Water x Fire

Challenges and opportunities for executives, policy makers, and innovators

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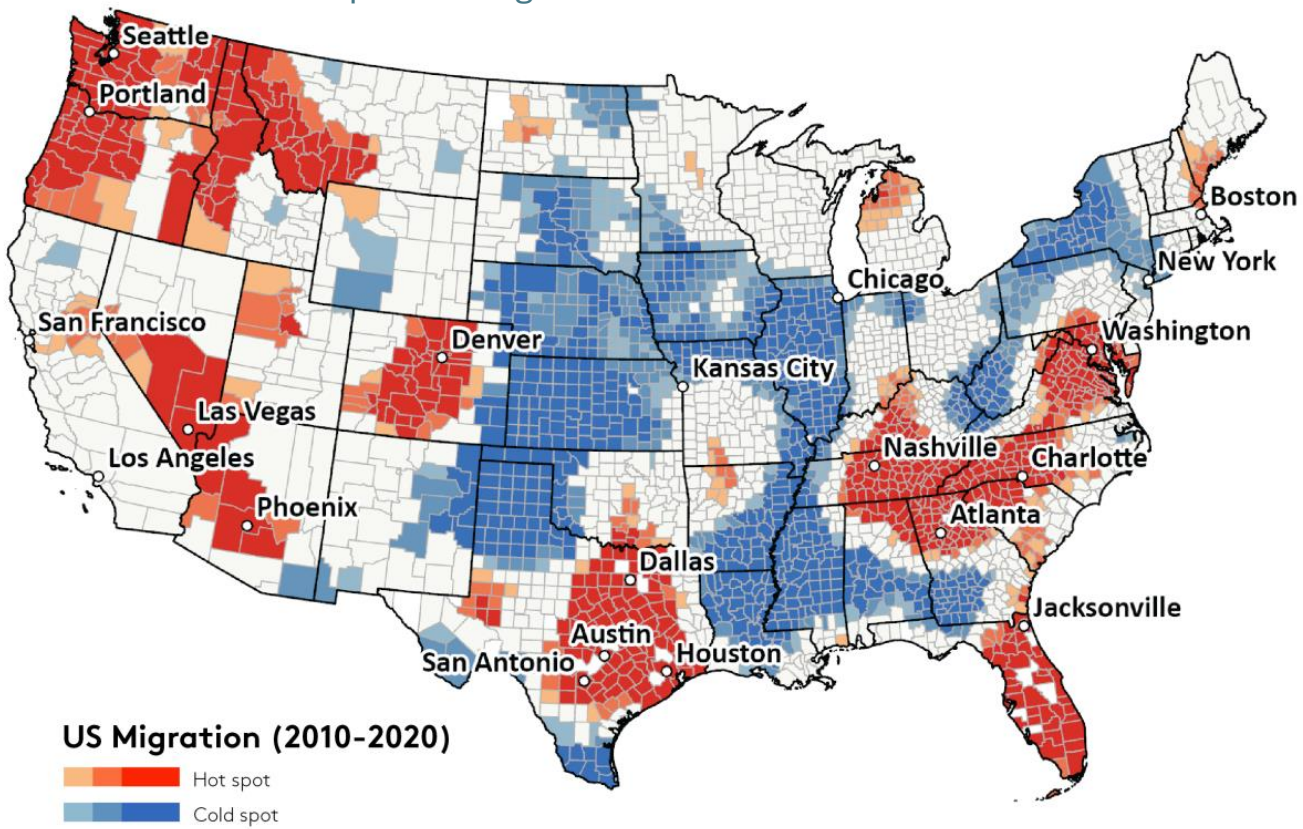
School of Sustainability and Environmental Eng.

PlumbingSafety.org CIPPSafety.org

2023 Kula Fire in Maui, Hawai'i

Clark et al. 2022. *Frontiers in Human Dynamics*.
https://doi.org/10.3389/fhumd.2022.886545



Wildfires cause health and safety risks, and are increasing in intensity as well as the number of acres burned (UNEP 2022)

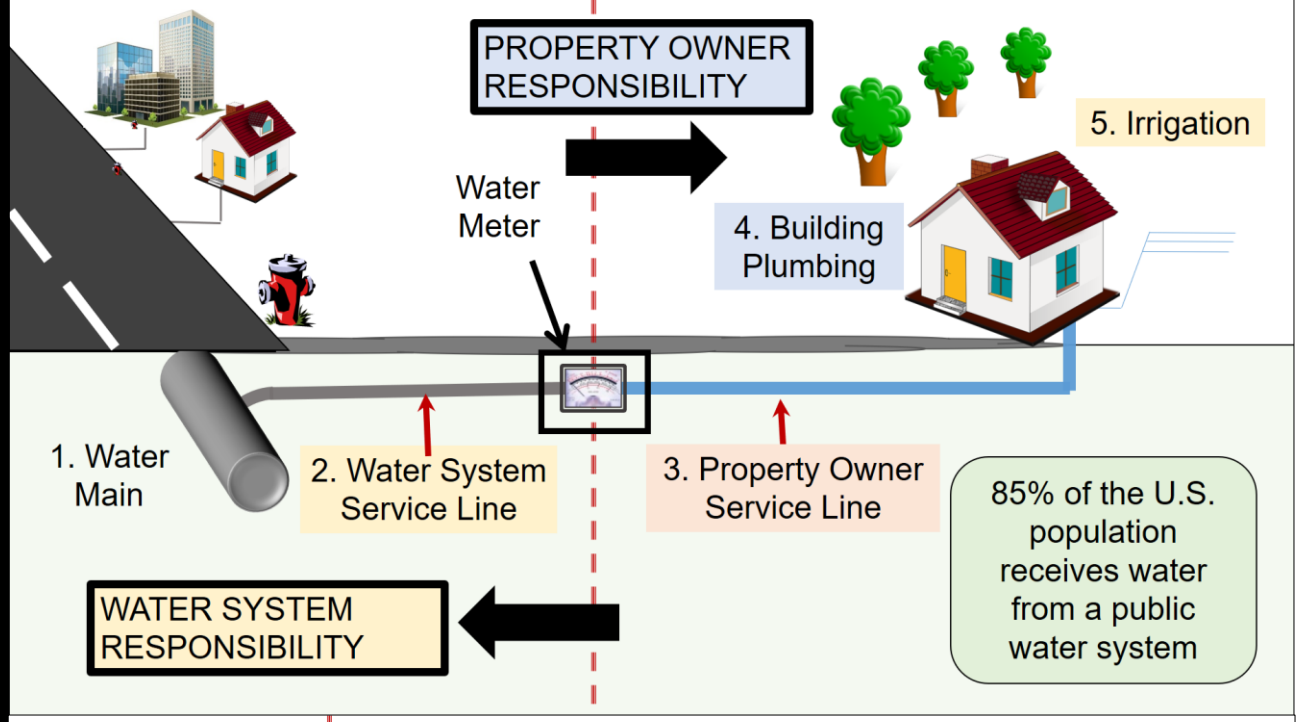
U.S. Fire Administration
Working for a fire-safe America

