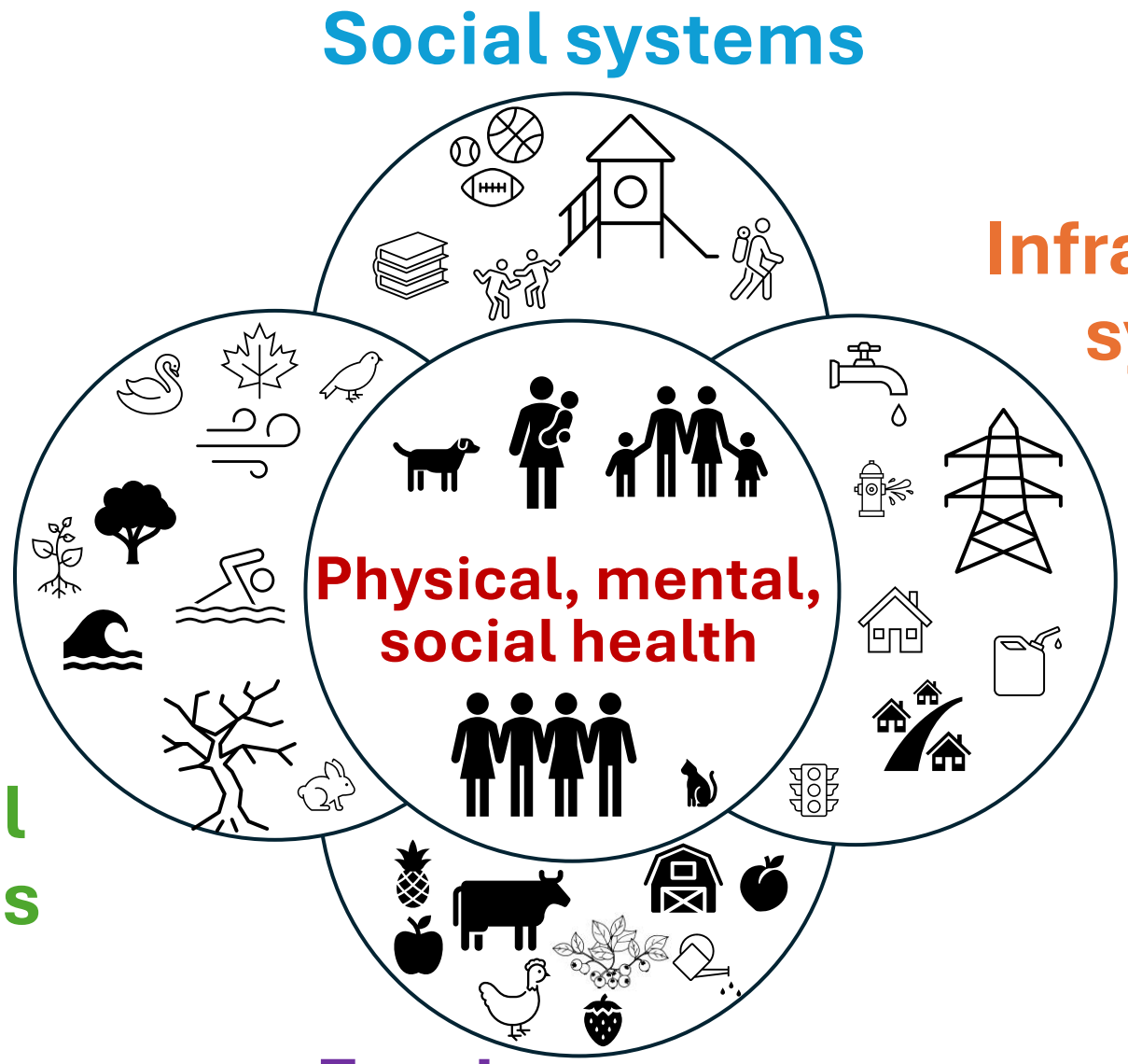


No Playbook Existed.
Now one does.

How the Camp Fire changed disaster recovery

Andrew Whelton, Ph.D.
Purdue University

Disasters directly and indirectly affect population health



Should I worry about debris blowing from next door?

What is my water company doing?

Will indoor purifiers make my air safe?

I think I got sick during reentry, what do I do?

What PPE do I need to visit my home? Or go outside?

Why won't FEMA give me $?

Can my family and my pets use my drinking water normally?

Is my soil contaminated?

What is a Right of Entry (ROE) form?

Is the contractor remediating correctly?

What should I ask my insurance company?



What is a Disaster Recovery Center?

Where do I get emergency drinking water?

Why won't people remove debris from my property?

Should I throw away my "soft goods"?

Is my septic system okay?

Where are the checkpoints and re-entry permits?

Should I remediate my property myself?

Will my neighbors' contamination enter my home?

Is my garden safe?

Is the daycare or school safe?

Can I eat fruit from my trees?

Is my HVAC system contaminated?

How do I clean my pool/spa?

Should I buy a water filter?

Do I have enough $ to repair or rebuild?

Did my contractors test correctly?

How do I keep my pets safe?

