structures, necessitating the evacuation of thousands of residents; and

WHEREAS the fire has forced the closure of roadways and continues to threaten critical infrastructure; and

WHEREAS high temperatures, low humidity, and erratic winds have further increased the spread of this fire; and

WHEREAS the Federal Emergency Management Agency has approved a Fire Management Assistant Grant to assist with the mitigation, management, and control of the Camp Fire; and

WHEREAS the circumstances of this fire, by reason of its magnitude, are or are likely to be beyond the control of the services, personnel, equipment, and facilities of any single local government and require the combined forces of a mutual aid region or regions to combat; and

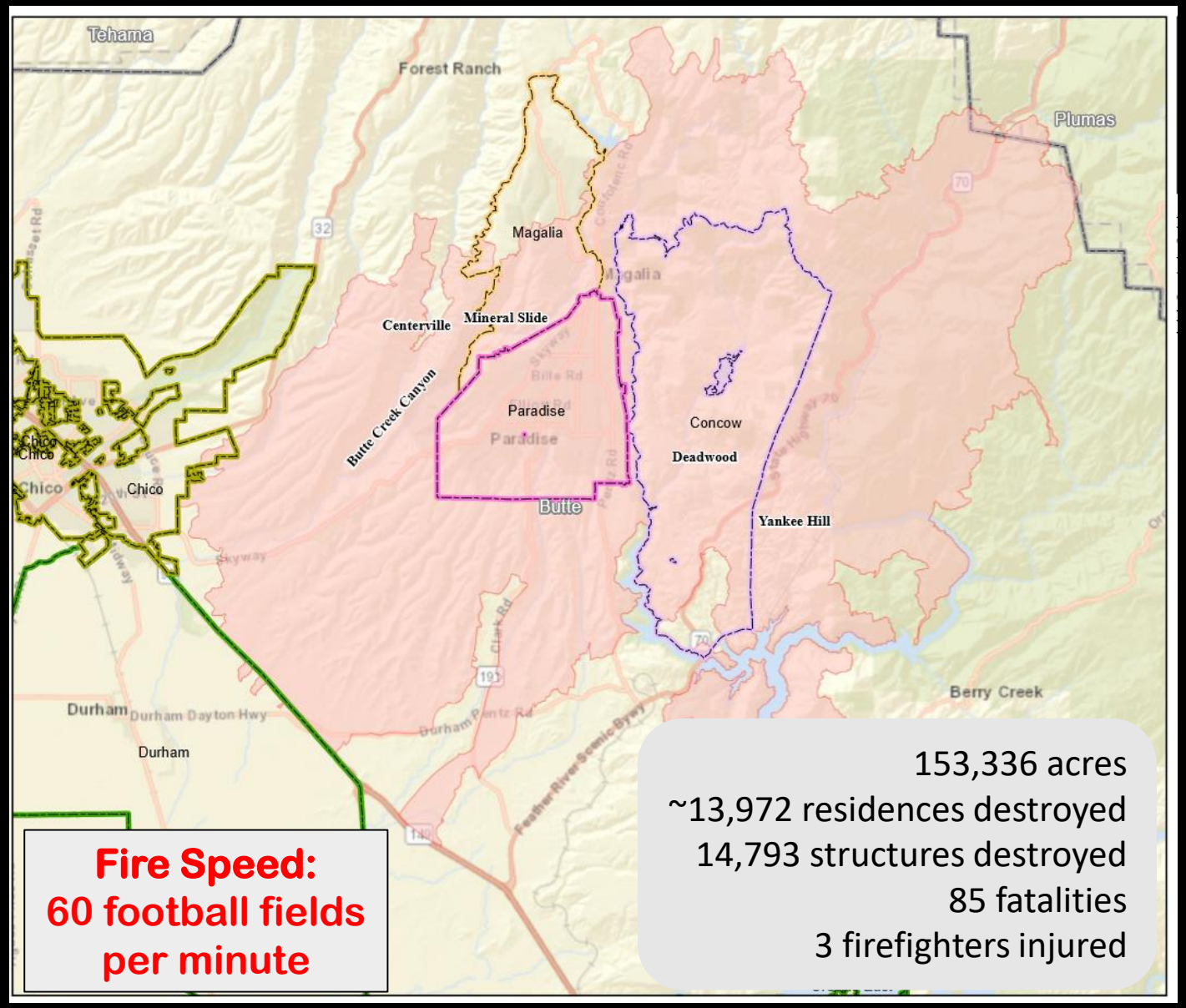
WHEREAS under the provisions of Government Code section 8558(b), I find that conditions of extreme peril to the safety of persons and property exists in Butte County due to this fire; and

WHEREAS under the provisions of Government Code section 8571, I find that strict compliance with the various statutes and regulations specified in this order would prevent, hinder, or delay the mitigation of the effects of the Camp Fire.

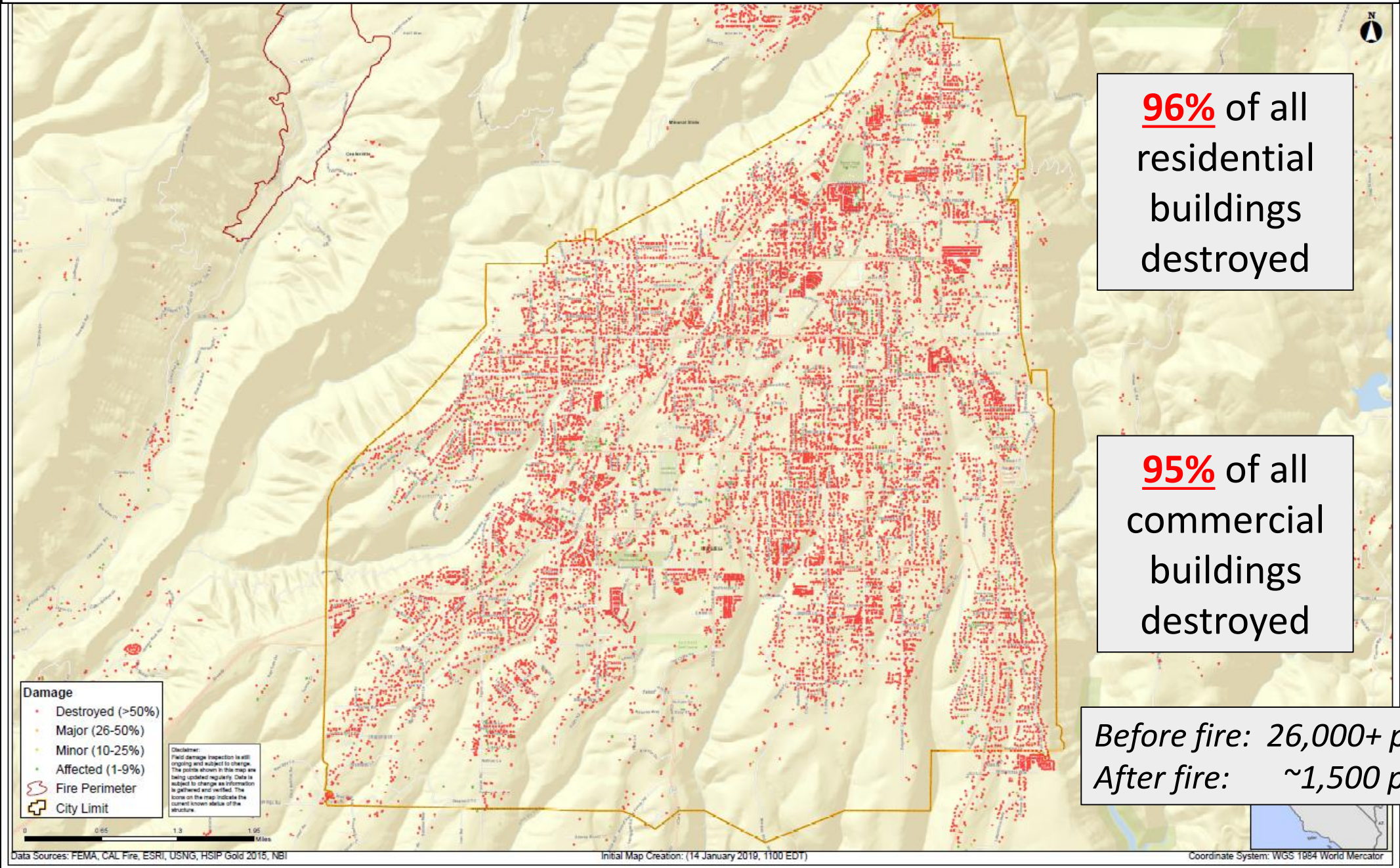
NOW, THEREFORE, I, GAVIN NEWSOM, Acting Governor of the State of California, in accordance with the authority vested in me by the State Constitution and statutes, including the California Emergency Services Act, and in particular, Government Code section 8625, **HEREBY PROCLAIM A STATE OF EMERGENCY** to exist in Butte County due to the Camp Fire.