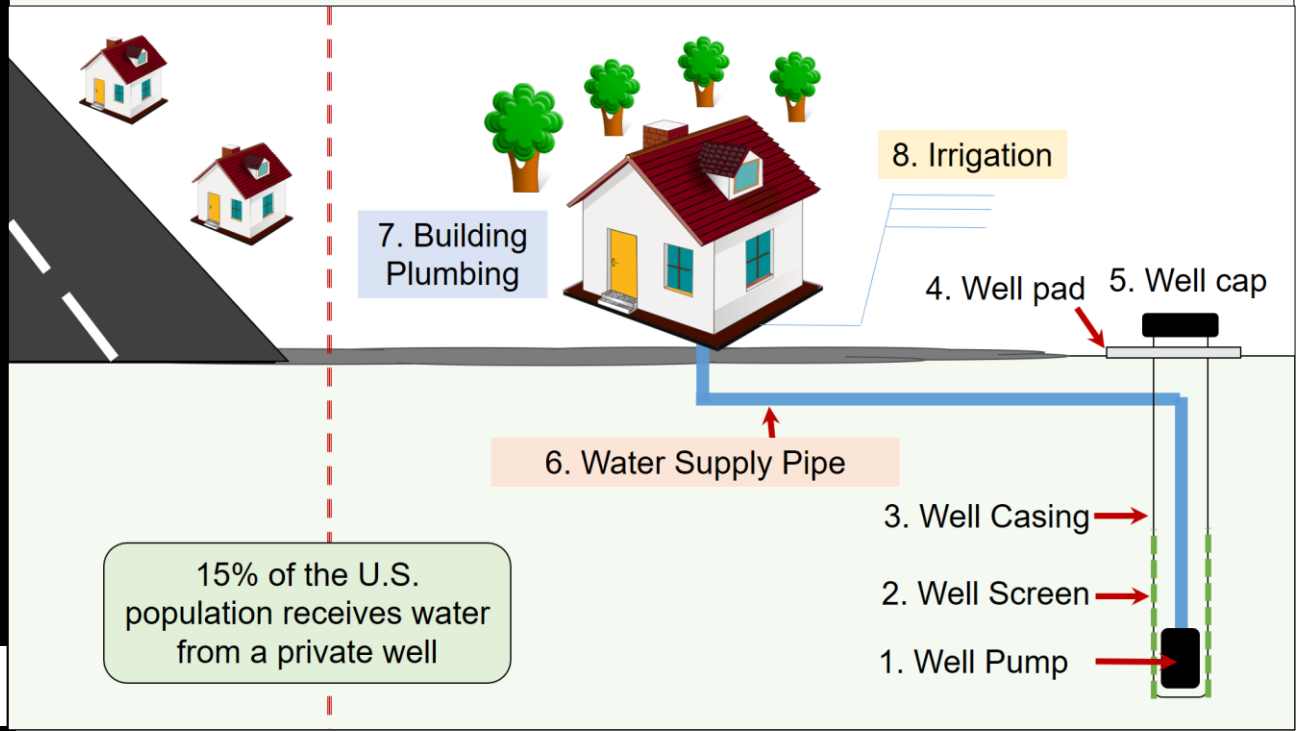
In the U.S. more than 46 million residences in 70,000 communities are at risk (USFA, 2022)

Wildfires threaten the health, safety, and economic security of communities

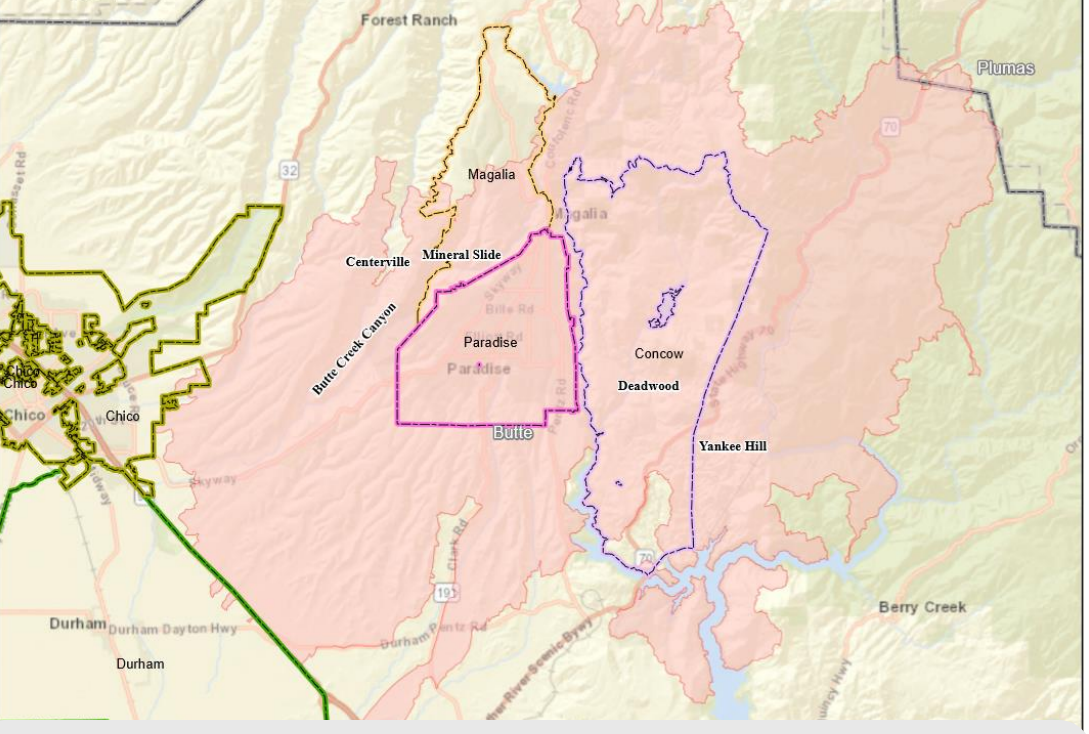
Water System Purpose

- ✓ Fire-fighting
- ✓ Hygiene, sanitation
- ✓ Healthcare
- ✓ Education
- ✓ Business
- ✓ Recreation
- ✓ Agriculture
- ✓ Industry





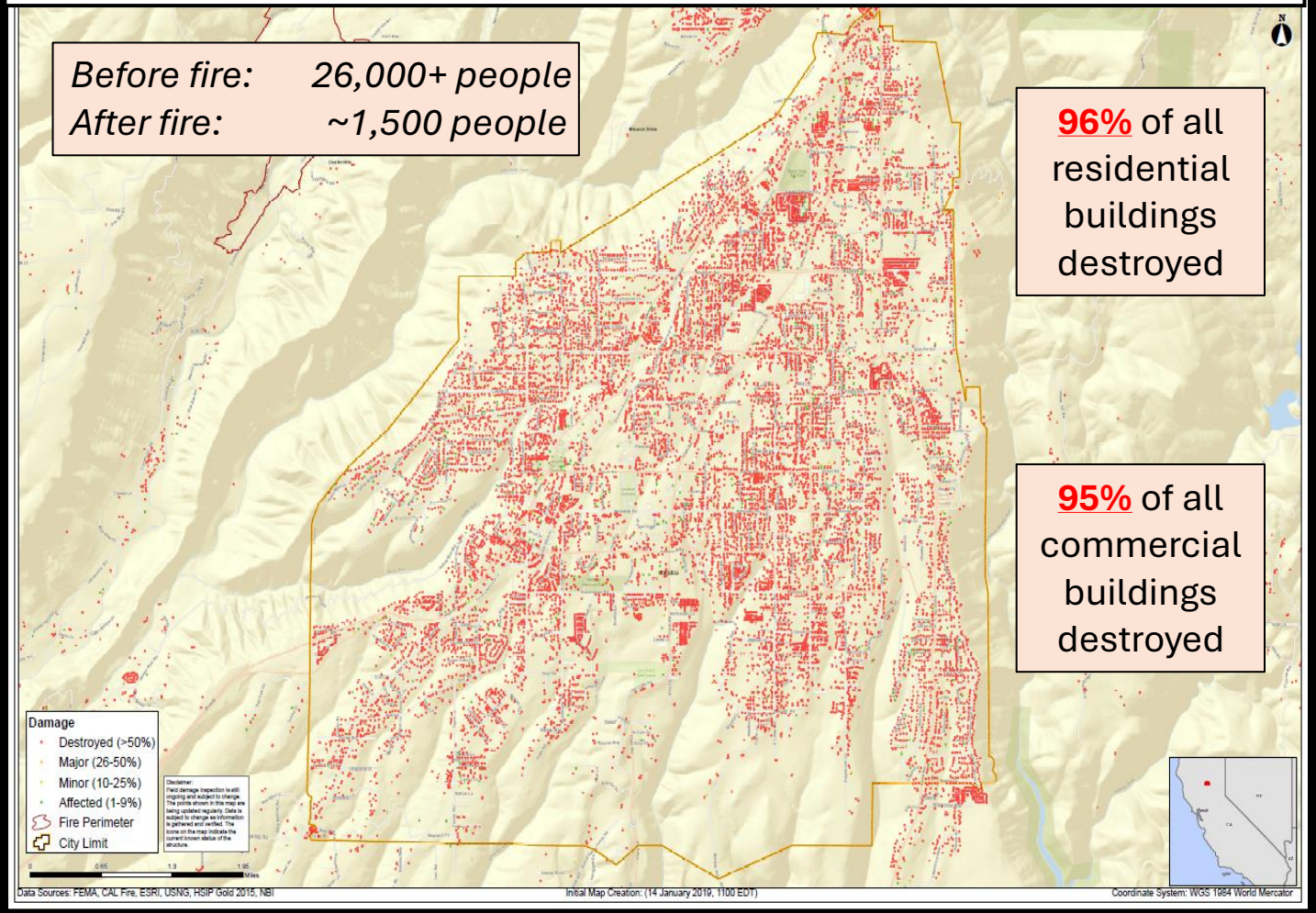
The 2018 Camp Fire in Paradise, California