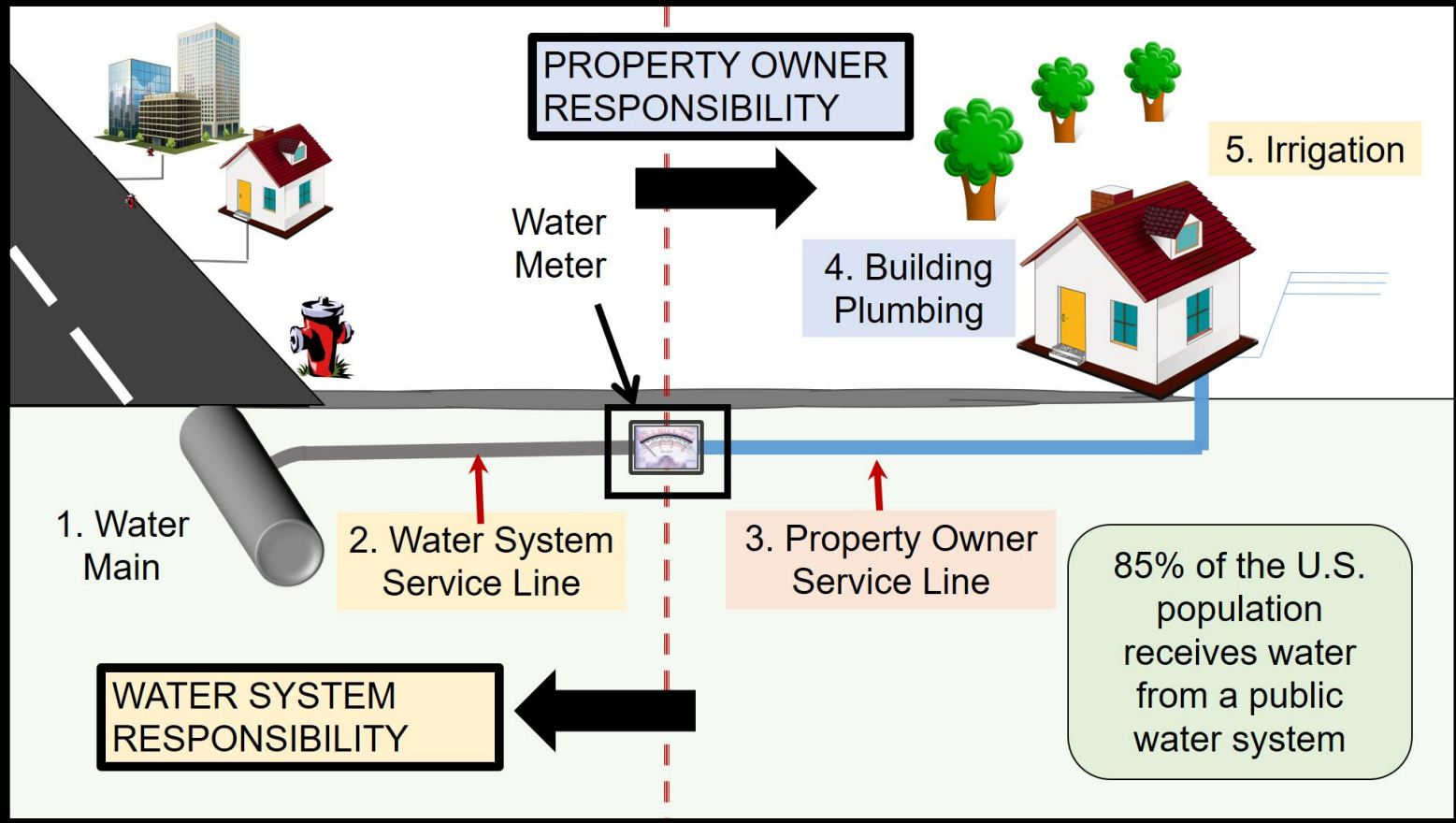
Is my plumbing contaminated?

Who will cut my burned trees?