IT IS HEREBY ORDERED THAT:

1. All agencies of the state government utilize and employ state personnel, equipment, and facilities for the performance of any and all activities consistent with the direction of the Office of Emergency Services and the State Emergency Plan. Also, all citizens are to heed the advice of emergency officials with regard to this emergency in order to protect their safety.
2. The Office of Emergency Services shall provide local government assistance to Butte County, if appropriate, under the authority of the California Disaster Assistance Act, Government Code section 8680 et seq., and California Code of Regulations, Title 19, section 2900 et seq.



Town of Paradise Limits



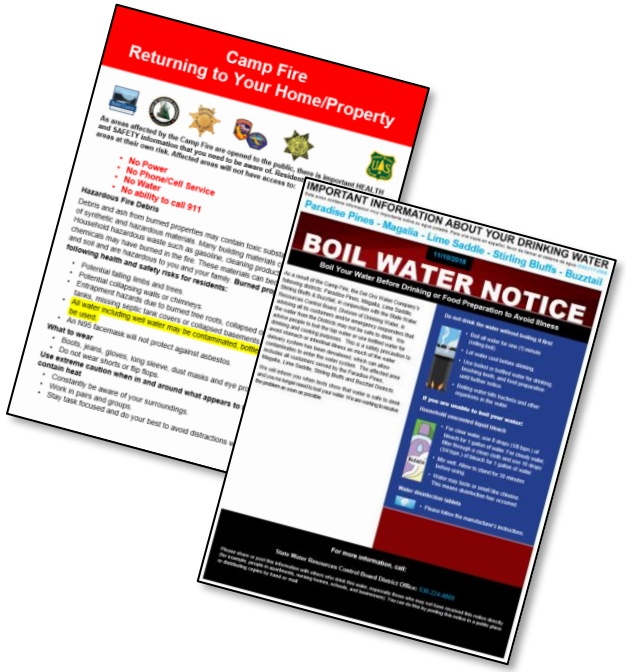
96% of all residential buildings destroyed

95% of all commercial buildings destroyed

Before fire: 26,000+ people
After fire: ~1,500 people

Public Water Systems (% Homes Gone)	Population	Source Water
Paradise Irrigation District (PID) (-96%)	26,032	Surface
Del Oro Water Company (DOWC) – Paradise Pines (-38%)	11,324	Surface
DOWC – Lime Saddle (-50%)	1,106	Surface
DOWC – Magalia (-89%)	924	Ground
DOWC – Stirling Bluffs (0%)	548	Surface
DOWC – Buzztail (-34%)	106	Ground
Foothill Solar Community	180	Ground
Forest Ranch Mobile Home Park	25	Ground
Forest Ranch Mutual Water Company	92	Ground
Gran Mutual Water Company	202	Ground
Humboldt Woodlands Mutual Water Company	75	Ground
Meadowbrook Oaks Mobile Home Park	50	Ground
Mountain Village Homeowners Association	40	Ground

Boil water advisories were issued to 40,000 people



Private wells
13,227 exist in Butte County
2,438 wells in Camp Fire area

February 2019:
3 day visit and briefing, 3 months post-fire





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CalOES, SWRCB, BCHD, FEMA, PID, DOWC, Town, CalFire did not understand how to proceed

< 50 samples had been collected by PID & DOWC

Benzene testing only; State assumed benzene was the only chemical present

Our onsite recommendations:

- Find out what's in the water (not just benzene)
- Reevaluate water use restrictions
- Isolate ➔ Test (72hr) ➔ Decon/replace
- Population in homes needs help, they were left to fend for themselves

Onsite Visit Response and Recovery Observations Presented to PID February 13, 2019

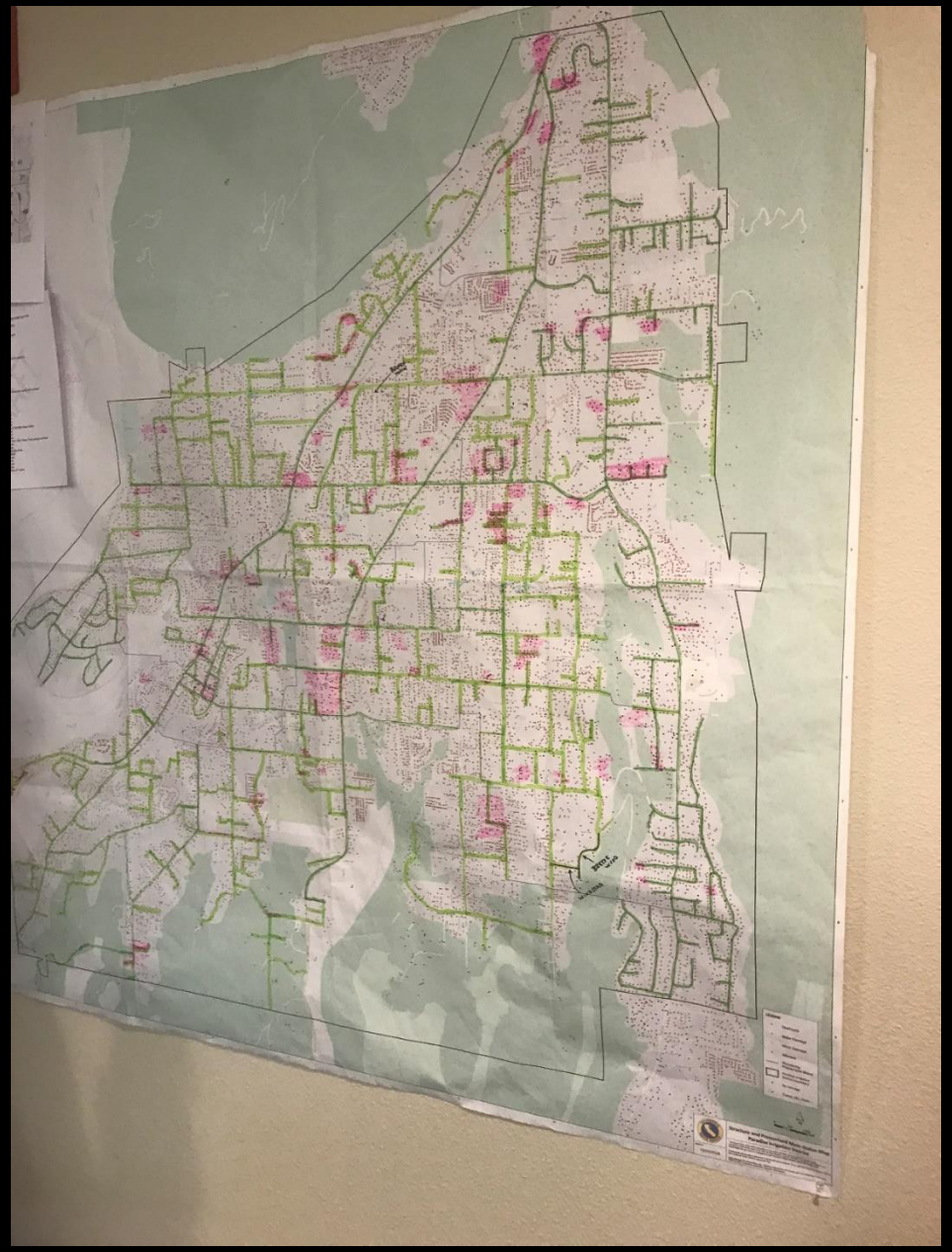
Purdue University & Manhattan College
Andrew J. Whelton, Ph.D., Amisha Shah, Ph.D.,
Juneseok Lee, Ph.D., P.E., Caitlin Proctor, Ph.D., David Yu, Ph.D.
Questions: awhelton@purdue.edu

A. Overall

- PID has done a good job in moving towards stabilizing their infrastructure. This includes repressurizing distribution systems, identifying damaged assets, fixing breaks/leaks, flushing out contaminated water, issuing appropriate water advisories, and other activities.
- The water system is still in the response phase because the system is not yet stabilized and there are many challenges to resolve: for example, how to test for contamination.
- Persons living in the disaster area have complicated the response because PID has had to take action to both respond to their system damage but also to requests of customers.
- A recommendation is that PID focus on completing the response and moving into recovery, but this is and will continue to be slowed by multiple demands on limited resources. For example, PID staffing has been reduced since the disaster took place and the disaster has created an enormous need for additional staffing for response and recovery.
- A critical element to moving forward in a timely manner will be clear and straight-forward recommendations from CalOES and FEMA regarding funding of response efforts.