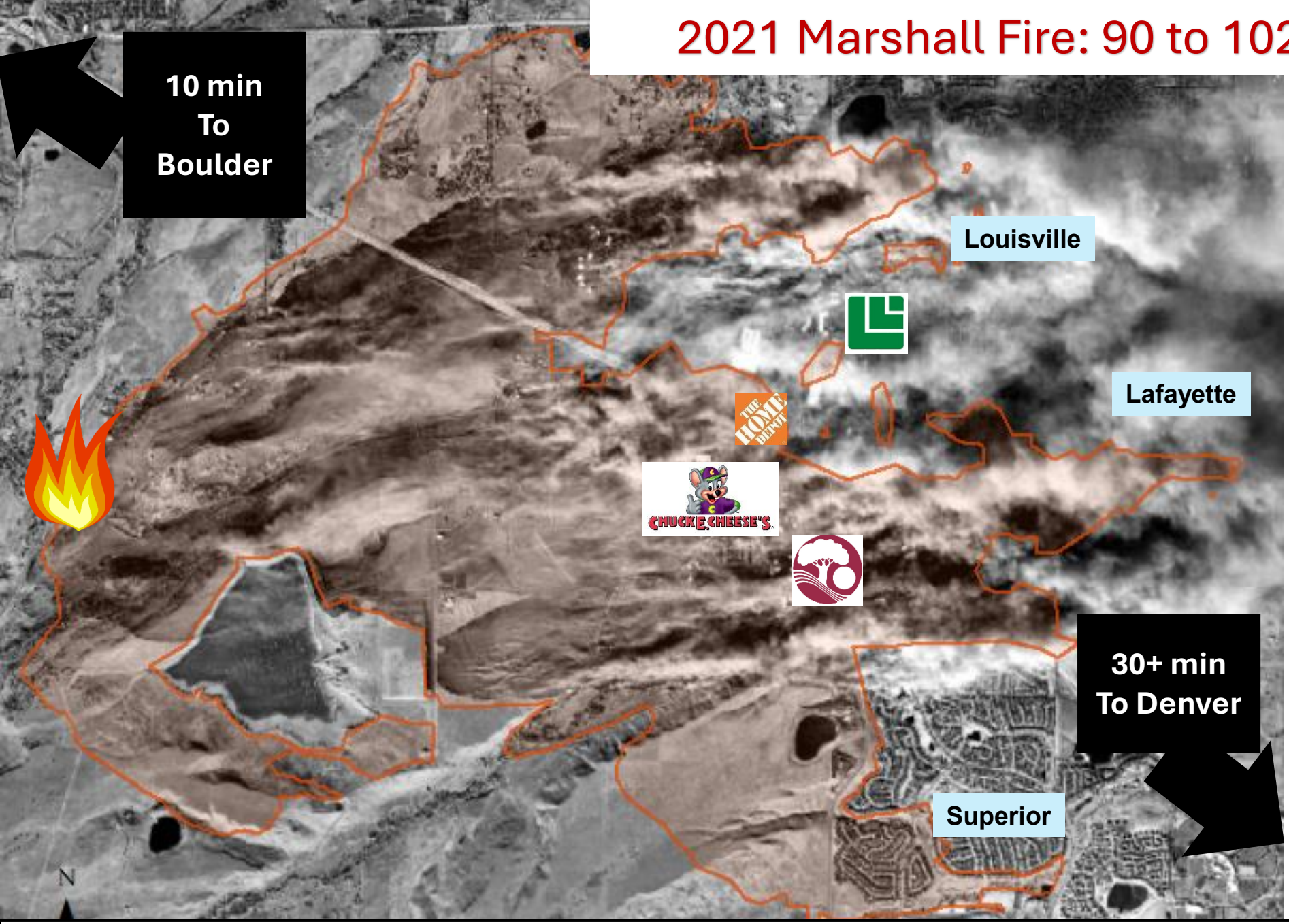
153,336 acres
86 fatalities

~13,972 residences destroyed
14,793 structures destroyed
3 firefighters injured

Town of Paradise Limits



2021 Marshall Fire: 90 to 102 mph wind gusts



December 30, 2021

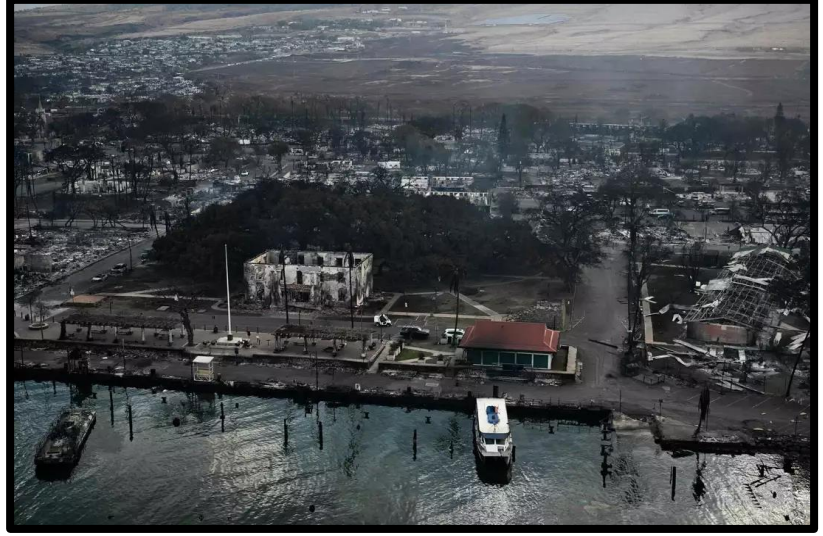
11:06 am, Fire in Boulder Co.
12:10 pm, Fire in Superior
12:50 pm, Fire in Louisville
1:00pm, 1,000 acres

60,000+ evacuation ordered

The 3 largest communities
Louisville: 21,266
Superior: 13,094
Lafayette: 30,411

6 regulated water systems impacted and private wells

Image source: Fischer et al. GEER. The 2021 Marshall Fire, Boulder County, CO.



Hurricane Dora

60-80 mph gusts onshore

Olinda Fire: 1,081 ac, 2 structures

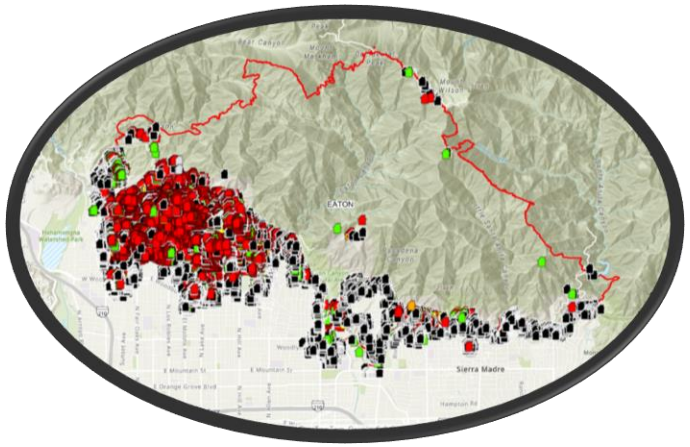
Kula Fire: 202 ac, 544 structures

Lahaina Fire: 2,170 ac, 2,207 structures

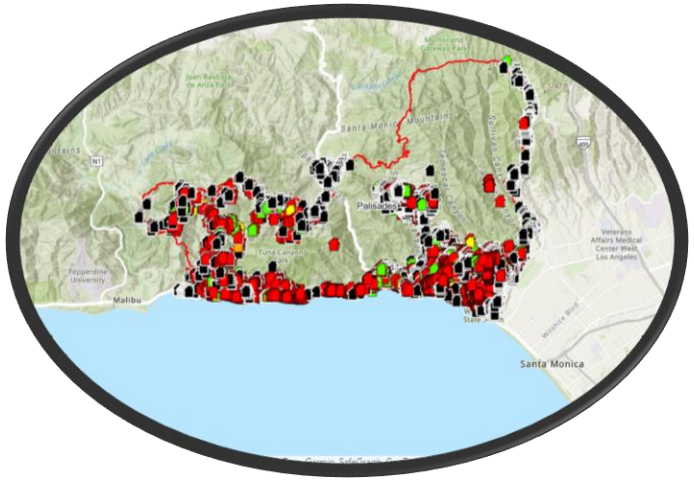
Puelho Fire: 5,300 ac, 0 structures

Maui Wildfires
August 8, 2023

Deadliest wildfire incident in modern U.S. history



L.A. Wildfires
January 7, 2025



Eaton Fire

14,021 acres
17 Fatalities
Structures Destroyed = 9,418
Structures Damaged = 1,073

Palisades Fire

23,707 acres
12 Fatalities
Structures Destroyed = 6,833
Structures Damaged = 973

Pressure

Asset and structure destruction, leaks

Power

Electric poles/lines, power and gas shutoff by provider, generators destroyed, fuel lacking

Telecommunications/Monitoring

Outages inhibit tank level, pressure, chemical feed, and pump status monitoring

Personnel

Hazardous situations, staff availability

Contamination

Chemicals and microbiologicals drawn into the water system, immediate health risk

AWWA Wat. Sci. 2020. *AWWA Wat. Sci*. 2023. *Env. Sci.: Wat. Res. Technol*. 2024.