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



Video: 2023 Kula Fire in Maui, Hawai'i



Lessons Learned from the 2017 Tubbs Fire and 2018 Camp Fire

AWWA WATER SCIENCE

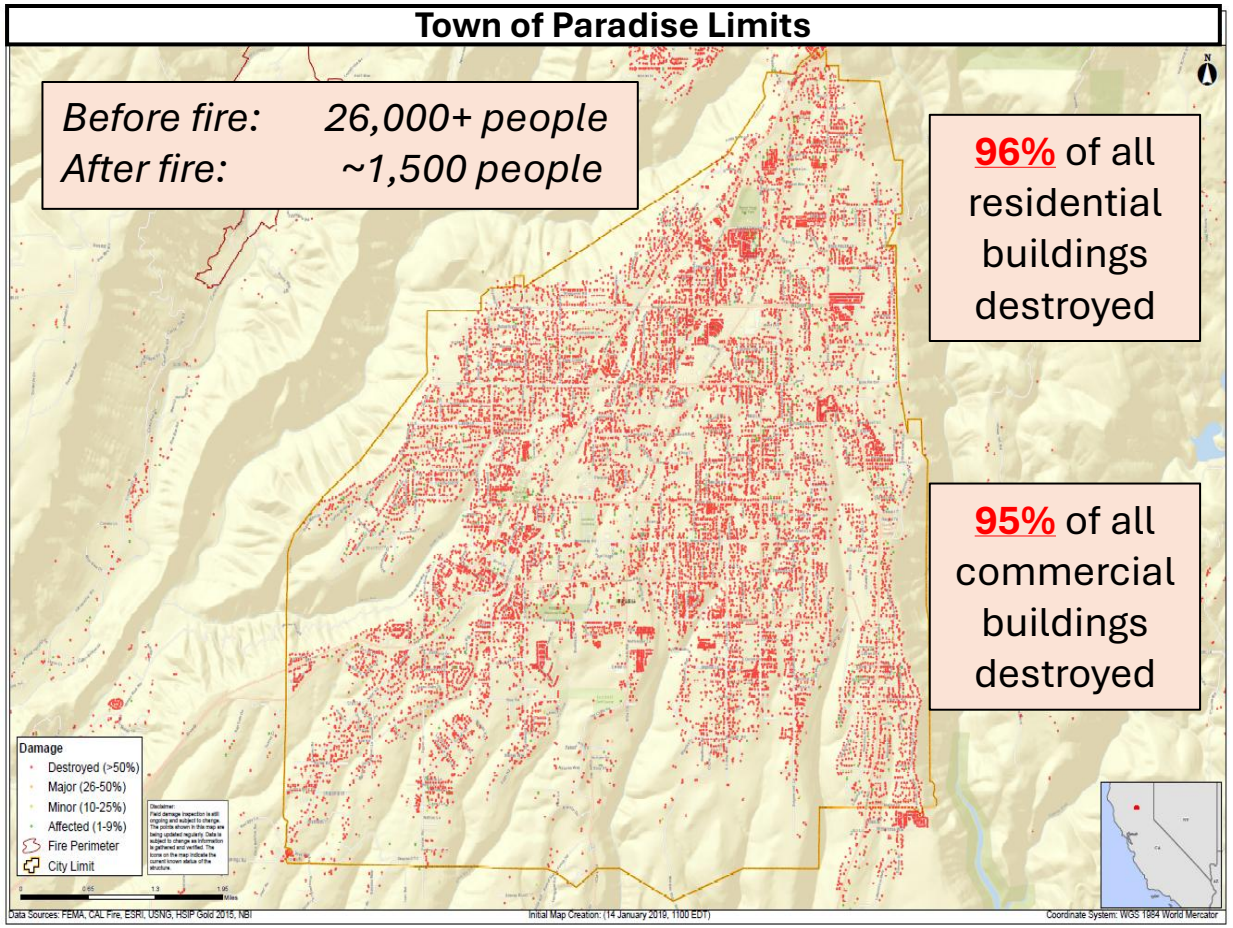
Wildfire caused widespread drinking water distribution network contamination

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.)

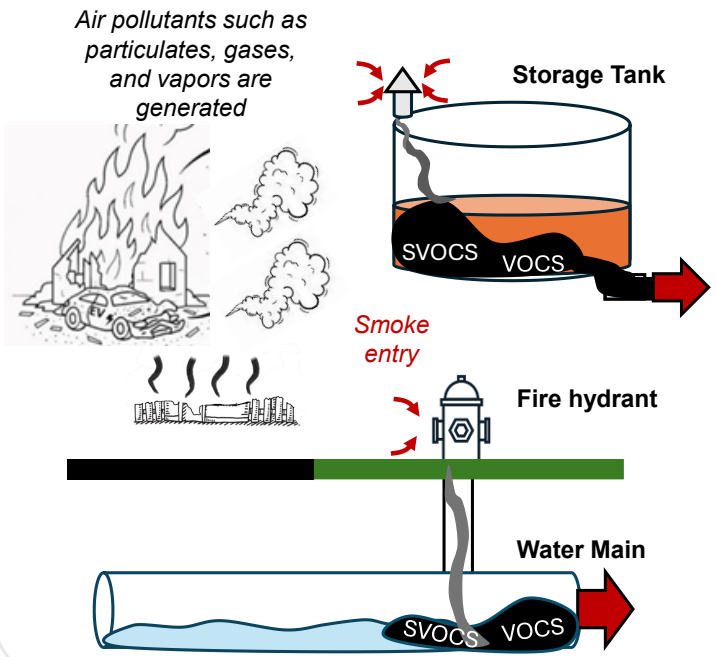
Do Not Use water order should be issued

Protect homeowners and their plumbing

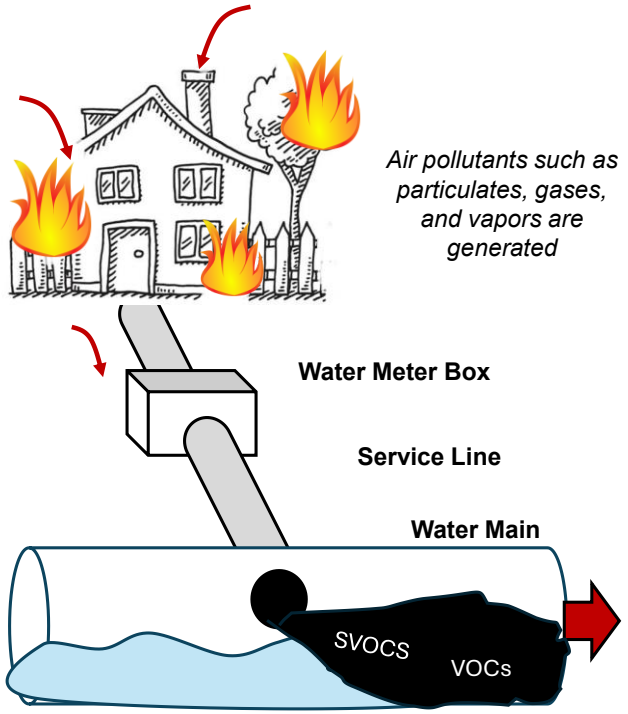


How did the water system in Santa Rosa and Paradise California get so contaminated with VOCs? We had 3 theories.