90%+ of their 172 mile water distribution system depressurized for hours to weeks

100s+ of leaks



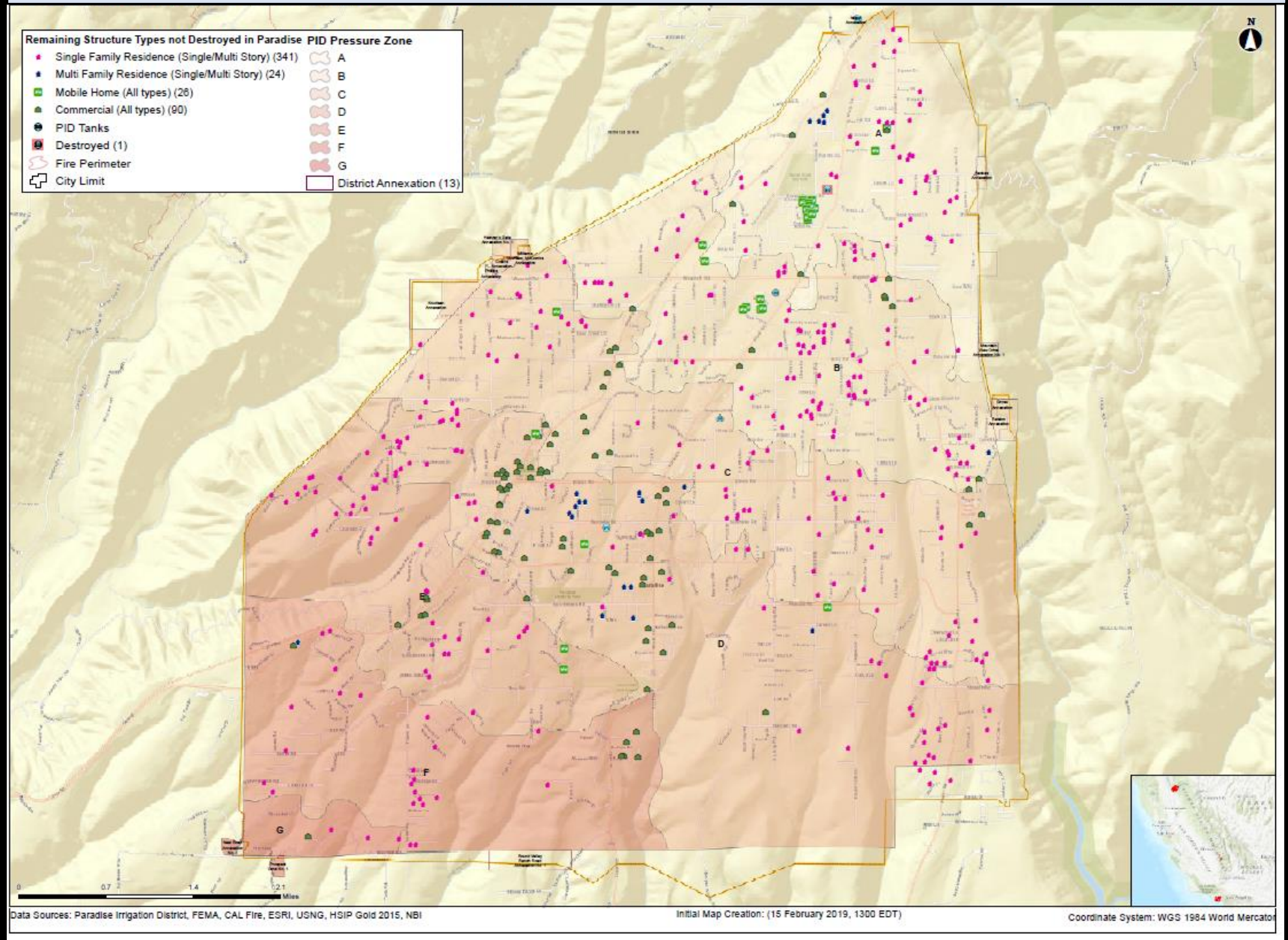
Standing homes were scattered throughout the contaminated water systems: PID Example

2 sources
1 treatment plant

7 pressure zones
172 miles of buried pipe
- PVC (35%)
- Steel (33%)
- CML (19%)
- AC (10%)
- Irons (6%)

1,400 fire hydrants
10,600 service lines and meters
- Cu, Brass, GIP, GSP, HDPE, PB

PID Pressure Zones vs. Standing Structures




11,000+ homes

Drinking Water Distribution System Impacts

500 ppb benzene – U.S. Federal RCRA hazardous waste limit

Chemical that Exceeded a Drinking Water Limit	2018 Camp Fire (8 months after the fire)				2017 Tubbs Fire (11 months after the fire)		
	PID	DOWC	Exceedance		Santa Rosa		
	Max, ppb	Max, ppb	Exceeded Long-Term Limit?	Exceeded ***Short-Term*** Limit?	Max, ppb	Exceeded Long-Term Limit?	Exceeded ***Short-Term*** Limit?
Benzene	>2,217	530	**Yes**	**Yes**	40,000	**Yes**	**Yes**
Methylene chloride	45	NA	**Yes**	No	41	**Yes**	No
Naphthalene	693	NA	**Yes**	**Yes**	6,800	**Yes**	**Yes**
Styrene	378	NA	**Yes**	No	460	**Yes**	No
Tert-butyl alcohol	13	NA	**Yes**	-	29	**Yes**	-
Toluene	676	NA	**Yes**	No	1,130	**Yes**	No
Vinyl chloride	1	NA	**Yes**	No	16	**Yes**	No

Long-term limit for an adult for 70 years
Short-term (1 day) limit for a 1 year old child

AWWA Water Science, Proctor et al. 2020
https://doi.org/10.1002/aws2.1183

Possible Primary Sources

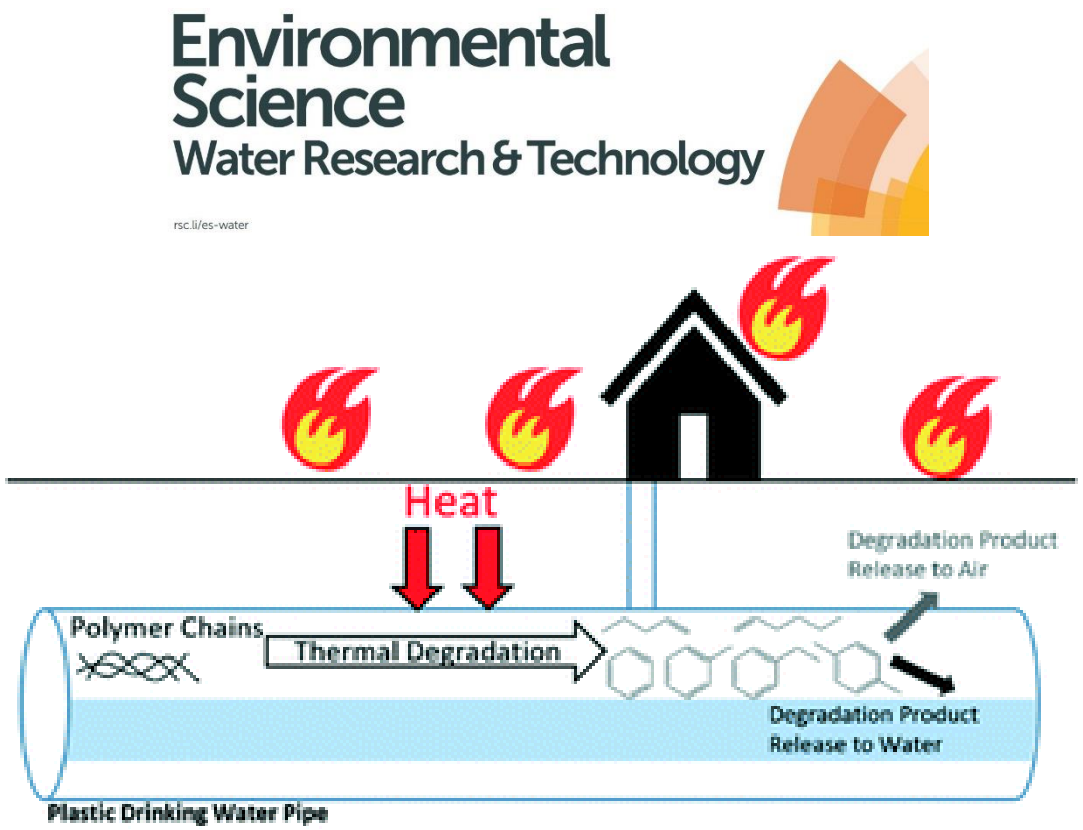
1. *In-situ* plastic thermal decomposition (PVC pipes, HDPE pipes, PB pipes, gaskets, meter components, etc.)
2. Contaminated air/materials drawn into depressurized system
3. Contaminated water from building plumbing drawn into compromised distribution system