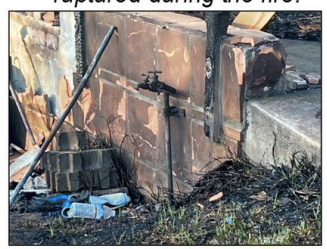


California · Colorado · Hawai'i · New Mexico · Oregon : 2017 Tubbs Fire · 2018 Camp Fire · 2020 Bear Fire · 2020 Oregon Fires · 2021 Marshall Fire · 2021 Lytton Fire · 2022 CC/HP Fire · 2023 Maui Wildfires · 2025 Los Angeles Fires

Two weeks after the incident, spot fires were still burning, damage was still being assessed, and the communities were being provided support.

Some water meters serving properties with destroyed structures had been removed.

After a water meter was shutoff, the homeowner reconnected their plumbing to the damaged distribution system. Some Olinda property owners replaced their service lines that ruptured during the fire.



A household that solely relied on a rainwater cistern had noticeable particulate debris on their roof.

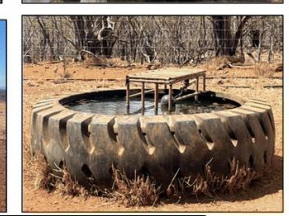
https://doi.org/10.1039/D4EW00216D

Some of the water system assets like wellheads, buildings, distribution piping, and storage tanks were located inside the burn area footprint and others were not.

More than 50,000 ft of HDPE pipes used for irrigation and animal watering were damaged or destroyed

Some animal watering equipment was unaffected, and other equipment seems to contained or be coated with particulate. This included livestock tubs, troughs, and tire waterers.

An underground fire was found during the field investigation.



https://doi.org/10.1021/acsestwater.5c00896

Challenge: Water and pressure to protect lives and property

Today's systems are not designed for wildfires

Building sprinkler systems enable evacuation

Residents run lawn sprinklers to wet their property

Hydrants opened and left

Power lost, water production and pumping impacted

Fires damage and destroy structures prompting uncontrolled water and pressure loss

For example....

500 structures x 13 GPM/each x 60 min =

390,000 gallons of water loss in 1 hour

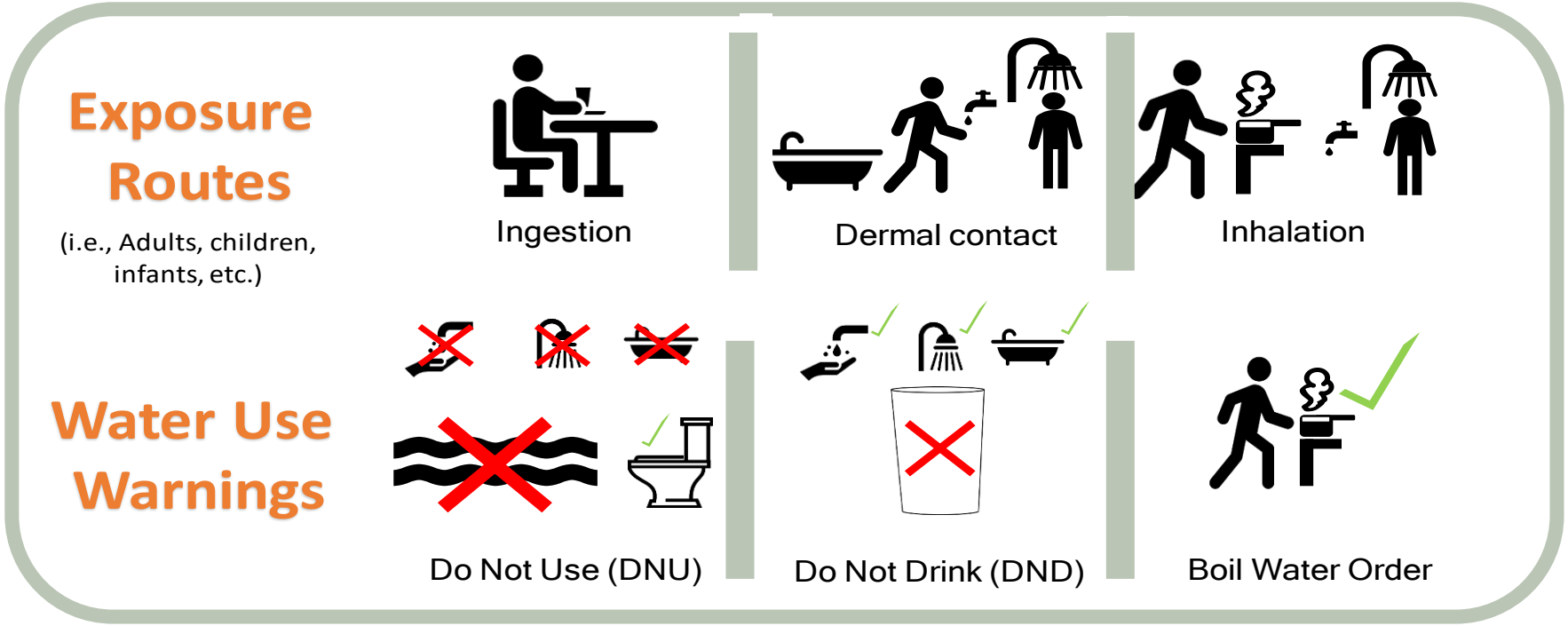
NFPA

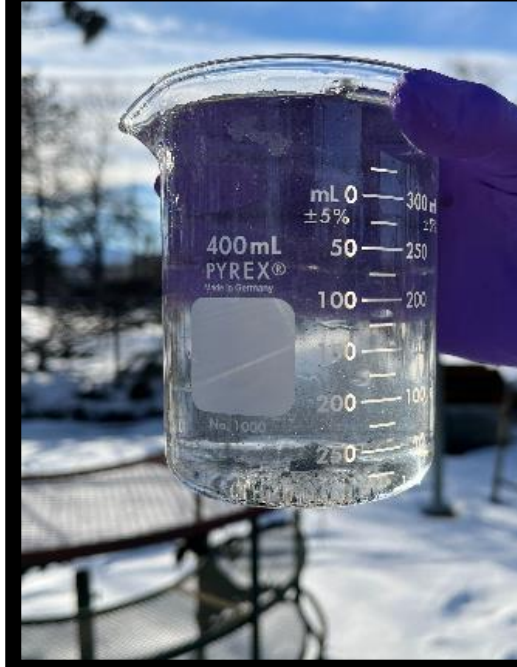
Challenge: Extreme drinking water contamination