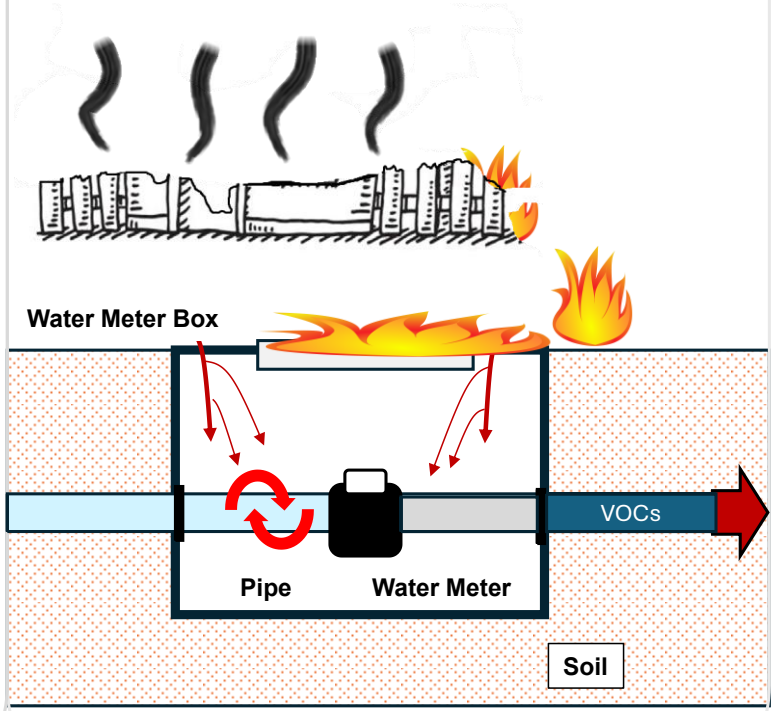
Burning or smoldering vegetation and other materials nearby traveling in ambient air



Burning or smoldering of structures traveling through the water service line



In-situ thermally degraded plastics due to fire effects



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

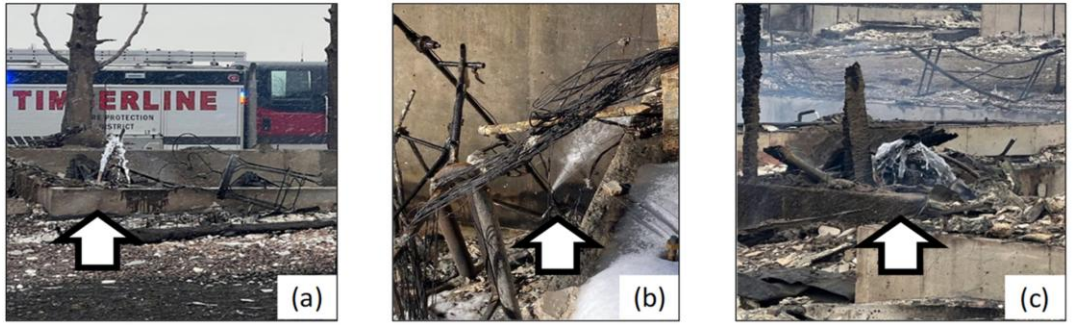
AWWA WATER SCIENCE *Published January 2023*

https://doi.org/10.1002/aws2.1318

1) Loss of power jeopardized fire-fighting and caused worker risks
2) Local/external resources were critical
3) SOPs for post-fire sampling, analysis, and rapid external labs are needed
4) Contamination seemed to be related to depressurization and property damage, but more work needed
5) Clarification on public health risks and water use conditions is needed

20 scientific and policy needs for improving water system disaster response and recovery

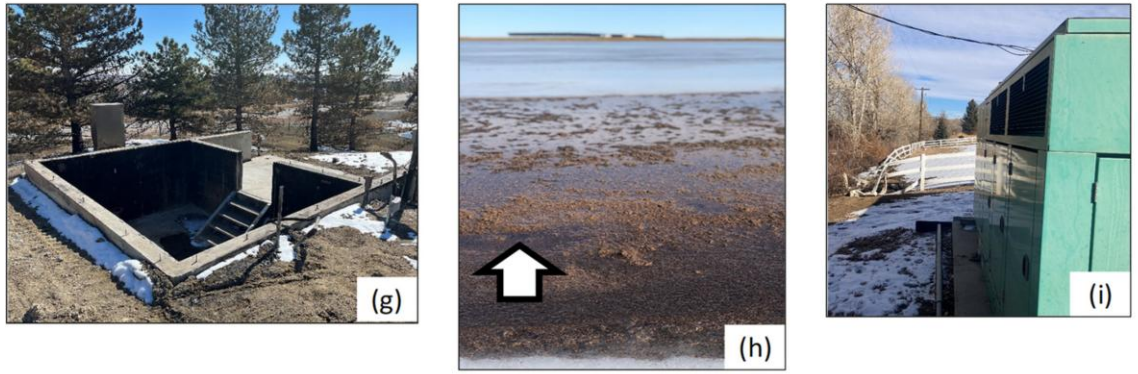
Water Distribution System Damage





Service lines, hydrants, and plumbing were damaged and leaking (a,b,c,d). Some hydrants were left open, fire-fighting equipment was left behind (f). Water meters to properties with destroyed structures were removed (e).