Confirmed Secondary Sources

Partitioning/Adsorption/Absorption:
Water ←→ Material

See video at
www.PlumbingSafety.org

December 2020 Study: Thermally damaged plastic pipes can be a source of water contamination



Drinking water contamination from the thermal degradation of plastics: implications for wildfire and structure fire response

Download FREE here:

https://doi.org/10.1039/D0EW00836B

Heating new HDPE, PEX, PVC, CPVC, and PP pipes < Tdeg generated VOCs and SVOCs

Benzene was generated by all pipes except PP

Once plastic cooled, chemicals leached into water

‘Standing Home’ Public Health Implications

Citizens were not adequately protected from contaminated water

- State officials told people to SMELL (not test) water to determine if its safe
- 2 systems contaminated (max. 530 ppb benzene) --- no water restrictions
- Some PID customers did not follow water use restrictions
- Home testing guidance by agencies defied hydraulics and chemistry
- Labs told people to flush taps for 10-15 min BEFORE taking water sample

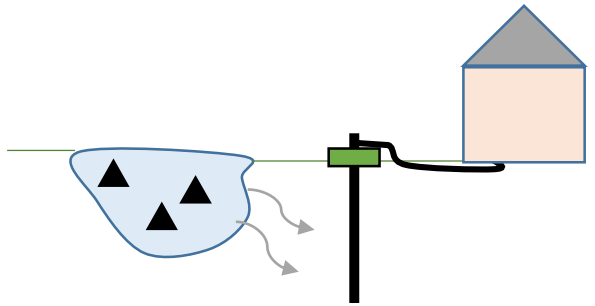
Contaminated water entered home plumbing for 6+ months

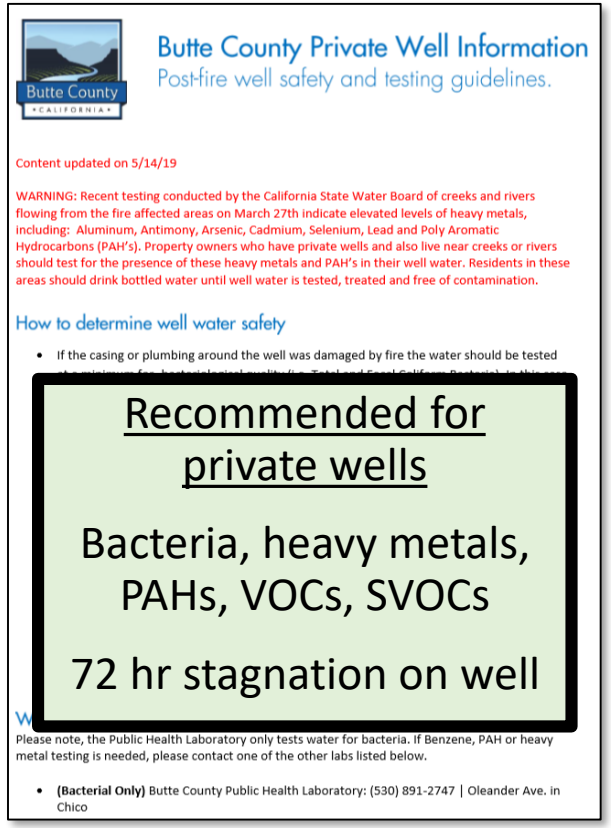
- Benzene found in homes by residents, State said they had no knowledge (because they didn’t credibly sample)
- Utilities were still trying to identify their contaminated assets
- Checkerboard recovery: Loss of pressure (main break, leak) *could move* contaminated water into a standing home service line

Plumbing received 6+ months of contaminated water

Cold and hot water systems became nonpotable
Trunk-and-branch vs. homerun designs
In-home treatment devices (est. $7 million)
Paying for water testing, results not representative
External water tank maintenance and microbiological growth
Some have no economic capacity to purchase bottled water, devices

Insurance companies made decisions (not USEPA, State or health department) about in-home treatment





Butte County Private Well Information

Post-fire well safety and testing guidelines.

Content updated on 5/14/19

WARNING: Recent testing conducted by the California State Water Board of creeks and rivers flowing from the fire affected areas on March 27th indicate elevated levels of heavy metals, including: Aluminum, Antimony, Arsenic, Cadmium, Selenium, Lead and Poly Aromatic Hydrocarbons (PAH’s). Property owners who have private wells and also live near creeks or rivers should test for the presence of these heavy metals and PAH’s in their well water. Residents in these areas should drink bottled water until well water is tested, treated and free of contamination.

How to determine well water safety

- If the casing or plumbing around the well was damaged by fire the water should be tested

Recommended for private wells

Bacteria, heavy metals, PAHs, VOCs, SVOCs

72 hr stagnation on well

Please note, the Public Health Laboratory only tests water for bacteria. If Benzene, PAH or heavy metal testing is needed, please contact one of the other labs listed below.

- **(Bacterial Only)** Butte County Public Health Laboratory: (530) 891-2747 | Oleander Ave. in Chico

UCSF
University of California
San Francisco

In-home testing was conducted 11 months after the fire

125 homes: PID (101), Del Oro (24)

First draw, kitchen sink cold water only, 12+ hr stagnation.

Looked for more than benzene

2 homes: benzene found, and less than 1 ppb CA MCL (11 months later)

4 homes: methylene chloride exceeded USEPA 5 ppb MCL (max. 9.2 ppb)

THF found above other state limits (no CA or federal limit)

Unclear home location or plumbing system type (plastic vs. metal)

Not statistically representative, homeowner service lines not tested

Hot water systems are separate, where inhalation exposure occurs, but were not tested