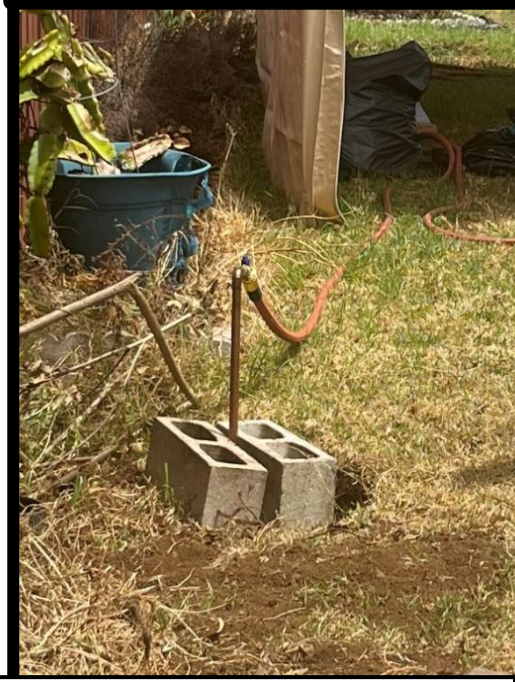
Immediate vs. long-term health risk

VOCs and other organic chemicals

Burned properties: Cross connections







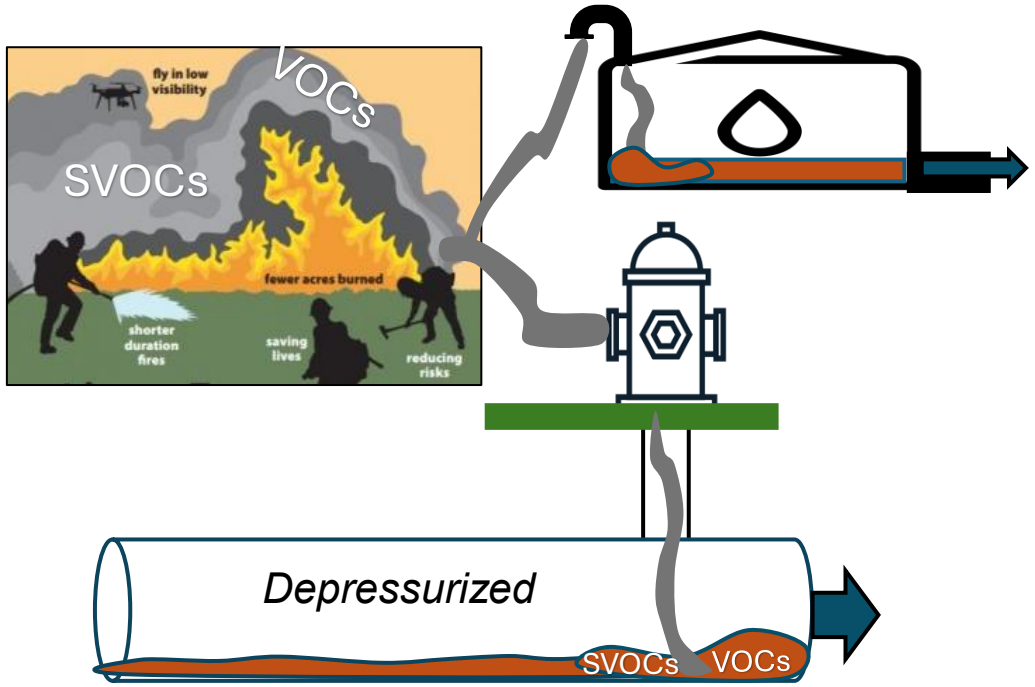
Max. Benzene, ppb	Event / Location	Pop.	System	Year
I can't recall	Eaton Fire/ California	9,600	Rubio Cañon Land and Water Assoc.	2025
440	Eaton Fire/ California	4,847	Las Flores Water Co.	2025
31	Eaton Fire/ California	16,126	Lincoln Ave. Water Co.	2025
22.5	Palisades Fire/ California	3,856,043	Los Angeles Dept. Water & Power	2025
40	Lahaina Fire/ Hawai'i	20,036	Maui County – Lahaina	2023
3.8	Kula Fire/ Hawai'i	7,686	Maui County – Upper Kula	2023
Other	Calf Canyon/Hermits Peak/ New Mexico	500	Pendaries Village Community Assoc.	2022
5.1	Marshall Fire/ Colorado	500	East Boulder County Water District	2021
220	Marshall Fire/ Colorado	20,319	City of Louisville	2021
5.5	Echo Mountain Fire/ Oregon	120	Whispering Pines Mobile Home Park	2020
11.3	Echo Mountain Fire/ Oregon	362	Hiland WC -Echo Mountain	2020
1.1	Echo Mountain Fire/ Oregon	760	Panther Creek Water District	2020
76.4	Almeda Fire/ Oregon	6,850	City of Talent	2020
44.9	Lionshead Fire/ Oregon	205	Detroit Water System	2020
1.5	North Complex Fire/ California	297	Lake Madrone Water District	2020
1.8	CZU Lightning Complex Fire/ California	1,650	Big Basin Water Company	2020
42	CZU Lightning Complex Fire/ California	21,145	San Lorenzo Valley Water District	2020
>2,217	Camp Fire/ California	26,032	Paradise Irrigation District	2018
38.3	Camp Fire/ California	924	Del Oro Water Co.-Magalia	2018
8.1	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

***BOLD and RED* exceeded a health-based drinking water limit in a wildfire impacted water system as of March 2024**

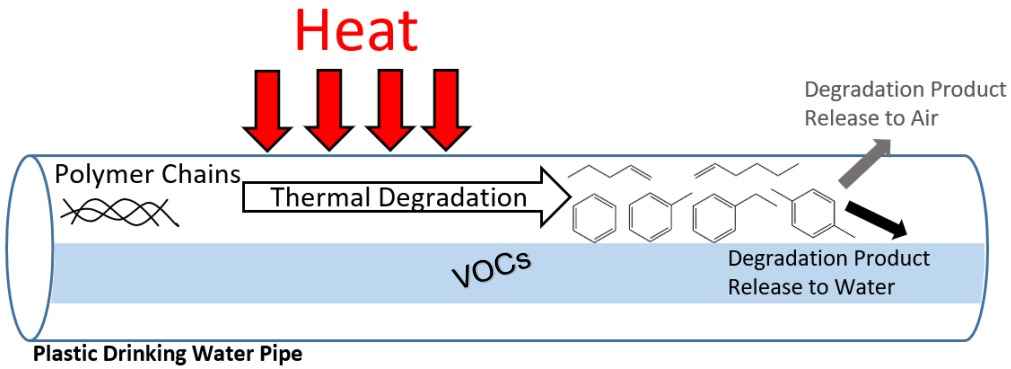
Acetonitrile	Chlorodibromomethane	Ethyl benzene	¥**Toluene****
¥Acetone	Chloromethane	**Ethylene dibromide (EDB) ****	1,2,3-Trichlorobenzene
Acrolein	4-Chlorotoluene	Ethyl-*tert*-butyl ether (ETBE)	1,2,4-Trichlorobenzene
Acrylonitrile	Dibromochloromethane	Iodomethane	1,1,1-Trichloroethane
¥**Benzene ****	**1,2-Dibromo-3-chloropropane (DBCP) ****	Isopropylbenzene	1,1,2-Trichloroethane
Bromochloromethane	1,2-Dichlorobenzene	**Methylene chloride****	Trichloroethylene
Bromodichloromethane	1,4-Dichlorobenzene	¥**Methyl ethyl ketone (MEK) ****	**Trichloromethane ****
Bromoform	1,1-Dichloroethane	Methyl iso butyl ketone (MIBK)	**1,2,3-Trichloropropane (TCP) ****
n-Butylbenzene	**1,2-Dichloroethane ****	**Methyl-*tert*-butyl ether (MTBE) ****	1,2,4-Trimethylbenzene
sec-Butylbenzene	1,1-Dichloroethene	¥**Naphthalene****	1,3,5-Trimethylbenzene
tert-Butylbenzene	*cis*-1,2-Dichloroethene	¥**Styrene****	**Vinyl chloride ****
Carbon disulfide	*trans*-1,2-Dichloroethylene	***tert*-Butyl alcohol (TBA) ****	¥*ortho*-Xylene
Carbon tetrachloride **	**1,2-Dichloropropane ****	Tetrachloroethylene	¥*meta*-Xylene
Chlorobenzene	¥Ethanol	**Tetrahydrofuran (THF) ****	¥*para*-Xylene

There are 3 ways water distribution systems become contaminated

1. Biomass and structure combustion



2. Plastic thermal degradation



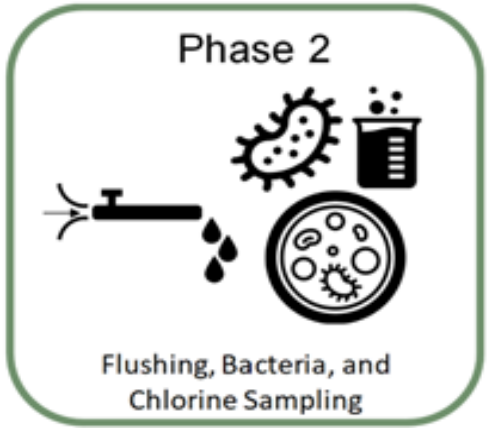
3. Contaminated water and material back siphonage

Secondary Sources: Infrastructure desorption

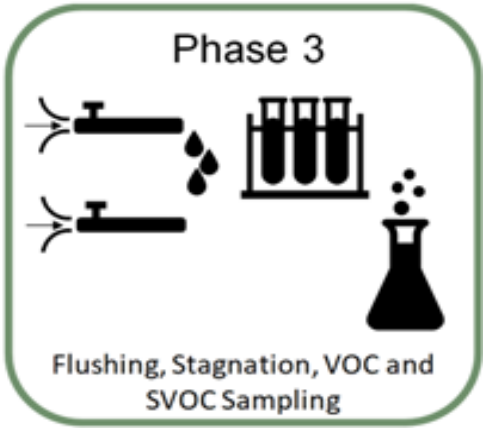
Whelton et al. 2025. Water Research Foundation. Denver, CO.