Damage on Facility Property



Ash was visible around and in the Superior reservoir (h), and the water treatment plant emergency generator was destroyed by fire (g). The EBCWD emergency generator air intake was clogged with debris and could not operate because of the gas shutoff (i).

Wildfires can contaminate drinking water systems both by thermal damage to plastic pipes and intrusion of smoke

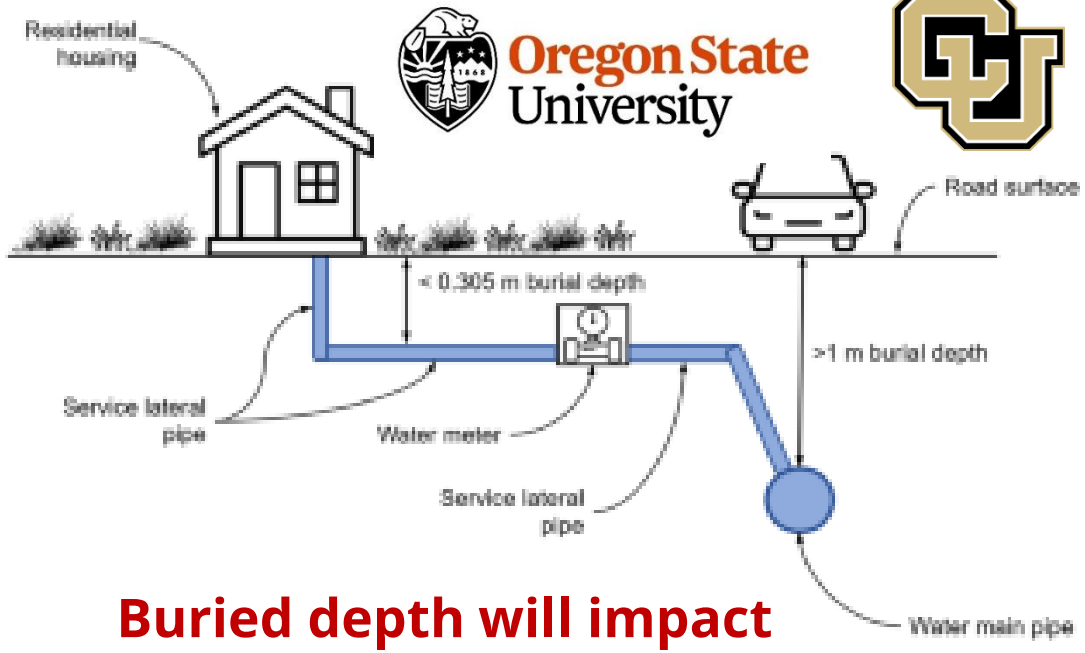
Characterized target and nontarget VOCs and SVOCs in water from **1** contaminated service line after the Camp Fire.

New PVC, PEX, and HDPE pipe **heating experiments** conducted

Results

PVC pipe heating: 32 compounds
HDPE/PEX pipes heating: 28 compounds
Service line: 55 compounds for uncontrolled burning of biomass and waste materials.

Draper et al. 2022. ACS EST Water.



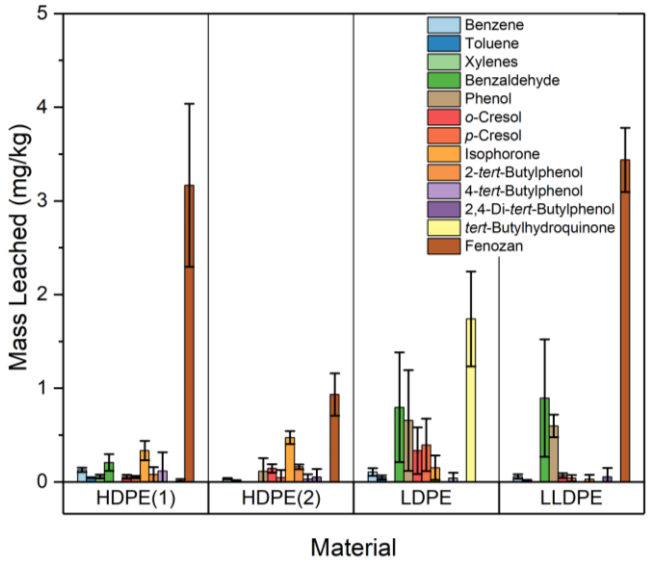
Buried depth will impact thermal vulnerability