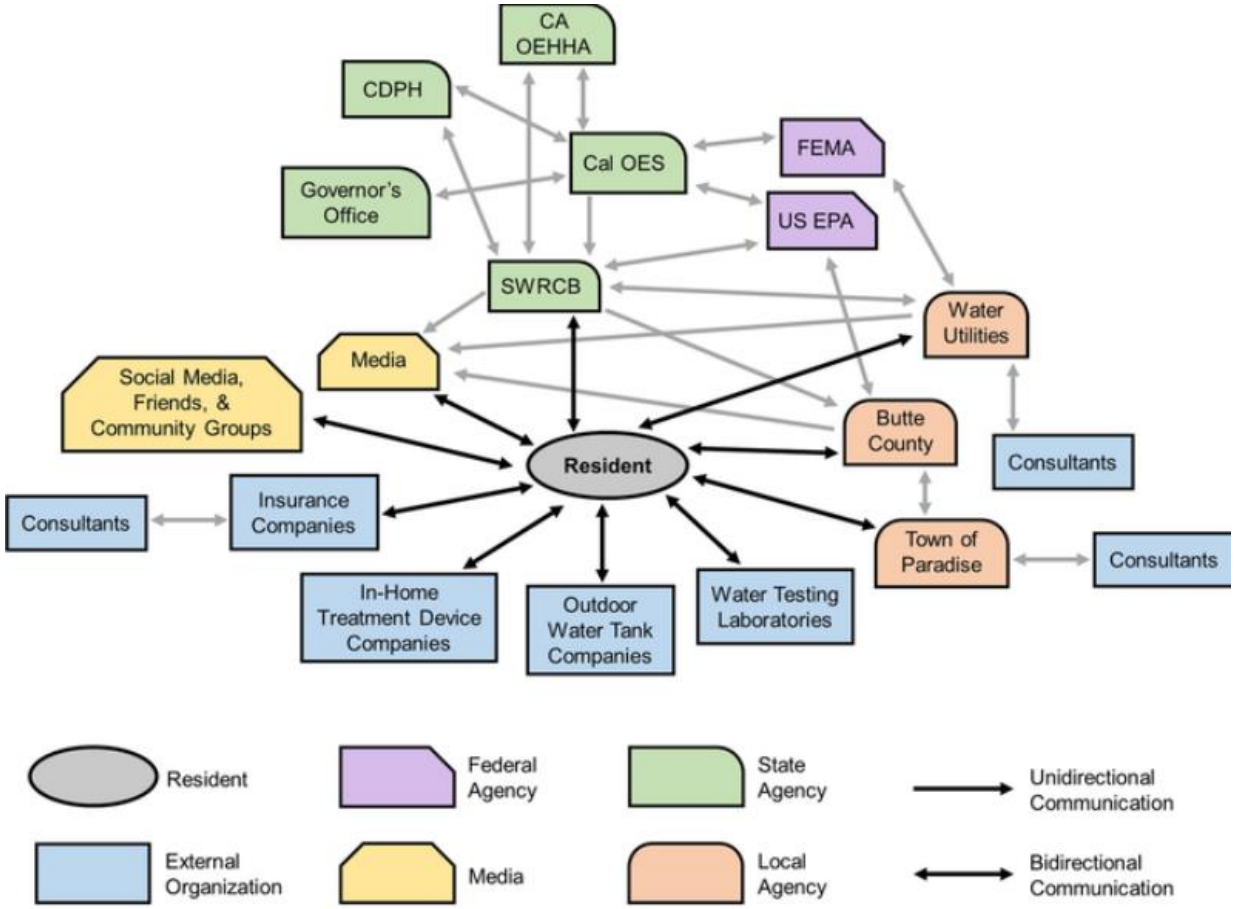
We recommended in-home testing to CalOES 8 months before, it was never initiated

Water safety attitudes, risk perception, experiences, and education for households impacted by the 2018 Camp Fire

Natural Hazards, Published May 2021 https://doi.org/10.1007/s11069-021-04714-9

Critical Public Health Issues

1) Water use restrictions,
2) **Plumbing** sampling and testing,
3) **Plumbing** decontamination methods and validation,
4) Water tank selection and maintenance,
5) In-home treatment device selection and maintenance, and
6) **Plumbing** design and material selection for property repairs and new construction.



1 Year Later….in Paradise

Population: Less than 3,000 of 26,000 pre-fire (now certified as rural)

Homes rebuilt: 11 of the 11,000+ homes that were destroyed

Debris removed: 7.3 billion pounds of ash, debris, metal, concrete, and contaminated soil (2x World Trade Center)

PID water:

- 150 of 172 miles of water main cleared free of contamination
- 47% of meter/service lines 'standing structures' cleared of contamination; Service lines to destroyed structures still need testing, maybe contaminated

Homeowners:

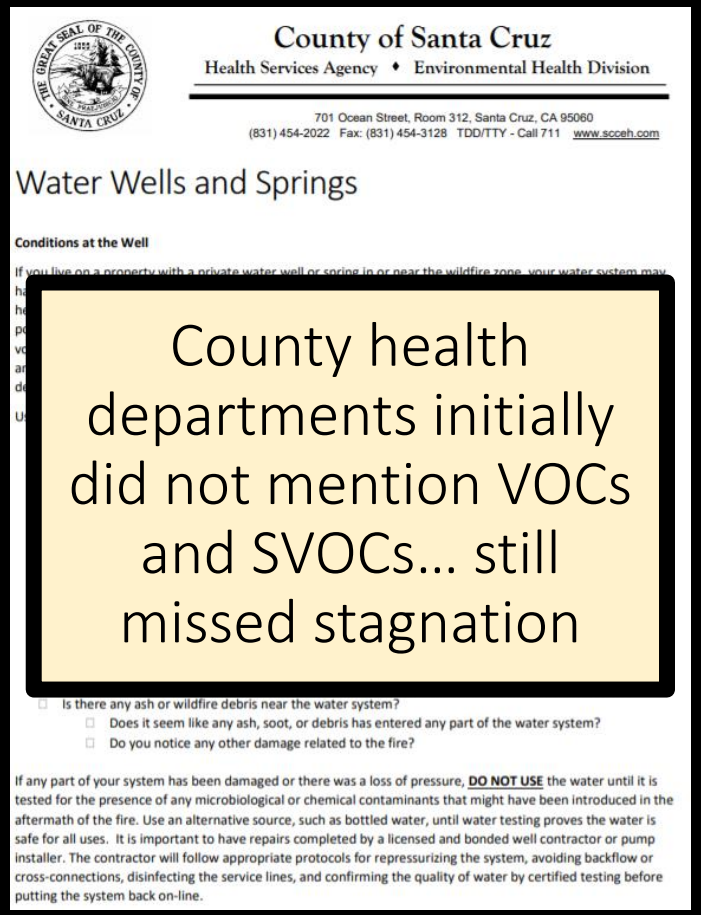
- Responsible for testing THEIR service line and THEIR plumbing – negligible support
- Insurance only sometimes covered plumbing testing and not full plumbing
- Many exclusively relied on in-home treatment systems, some on water tanks
- Some stayed, some returned, others left, others uncertain

Q: Should COTS POU water filtration devices be used to treat wildfire contaminated drinking water?

Water Collected and Analyze	Preliminary Results, ppb			
	Benzene	Toluene	Ethyl Benzene	Xylene
Entering the filter	713	911	87	212
Exiting the filter				
1 L	20	15	3	4
1.5 L	33	30	5	9
2 L	47	46	6	11
3 L	64	75	10	21
3.5 L	62	75	10	20
4 L	24	22	4	5
4.5 L	87	98	11	21
5 L	37	37	5	8

The devices are NOT designed for this. The range of contamination must be known + testing.

In 2019, CA OEHHA concluded that short-term 26 ppb benzene exposure would prompt an increased risk of blood effects in children such as a decrease in lymphocytes and white blood cells; Benzene has a 5 ppb Federal MCL, 1 ppb CA MCL



County of Santa Cruz
Health Services Agency • Environmental Health Division

701 Ocean Street, Room 312, Santa Cruz, CA 95060
(831) 454-2022 Fax: (831) 454-3128 TDD/TTY - Call 711 www.sceh.com

Water Wells and Springs

Conditions at the Well

If you live on a property with a private water well or spring in or near the wildfire zone, your water system may ha
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- Is there any ash or wildfire debris near the water system?
- Does it seem like any ash, soot, or debris has entered any part of the water system?
- Do you notice any other damage related to the fire?

If any part of your system has been damaged or there was a loss of pressure, **DO NOT USE** the water until it is tested for the presence of any microbiological or chemical contaminants that might have been introduced in the aftermath of the fire. Use an alternative source, such as bottled water, until water testing proves the water is safe for all uses. It is important to have repairs completed by a licensed and bonded well contractor or pump installer. The contractor will follow appropriate protocols for repressurizing the system, avoiding backflow or cross-connections, disinfecting the service lines, and confirming the quality of water by certified testing before putting the system back on-line.

County health departments initially did not mention VOCs and SVOCs… still missed stagnation

2020 CZU Lightning Complex Fire

SLVWD 42 ppb benzene + more

(Yes bathe, no wait don't bathe)

BBWC 1.8 ppb benzene + more

2020 LNU Lightning Complex Fire

Napa 31 chems, other systems…

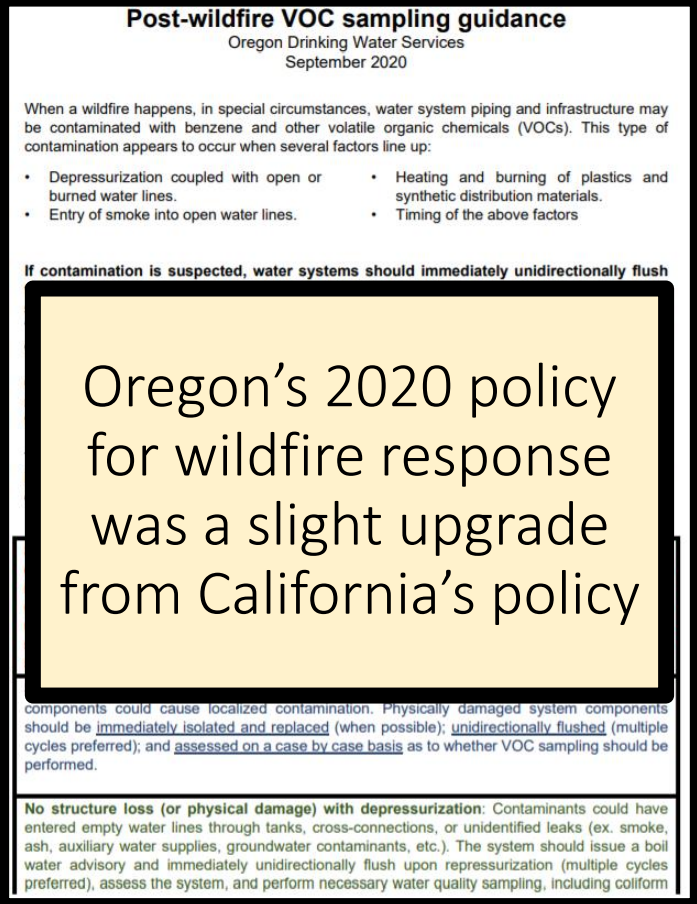
2020 Oregon Fires

Phoenix, Talent, Gates, Detroit, ….