Challenge: Restoring Service for Public Safety, Health, and Economic

Support firefighting
Isolate damage
Maintain pressure
Water use warnings



Personnel surge
Restore control, pressure
Repeated sampling
Laboratories



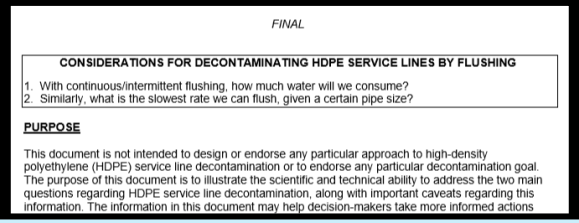
Personnel surge
Repeated sampling
Laboratories
Decon, remove, replace

Inspection, Testing, and Repair vs. Replace

Water Meters vs. Hydrants vs. Water Quality

THE Water Research FOUNDATION

Challenge: Decontamination


FINAL

CONSIDERATIONS FOR DECONTAMINATING HDPE SERVICE LINES BY FLUSHING

1. With continuous/intermittent flushing, how much water will we consume?
2. Similarly, what is the slowest rate we can flush, given a certain pipe size?

PURPOSE

This document is not intended to design or endorse any particular approach to high-density polyethylene (HDPE) service line decontamination or to endorse any particular decontamination goal. The purpose of this document is to illustrate the scientific and technical ability to address the two main questions regarding HDPE service line decontamination, along with important caveats regarding this information. The information in this document may help decision-makers take more informed actions

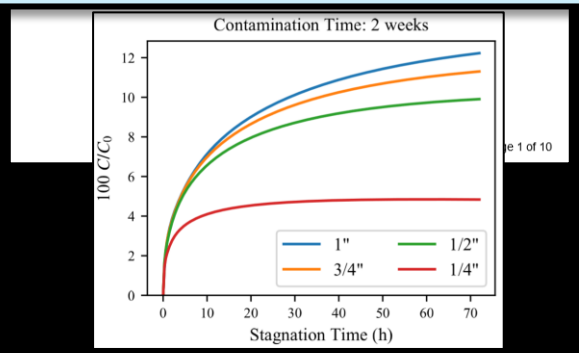
Water Distribution System Decontamination

Collaboration between Us & USEPA

Hydraulics

Polymer Science

Environmental Engineering



Numerical modeling:

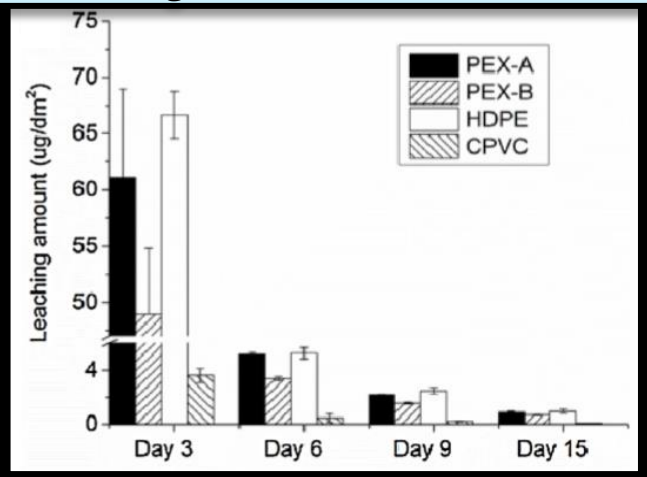
Greater than 286 days vs. less than 64 days of continuous water flushing for 1-inch HDPE service line

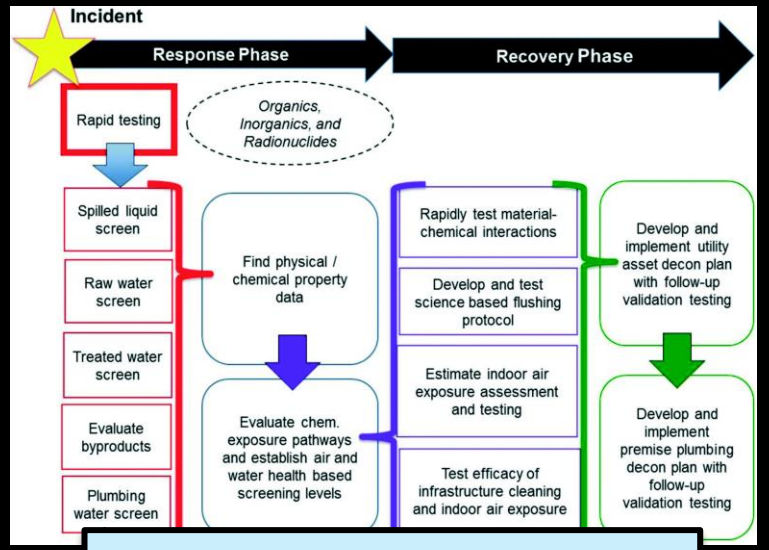
(Haupert et al. 2019)

Stagnation needed to find contamination

Different plastic pipes uptake and leach different amounts of VOCs and SVOCs

Huang et al. 2017. J. HazMat.





There is a step-wise process for responding to and recovering from contamination

Whelton et al. 2017. ES: WR&T.

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UNIVERSITY OF CALIFORNIA, BERKELEY

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ORIGINAL RESEARCH

AWWA WATER SCIENCE

Wildfire caused widespread drinking water distribution network contamination

Caitlin R. Proctor[1,2,3,4] | Juneseok Lee[5] | David Yu[4,6] | Amisha D. Shah[3,4] | Andrew J. Whelton[3,4]

Natural Hazards (2021) 108:947–975
https://doi.org/10.1007/s11069-021-04714-9

ORIGINAL PAPER

Check for updates

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

Tolulope O. Odimayomi[1] · Caitlin R. Proctor[2] · Qi Erica Wang[1] · Arman Sabbaghi[3] · Kimberly S. Peterson[4] · David J. Yu[5] · Juneseok Lee[6] · Amisha D. Shah[7] · Christian J. Ley[1] · Yoorae Noh[8] · Charlotte D. Smith[9,10] · Jackson P. Webster[11] · Kristin Milinkevich[12] · Michael W. Lodewyk[12] · Julie A. Jenks[13,14] · James F. Smith[15] · Andrew J. Whelton[7]

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

Kristofer P. Isaacson,[a] Caitlin R. Proctor,[ab] Q. Erica Wang,[a] Ethan Y. Edwards,[a] Yoorae Noh,[c] Amisha D. Shah[ac] and Andrew J. Whelton[abc]

ACS ES&T Water

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Prediction of Water Distribution System Contamination Based on Wildfire Burn Severity in Wildland Urban Interface Communities

Stefanie S. Schulze* and Erica C. Fischer

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The Marshall Fire: Scientific and policy needs for water system disaster response

Andrew J. Whelton[1] | Chad Seidel[2] | Brad P. Wham[3] | Erica C. Fischer[4] | Kristofer Isaacson[5] | Caroline Jankowski[5] | Nathan MacArthur[2] | Elizabeth McKenna[2] | Christian Ley*

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Article

Organic Chemical Contaminants in Water System Infrastructure Following Wildfire

William M. Draper, Na Li, Gina M. Solomon, Yvonne C. Heaney, Reese B. Crenshaw, Richard L. Hinrichs, and R. Esala P. Chandrasena*

Oregon State University

Fire Technology, 58, 1889–1915, 2022
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Simulation of Heat Transfer Through Soil for the Investigation of Wildfire Impacts on Buried Pipelines

UCSF

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Article

Fire and Water: Assessing Drinking Water Contamination After a Major Wildfire

Gina M. Solomon,* Susan Hurley, Catherine Carpenter, Thomas M. Young, Paul English, and Peggy Reynolds

FIRE SAFETY RESEARCH INSTITUTE UL

Fire Technology, 60, 1–18, 2024
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https://doi.org/10.1007/s10694-023-01487-4

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Pilot Study on Fire Effluent Condensate from Full Scale Residential Fires

Gavin P. Horn and Nicholas W. Dow, Fire Safety Research Institute, UL Research Institutes, Columbia, MD 21045, USA*
Danielle L. Neumann, Enterprise Sustainability, UL Solutions, Brea, CA 92821, USA

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Residential Water Soft… Require Remediation …