Mathematical Thermal Modeling Results

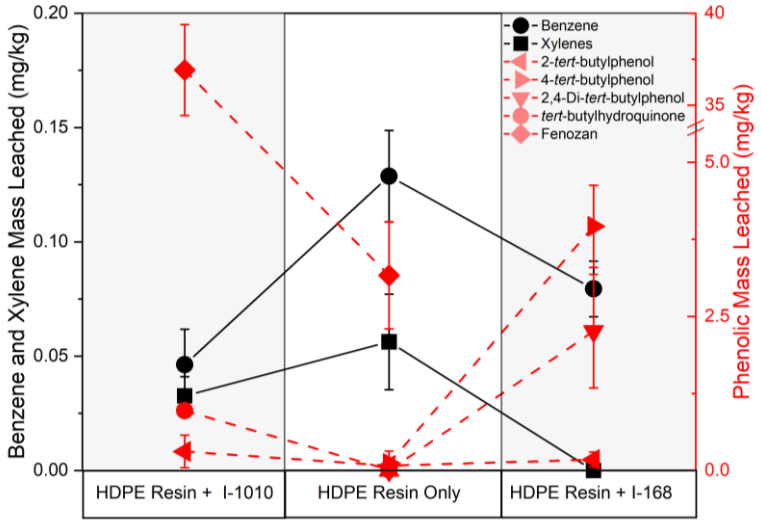
- Upper limit temperature for pressure service of the pipelines was exceeded at depths up to 0.45 m (1.5 ft).
- Upper limit temperature will be exceeded at least 50% of the time at depths up to 0.19 m (0.6 ft).

Metz et al. 2022. Fire Technology.

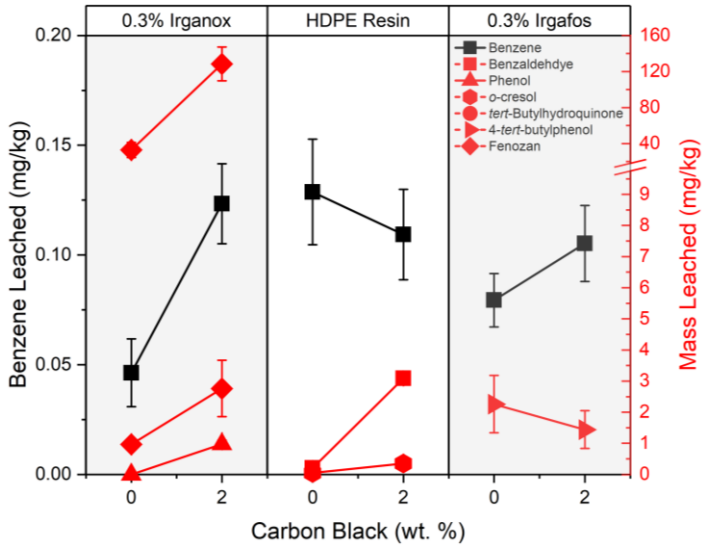
Type of resin type, antioxidant loading, and carbon black influenced VOCs found in water



The type of virgin PE resin used impacts VOCs found in water



The presence of AOX decreased VOCs released but increased levels of AOX degradation products detected



CB had complex impacts on VOCs found in water

When CB ↑, benzene ↓
When AOX1 ↑, benzene ↓
When AOX2 ↑, benzene ↓
When CB + AOX, benzene =

Isaacson et al. 2025. *J. HAZMAT.* https://doi.org/10.1016/j.jhazmat.2025.137562

Pilot Study on Fire Effluent Condensate from Full Scale Residential Fires

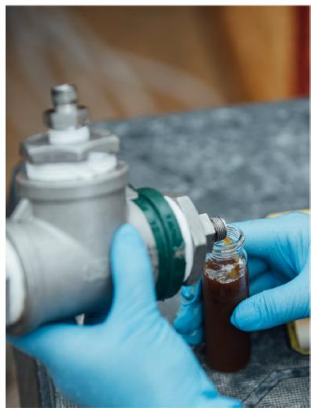












Exp. #	Room 1: 1	Room 1: 2	Room 2: 3	Room 2: 4	Room 2: 5
pH	2.56	1.10	1.93	1.96	1.59
Bromide	<3.0	5.5	6.6	9.8	13
Chloride	270	39,000	3,000	2,400	4,700
Nitrate	13	2.4	5.7	<1.0	6.4
Sulfate	330	9,200	2,700	2,100	2,300

ppb

Exp. #	Room 1: 1	Room 1: 2	Room 2: 3	Room 2: 4	Room 2: 5
Benzene	1,100	6,400	2,600	3,600	33,000
Styrene	<400	1,200	470*	1,400	1,800
Toluene	180*	1,000	<340	660	3,900
Xylenes	<290	110*	<740	153	910*
Naphthalene	2,700*	8,100	7,400*	8,100	10,000
2-Butanone	2,100*	3,600*	7,300*	13,000	31,000
Acetone	57,000	31,000	74,000	110,000	250,000
Ethanol	<40,000	<40,000	67,000*	49,000	61,000*

Chemicals often not looked for in water systems

Horn et al. 2023. *Fire Technology.*



2 Weeks After the 2023 Maui Wildfires

2024. *Environ. Sci: Wat. Res. Technol.*
https://doi.org/10.1039/D4EW00216D

1) After the evacuation order was lifted, above/below ground smoldering continued
2) Interviewed households had received no government communication; All used drinking water before hearing it was unsafe to use.
3) Households used pool test kits and bought at-home kits, that could not find all fire-related chemicals.
4) Agricultural water system damage was like residential systems. 50,000 ft of HDPE animal watering pipe destroyed at 1 property.
5) Public health recommendations provided.

