No SVOC testing

Private well testing data not found

BWAs issued, then lifted, then tested, then found contamination



Post-wildfire VOC sampling guidance

Oregon Drinking Water Services
September 2020

When a wildfire happens, in special circumstances, water system piping and infrastructure may be contaminated with benzene and other volatile organic chemicals (VOCs). This type of contamination appears to occur when several factors line up:

- Depressurization coupled with open or burned water lines.
- Entry of smoke into open water lines.
- Heating and burning of plastics and synthetic distribution materials.
- Timing of the above factors

If contamination is suspected, water systems should immediately unidirectionally flush

components could cause localized contamination. Physically damaged system components should be immediately isolated and replaced (when possible); unidirectionally flushed (multiple cycles preferred); and assessed on a case by case basis as to whether VOC sampling should be performed.

No structure loss (or physical damage) with depressurization: Contaminants could have entered empty water lines through tanks, cross-connections, or unidentified leaks (ex. smoke, ash, auxiliary water supplies, groundwater contaminants, etc.). The system should issue a boil water advisory and immediately unidirectionally flush upon repressurization (multiple cycles preferred), assess the system, and perform necessary water quality sampling, including coliform

Oregon's 2020 policy for wildfire response was a slight upgrade from California's policy

Oregon 2020 Fires: Regulated Contaminants

At least 7 PWSs contaminated in Oregon as of May 10, 2021
VOCs have been the sole focus; EPA method 524.2 for VOCs was applied for all samples
No data was found for SVOC testing. It was likely never conducted.
Vinyl chloride and MTBE exceeded federal MCLs in water samples with no benzene.
Methylene chloride was not reported above the 5 ppb MCL

Volatile Organic Compound	Maximum Concentration of Contaminant (ppb)							Exposure Limits (ppb)		
	Detroit Water System	City of Gates	Whispering Pines Mobile Home Park	City of Phoenix	City of Talent	Hiland WC-Echo Mountain	Panther Creek	Federal MCL	CA MCL	USEPA 1-day Health Advisory (for 10kg child)
Benzene	**44.9**	ND	**5.5**	ND	**76.4**	**11.3**	**1.1**	5	1	200
Vinyl Chloride	**0.6**	**8.2**	ND	ND	ND	ND	ND	2	0.5	3,000
Chlorobenzene	**127**	ND	6.08	ND	ND	4.6	ND	100	70	4,000
Dichloroethane	ND	ND	**1.05**	ND	ND	ND	ND	5	0.5	700
1,4-dichlorobenzene	**9**	ND	**10.8**	ND	ND	ND	ND	75	5	11,000
Methyl-*tert*-butyl ether (MTBE)	**358**	ND	ND	589	ND	3.17	ND	N/A	13	N/A
Service Population	205	490	120	4,630	6,850	362	760	____	____	_____

CA OEHHA concluded that 26 ppb benzene in drinking water would prompt an increased risk of blood effects in children such as a decrease in lymphocytes and white blood cells

Oregon 2020 Fires: Unregulated Contaminants

Volatile Organic Compound	Maximum Concentration of Contaminant (ppb)					Exposure Limits
	Blue River	Whispering Pines Mobile Home Park	City of Talent	Hiland WC-Echo Mountain	Medford Water Commission	USEPA 1-day Health Advisory (for 10kg child)
Acetone	10,600	206,000	ND	1,290	ND	N/A
Acrolein	ND	ND	8.9	ND	ND	N/A
Methyl ethyl ketone (MEK)	3,890	138,000	638	2,440	900	75,000
Tetrahydrofuran (THF)	26	14,300	ND	200	ND	N/A

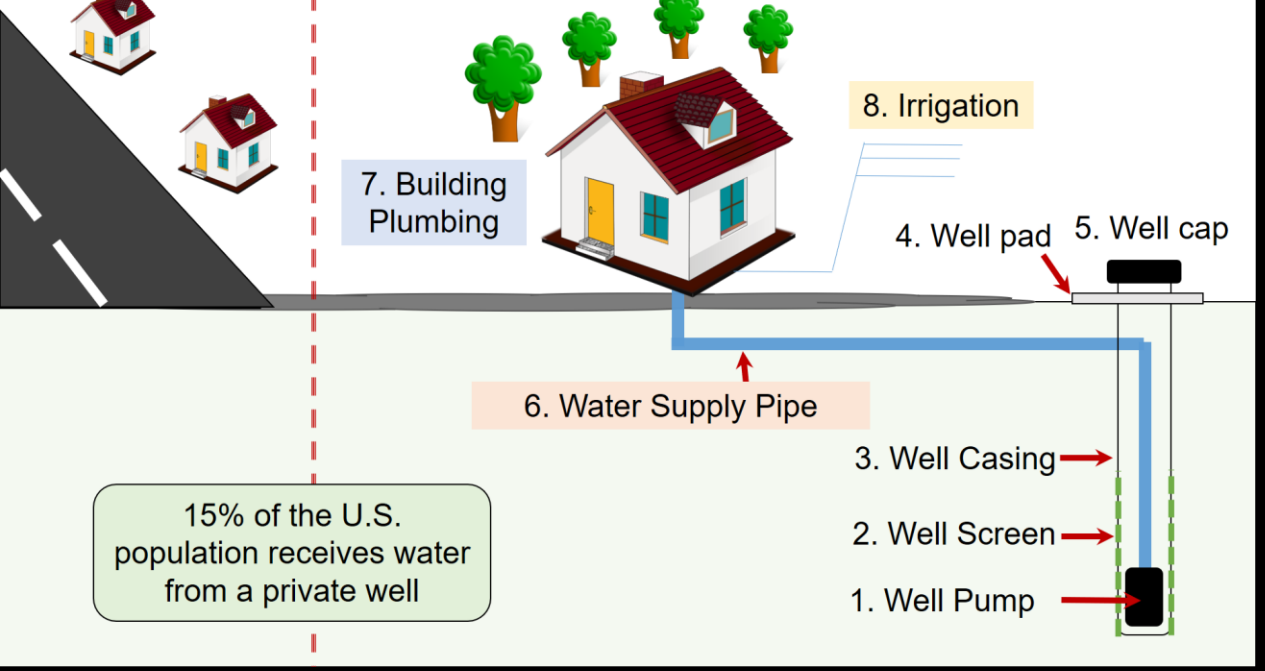
Potential sources: Organic solvents and used in plastic manufacture

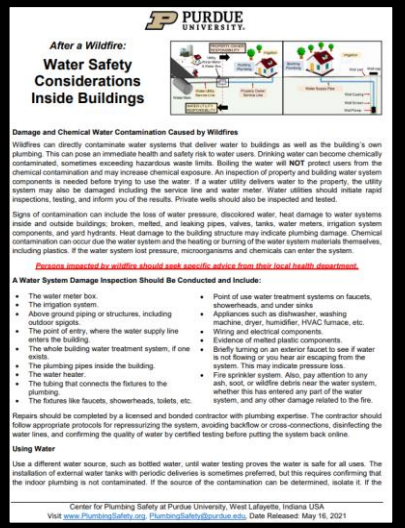
MEK exceeded the US EPA 1-day health advisory level

(138,000 ppb found in the absence of benzene)

No OR or CA advisory levels for these chemicals, but exceeded some for other states

All compounds found in samples with and without benzene

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After a Wildfire:

Water Safety Considerations Inside Buildings

Damage and Chemical Water Contamination Caused by Wildfires

Wildfires can directly contaminate water systems that deliver water to buildings as well as the building's own plumbing. This can pose an immediate health and safety risk to water users. Drinking water can become chemically contaminated, sometimes exceeding hazardous waste limits. Boiling the water will **NOT** protect users from the chemical contamination and may increase chemical exposure. An inspection of property and building water system components is needed before trying to use the water. If a water utility delivers water to the property, the utility system may also be damaged including the service line and water meter. Water utilities should initiate rapid inspections, testing, and inform you of the results. Private wells should also be inspected and tested.