Caroline M. Jankowski, Lauren A. … Aliya B. Ehde, Madeline B. Larsen, William J. Schmidt, Amisha D. Sh…

ORIGINAL RESEARCH

AWWA WATER SCIENCE

Plastic water supp… contamination, an…

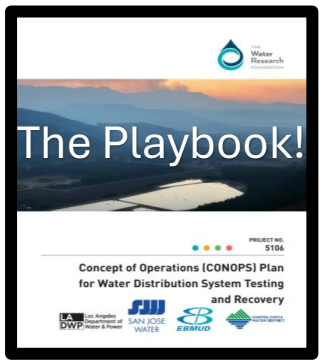
Kristofer P. Isaacson[1] | … Amisha D. Shah[4] | Andr…

ORIGINAL RESEARCH

AWWA WATER SCIENCE

Wildfire damage and contamination to private drinking water wells

Caroline Jankowski[1] | Kristofer Isaacson[1] | Madeline Larsen[1] | Christian Ley[2] | Myles Cook[1] | Andrew J. Whelton[1]



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11. Decision-making considerations using results
12. Communication and general questions

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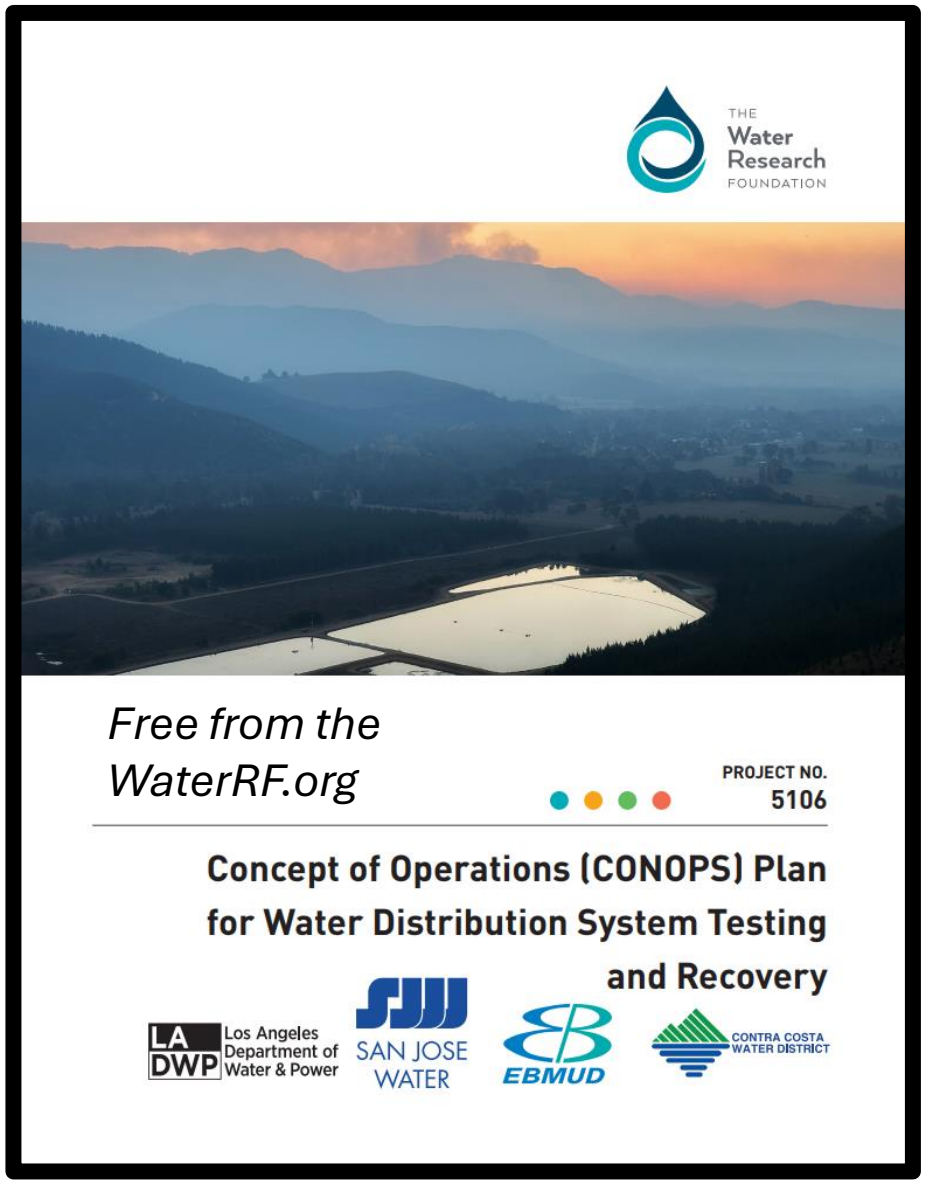
B. CDC guidance about water advisories
C. Target chemicals for water sampling
D. Water sampling SOPs
E. Example FAQs
F. Guidance about water testing reports for the general public



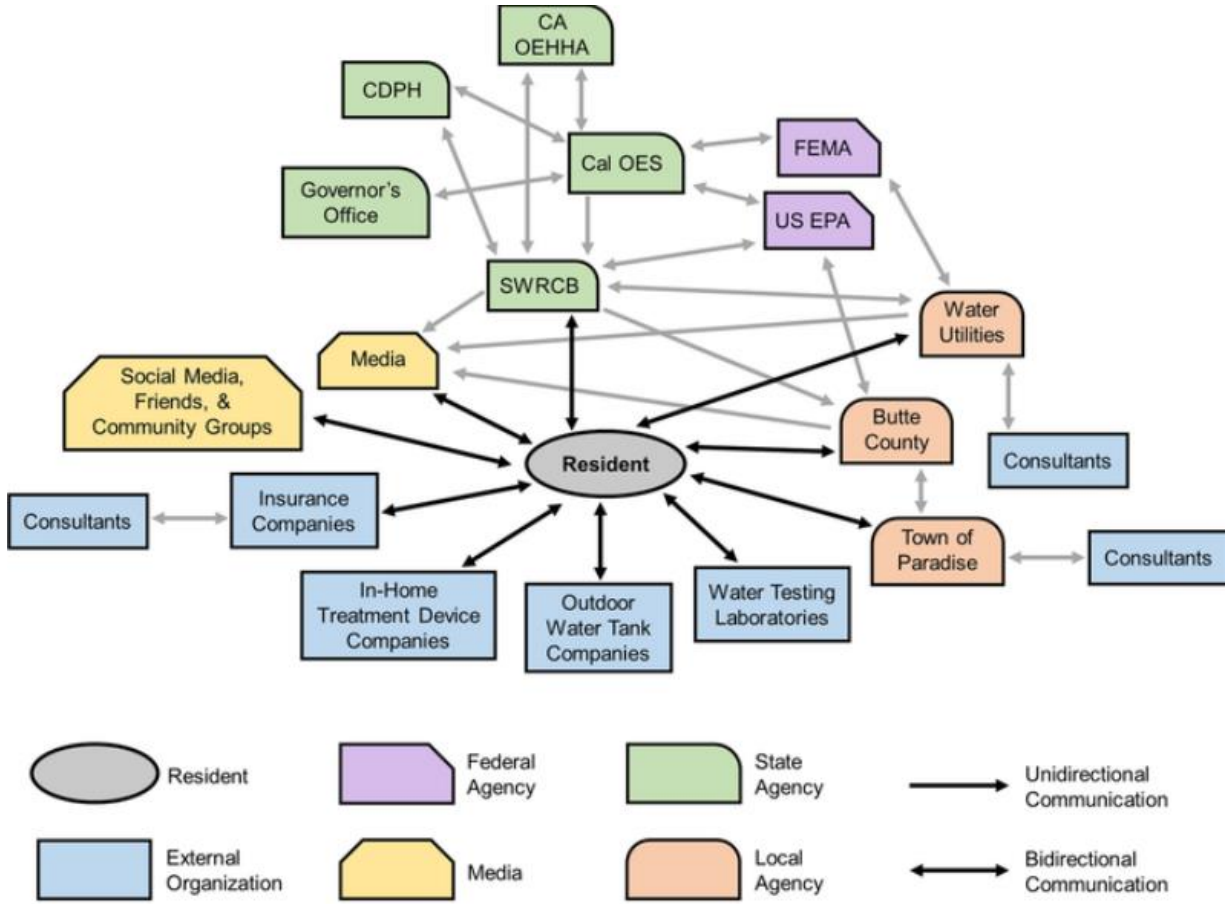
Water safety attitudes, risk perception, experiences, and education for households impacted by the 2018 Camp Fire

Natural Hazards, Published May 2021

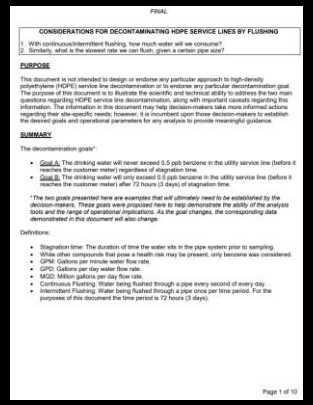
https://doi.org/10.1007/s11069-021-04714-9

Households Require Support

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
6) **Plumbing** design and material selection for property repairs and new construction

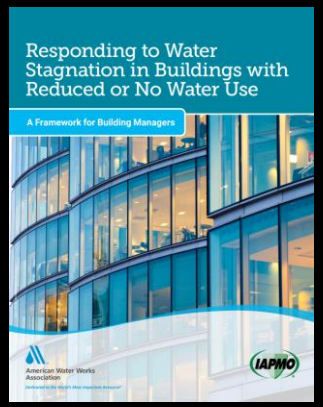


Post-Fire Sampling...