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

PURDUE UNIVERSITY

California State University Chico

Butte College

School of Public Health, University of California, Berkeley

PURDUE UNIVERSITY

Oregon State University

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]

Environmental Science Water Research & Technology

ROYAL SOCIETY OF CHEMISTRY

COMMUNICATION

View Article Online

Check for updates

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

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

ACS ES&T Water

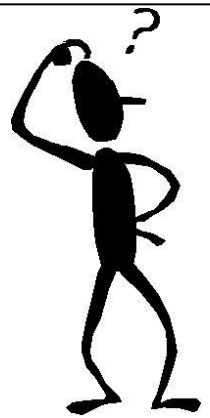
Made available for a limited time for personal research and study only License.

pubs.acs.org/estwater

Article

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

Stefanie S. Schulze* and Erica C. Fischer



PURDUE UNIVERSITY

University of Hawai'i

Environmental Science Water Research & Technology

ROYAL SOCIETY OF CHEMISTRY

COMMUNICATION

View Article Online

Check for updates

Two weeks after the 2023 Maui wildfires: drinking water experiences and needs†

Andrew J. Whelton, Paula D. Coelho, Christopher Shuler, Aurora Kagawa-Viviani, Kellie D. P. Cole, Stefanie Surdyka and Stephanie Heffner

PURDUE UNIVERSITY

CORONA ENVIRONMENTAL CONSULTING

Oregon State University

ORIGINAL RESEARCH

AWWA WATER SCIENCE

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*

UCSF

CDPH

California Water Boards

ACS ES&T Water

Made available for a limited time for personal research and study only License.

pubs.acs.org/estwater

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
© 2022 The Author(s), under exclusive licence to Springer Science+Business Media, LLC, part of Springer Nature
Manufactured in The United States
https://doi.org/10.1007/s10694-022-01232-3

Check for updates

Simulation of Heat Transfer Through Soil for the Investigation of Wildfire Impacts on Buried Pipelines

UCSF

ACS ES&T Water

pubs.acs.org/estwater

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
© 2023 The Author(s)
Manufactured in The United States
https://doi.org/10.1007/s10694-023-01487-4

Check for updates

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

PURDUE UNIVERSITY

Environmental Science & Technology

pubs.acs.org/est

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…

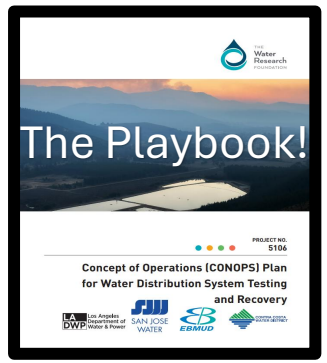
Kristofer P. Isaacson[1] | …
Amisha D. Shah[4] | Andr…

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]





PURDUE UNIVERSITY



Developed for utilities/public works, by utilities based on my Army CIV experiences

Draws from experiences from multiple states

The first and only evidence-based guidance

- How to detect the full extent of water system chemical contamination and damage
- Unique testing and sampling procedures
- Unique customer notifications about health risks from contaminated drinking water
- Actions to restore pressure and remove contaminated water from the system
- Communicating postfire drinking water safety issues to customers, elected leaders, and support organizations

Table of Contents

…

4. Roles and responsibilities of key orgs
5. Conditions that prompt wildfire caused drinking water contamination
6. Response and key decisions
7. Post-fire exposures and warnings
8. Post-fire chemicals, concentrations, and comparing results to drinking water exposure limits
9. Post-fire chemical analysis
10. Water sampling considerations
11. Decision-making considerations using water sample results
12. Communication and general questions

Concept of Operations Plan (CONOPS) for Water Distribution Response and Recovery

2024. Water Research Foundation. Denver, CO USA. Whelton et al.

Appendices

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

Pressure, utility network and building plumbing: Leaking, destruction

Power: Electric poles down, shutoff by provider, natural gas generators destroyed, lacking fuel

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

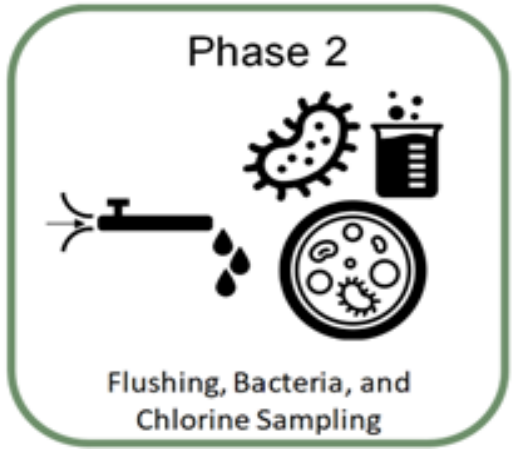
Personnel: Hazard situations, unable to respond due to staff availability

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

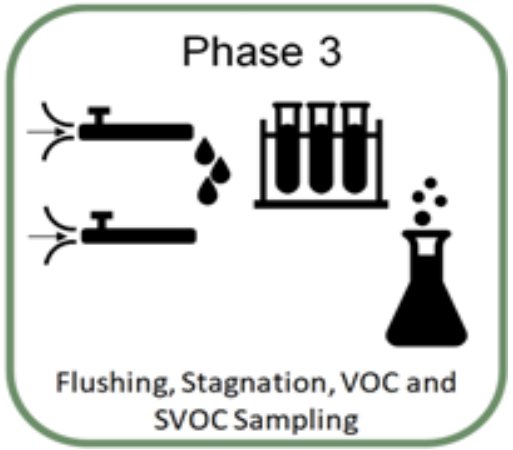
There are 3 main phases of water utility response decisions