Signs of contamination can include the loss of water pressure, discolored water, heat damage to water systems inside and outside buildings; broken, melted, and leaking pipes, valves, tanks, water meters, irrigation system components, and yard hydrants. Heat damage to the building structure may indicate plumbing damage. Chemical contamination can occur due the water system and the heating or burning of the water system materials themselves, including plastics. If the water system lost pressure, microorganisms and chemicals can enter the system.

Persons impacted by wildfire should seek specific advice from their local health department.

A Water System Damage Inspection Should Be Conducted and Include:

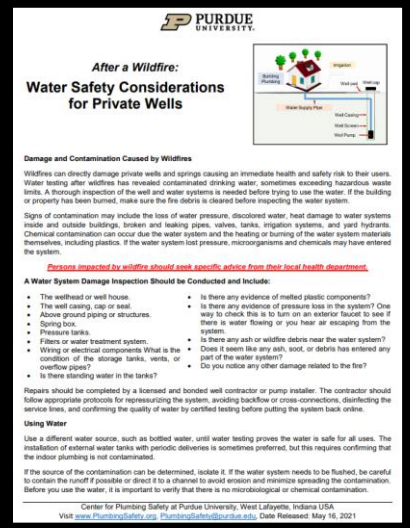
- The water meter box.
- The irrigation system.
- Above ground piping or structures, including outdoor spigots.
- The point of entry, where the water supply line enters the building.
- The whole building water treatment system, if one exists.
- The plumbing pipes inside the building.
- The water heater.
- The tubing that connects the fixtures to the plumbing.
- The fixtures like faucets, showerheads, toilets, etc.
- Point of use water treatment systems on faucets, showerheads, and under sinks
- Appliances such as dishwasher, washing machine, dryer, humidifier, HVAC furnace, etc.
- Wiring and electrical components.
- Evidence of melted plastic components.
- Briefly turning on an exterior faucet to see if water is not flowing or you hear air escaping from the system. This may indicate pressure loss.
- Fire sprinkler system. Also, pay attention to any ash, soot, or wildfire debris near the water system, whether this has entered any part of the water system, and any other damage related to the fire.

Repairs should be completed by a licensed and bonded contractor with plumbing expertise. The contractor should follow appropriate protocols for repressurizing the system, avoiding backflow or cross-connections, disinfecting the water lines, and confirming the quality of water by certified testing before putting the system back online.

Using Water

Use a different water source, such as bottled water, until water testing proves the water is safe for all uses. The installation of external water tanks with periodic deliveries is sometimes preferred, but this requires confirming that the indoor plumbing is not contaminated. If the source of the contamination can be determined, isolate it. If the

Center for Plumbing Safety at Purdue University, West Lafayette, Indiana USA
Visit www.PlumbingSafety.org. PlumbingSafety@purdue.edu. Date Released: May 16, 2021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After a Wildfire:

Water Safety Considerations for Private Wells

Damage and Contamination Caused by Wildfires

Wildfires can directly damage private wells and springs causing an immediate health and safety risk to their users. Water testing after wildfires has revealed contaminated drinking water; sometimes exceeding hazardous waste limits. A thorough inspection of the well and water systems is needed before trying to use the water. If the building or property has been burned, make sure the fire debris is cleared before inspecting the water system.

Signs of contamination may include the loss of water pressure, discolored water, heat damage to water systems inside and outside buildings, broken and leaking pipes, valves, tanks, irrigation systems, and yard hydrants. Chemical contamination can occur due the water system and the heating or burning of the water system materials themselves, including plastics. If the water system lost pressure, microorganisms and chemicals may have entered the system.

Persons impacted by wildfire should seek specific advice from their local health department.

A Water System Damage Inspection Should be Conducted and Include:

- The wellhead or well house.
- The well casing, cap or seal.
- Above ground piping or structures.
- Spring box.
- Pressure tanks.
- Filters or water treatment system.
- Wiring or electrical components What is the condition of the storage tanks, vents, or overflow pipes?
- Is there standing water in the tanks?
- Is there any evidence of melted plastic components?
- Is there any evidence of pressure loss in the system? One way to check this is to turn on an exterior faucet to see if there is water flowing or you hear air escaping from the system.
- Is there any ash or wildfire debris near the water system?
- Does it seem like any ash, soot, or debris has entered any part of the water system?
- Do you notice any other damage related to the fire?

Repairs should be completed by a licensed and bonded well contractor or pump installer. The contractor should follow appropriate protocols for repressurizing the system, avoiding backflow or cross-connections, disinfecting the service lines, and confirming the quality of water by certified testing before putting the system back online.

Using Water

Use a different water source, such as bottled water, until water testing proves the water is safe for all uses. The installation of external water tanks with periodic deliveries is sometimes preferred, but this requires confirming that the indoor plumbing is not contaminated.

If the source of the contamination can be determined, isolate it. If the water system needs to be flushed, be careful to contain the runoff if possible or direct it to a channel to avoid erosion and minimize spreading the contamination. Before you use the water, it is important to verify that there is no microbiological or chemical contamination.

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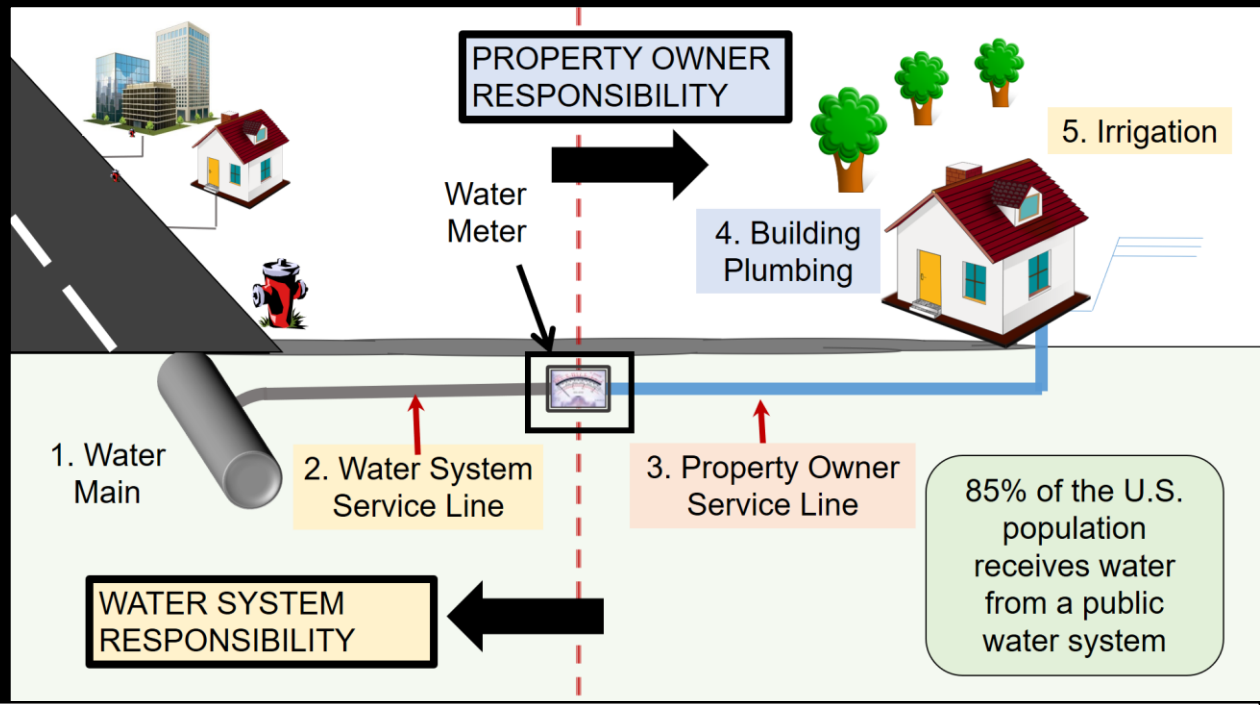
We created 2 page inspection and water testing guidance for private wells and building water systems

Access here ➔ [Click]



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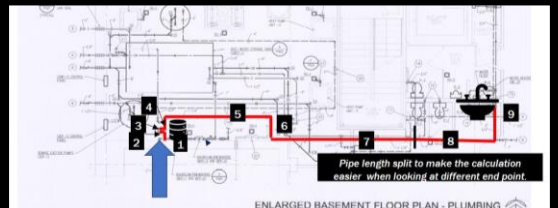

Input from practicing engineers, scientists, utilities and public health officials.