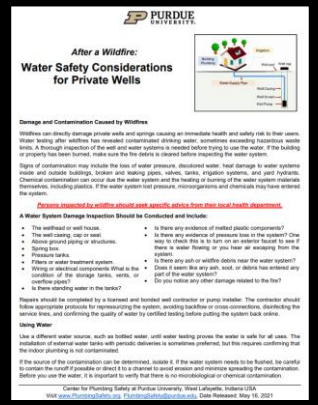
2019

Inside Buildings...



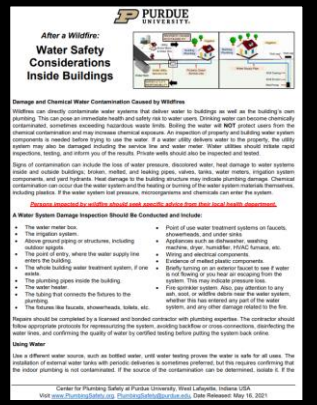
2020

Private wells...



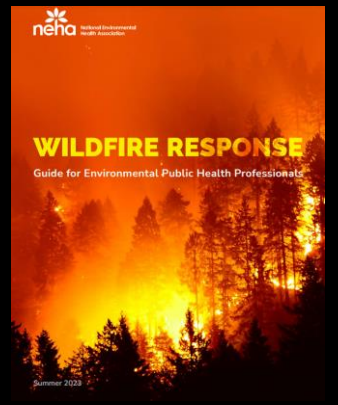
2021

Inside Buildings...



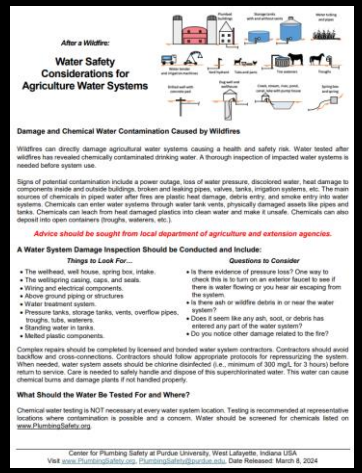
2021

Environmental health basics...



2023

Agricultural water systems...

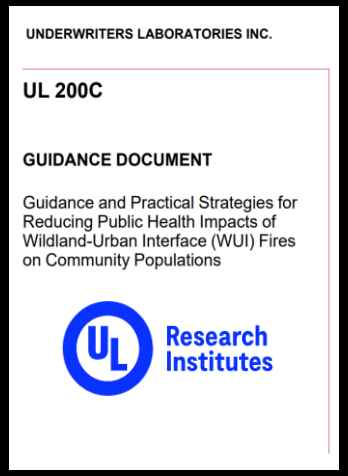


2023

Bipartisan Commission report...

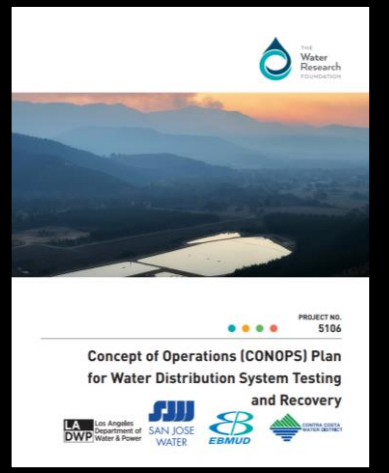
2023

Public health basics...



2024

Post-fire utility and health decisions



2024

LA Blue Ribbon Commission

2025

...

PURDUE UNIVERSITY


WELCOME
to the
ZOO
ZONE 5


SOUTH
ENTRANC
WE HAVE A
RIDGE
BERKELEY

Opportunities for Prevention and Recovery:

Lessen the impact of fires

- ✓ Adopt fire safe **setback** distances and **design** for utility assets
- ✓ Lessen **power loss**: Backup power, emergency generators
- ✓ Evaluate **fire flow vulnerability** with hydraulic models
- ✓ Install **emergency interconnections** to neighbor water systems
- ✓ Where vulnerable to fire, protect or minimize/avoid **plastic use**
- ✓ Have **bypass capability** for raw water sources and treatment plant
- ✓ **Zone** the water distribution system to prevent backflows
- ✓ Adopt **service line backflow prevention** devices/ check valves
- ✓ Adopt remote **automatic shutoffs**
- ✓ Develop and issue evidence-based drinking **water use warnings**

Opportunities: Lessen the time to restore safe water service

Establish and strengthen **mutual aid** networks

Develop evidence-based and technology assisted physical **damage assessments**

Identify **chemical source** profiles

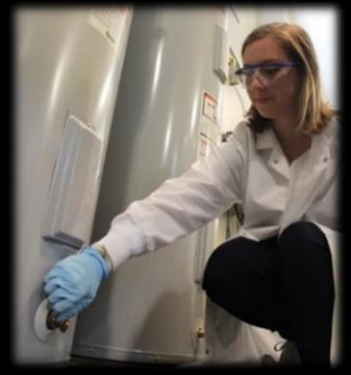
Innovate infrastructure **decon technologies**

Share knowledge and mitigation methods and practices nationwide

Create evidence-based asset repair vs. replacement **decision framework**

Support small water systems who do not have technical expertise, $$, or personnel to recover

Thank you

Visit our wildfire response and recovery resources page at www.PlumbingSafety.org

- ✓ Post-fire chemicals to test for
- ✓ Brief videos for emergency managers and health officials
- ✓ Guidance for private well owners
- ✓ Guidance for building owners
- ✓ Government agency resources
- ✓ FEMA mitigation guidance
- ✓ Other training resources

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Special thanks to…

Paradise Irrigation District
City of Louisville, Colorado · Since 1878
County of Maui, State of Hawaii
Boulder County
EBMUD
LA DWP Los Angeles Department of Water & Power
Contra Costa Water District
San Jose Water Company
Medford Water Commission
EWEB
City of Napa
City of Santa Rosa

Support from…

Rotary Club of Paradise, California
NSF
United States Environmental Protection Agency
The Water Research Foundation
R&S Kayne Foundation
Andrew Whelton's Wallet

PURDUE UNIVERSITY

John Snow Pump
Soho, London

Water & Infrastructure Resilience: Public Health & Extreme Events

March 14-23, 2025

Aero. & Astronautical Eng.
Chem. Eng.
Civil Eng.
Construction Eng.
Electrical Eng.
Environ. & Eco. Eng.
Environ. & Nat. Res. Eng.
Mechanical Eng.

Study Abroad Engagement:

LFB LONDON FIRE BRIGADE

dwi

love every drop anglianwater

The Guardian

Imperial College London

PURDUE UNIVERSITY

CE 597: Disasters & Emergencies

Science, engineering, policy, law, insurance, emergency management, social science, communications, journalism

Course Description: Focused on introducing and inspiring students about the engineering, science, and policy challenges associated with disasters and emergencies. Topics will span infrastructure, the environment, public safety, and public health.

Learning Objectives:

- ID key population needs following natural and man-made disasters;
- Explain the roles and responsibilities of common organizations responding to incidents;
- Recognize the wide-breadth of expertise involved in response and recovery;
- Communicate technical concepts effectively with audiences with widely-varying backgrounds;
- Recognize the different expertise involved in incident response and recovery.

Approach: Field trip; NIIMS/ICS training; NSF CONVERGE trainings; Speaker reflections; Sci. paper/report reflections; quizzes; Hurricane exercise; Chemical exercise; Press conference; Final report and video.