A training tool, an encyclopedia, and an extensive FAQ, designed to be immediately applicable in the field.

Modules do not have to be taken in sequence.




If interested e-mail awhelton@purdue.edu

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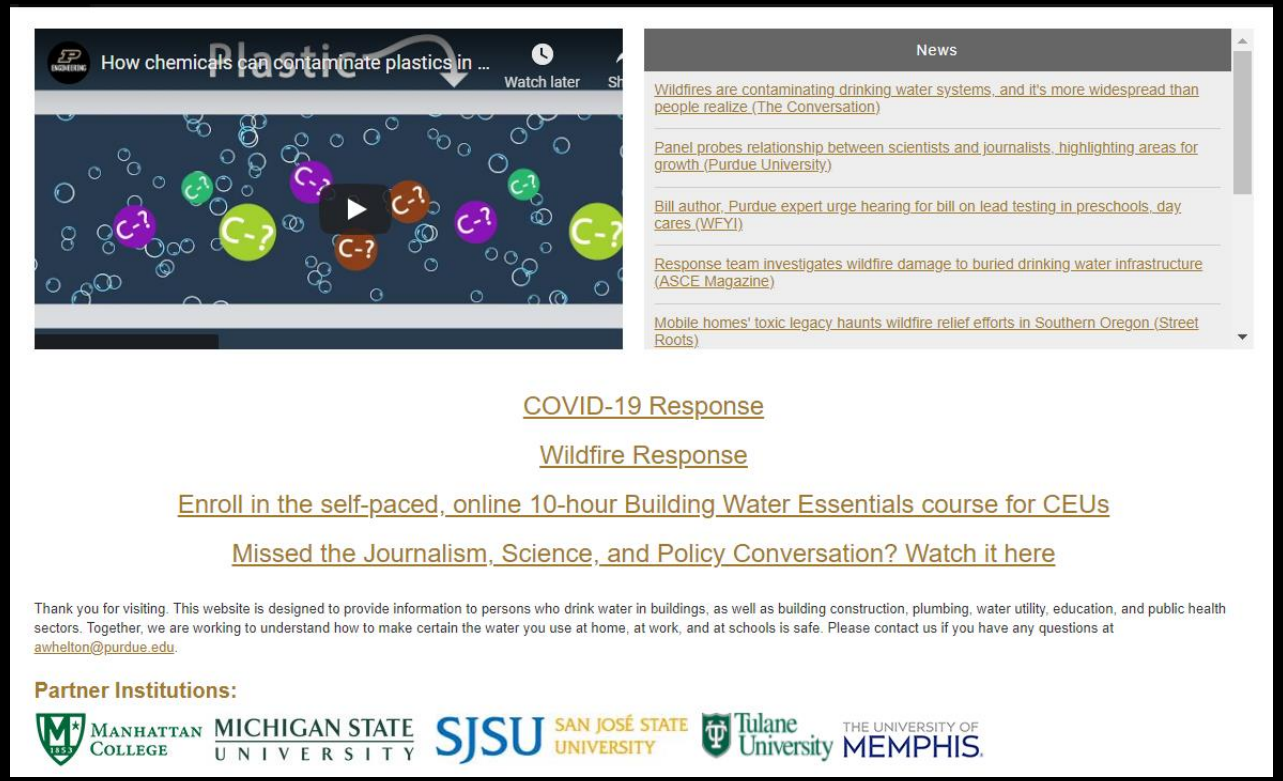
Thank you.

Andrew Whelton, Ph.D. awhelton@purdue.edu @TheWheltonGroup



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10 hr, 1 CEU, Self-paced, Online Building Water Essentials Short-Course:
https://engineering.purdue.edu/online/certifications/building-water-essentials

www.PlumbingSafety.org

Published… so far

Initiative	Lead	Stage
Residential Building City Water Chemistry and Microbiology 4 month startup: https://doi.org/10.1016/j.chemosphere.2017.11.070	Purdue-MSU	Published
Residential Building City Water Chemistry 1 Year Study: https://doi.org/10.1039/D0EW00334D	Purdue-Memphis-MSU	Published
Residential Building City Water Microbiology 1 Year Study: https://doi.org/10.1039/D0EW00334D	Tulane-Purdue-MSU	Published
Residential Building Reverse QMRA for *P. aerugi*nosa Exposure: https://doi.org/10.1061/(ASCE)EE.1943-7870.0001641	MSU	Published
Residential Building Rainwater Chemical/Micro Transition Study: https://10.1021/acs.est.0c03641	Purdue-Tulane-MSU	Published
Dose Response *Naegleria fowleri*: https://doi.org/10.2166/wh.2018.181	MSU	Published
LEED School Green Building Chemistry Study: https://doi.org/10.1039/D0EW00520G	Purdue-Tulane	Published
Dose Response *P. aeruginosa*: https://doi.org/10.1016/j.mran.2020.100115	MSU	Published
Synthesis Study: Plumbing Research Needs: https://doi.org/10.1002/aws2.1177	MSU-Purdue-Manhattan	Published
Heavy Metal Accumulation on Plastic Plumbing, Field Study: https://doi.org/10.5942/jawwa.2017.109.0117	Purdue	Published
Water Quality in Mixed GIP-PEX Plumbing: https://doi.org/10.1016/j.jhazmat.2019.121585	Purdue	Published
Heavy Metal Degradation of Downstream PEX Plumbing: https://doi.org/10.1016/j.chemosphere.2019.07.060	Purdue	Published
TTHM Generation and Fate in PEX Plumbing: https://doi.org/10.1039/D0EW00262C	Purdue	Published
Synthesis Study: Stagnation Water Quality Impact Review: https://doi.org/10.1002/aws2.1186	Purdue	Published
Dose Response *Acanthamoeba*: https://doi.org/10.1111/risa.13603	MSU	Accepted

In review, undergoing data analysis, planning, and more…

Initiative	Lead	Stage
LEED Institutional Buildings Chemistry and Microbiology Study (Gim Aw et al.)	MSU	In peer-review
ID variables that influence legionella in building plumbing (Julien et al.)	MSU-Purdue	In peer-review
Enumeration and Characterization of Five pathogenic Legionella species from Large Research and Educational Buildings (Logan et al.)	MSU	In peer-review
The Occurrence of 5 Pathogenic Legionella species from Source (Groundwater) to Exposure (Taps and Cooling Towers) In a Complex Water System (Logan et al.)	MSU	In peer-review
Residential Building Upstream Fixture Water Use Prediction Study (Kropp et al.)	MSU-Manhattan-Purdue	In peer-review
Influence of thermal gradients on legionella in residential plumbing (Julien et al.)	MSU	Data analysis
Residential Building Water Age/HRT Modeling (Julien et al.)	MSU-Purdue	Data analysis
LEED Office Green Building Chemistry and Microbiology Study (Montagnino et al.)	Purdue-Tulane	Data analysis
Residential Building City Water Hydraulic Plumbing Study (Palmegiani et al.)	Manhattan-Purdue	Data analysis
Residential Building City Water Integrative Hydro-Water Quality Study (Lee et al.)	Manhattan-Purdue	Data analysis
LEED School Green Building Opportunistic Pathogen Study (Gim Aw et al.)	Tulane-Purdue	Data analysis
Legionella and amoeba in cooling towers and building water systems (Logan et al.)	MSU	Data analysis
Synthesis Study: Copper in Schools (Montagnino et al.)	Purdue-MSU	Data analysis
Risk Based Decision Support Tool (Nedjashimi et al.)	MSU-Manhattan-Purdue	Planning
Synthesis Study: Plumbing Safety of the Future	Purdue-MSU-UM-Manhattan-Tulane	Planning
And more….		