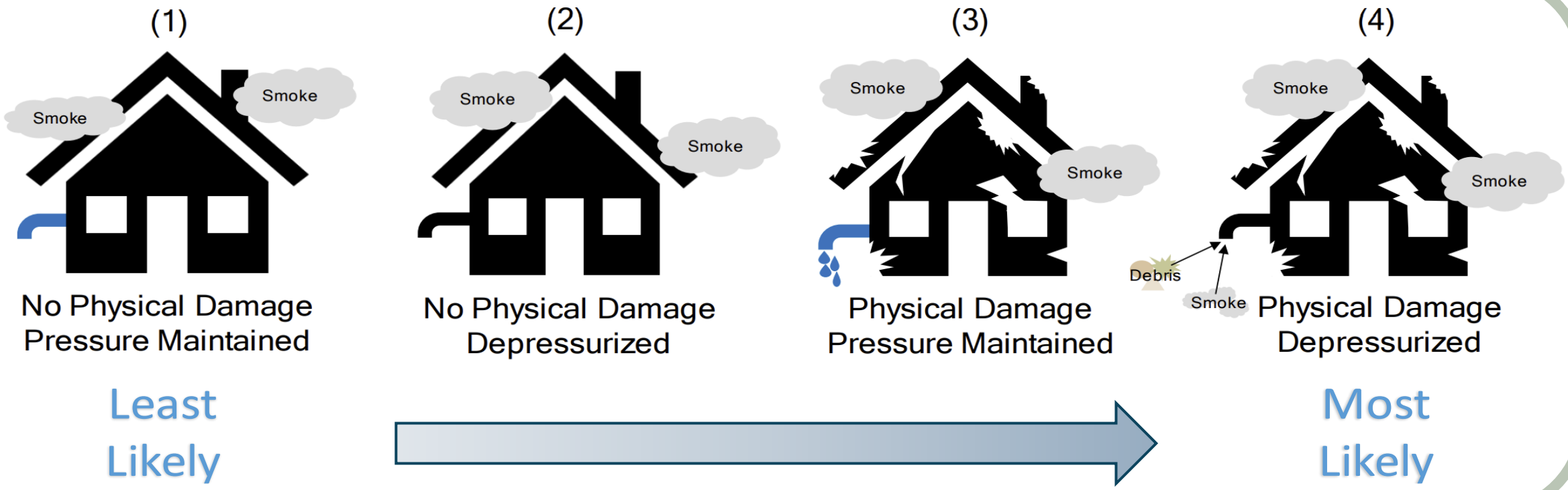
Support firefighting
Isolate damage
Maintain pressure
Water use warnings



Personnel surge
Restore control, pressure
Repeated sampling
Laboratories



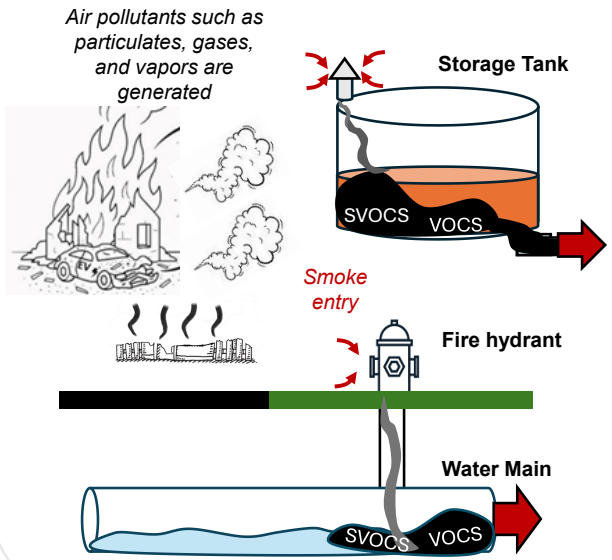
Personnel surge
Repeated sampling
Laboratories
Decon, remove, replace



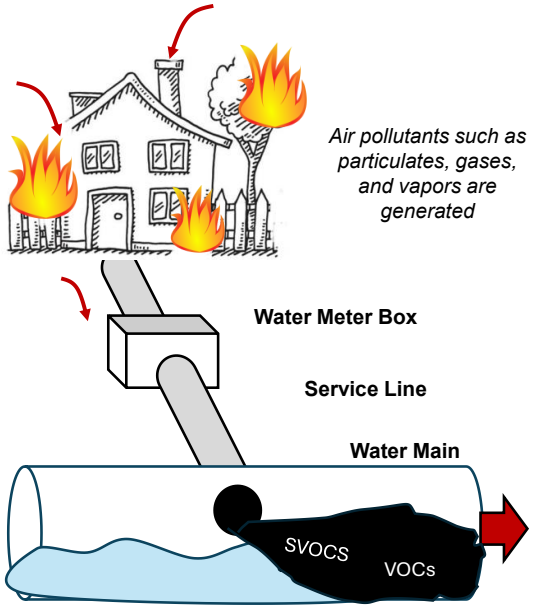
Different scales of wildfire property damage will relate to the **potential for contaminated drinking water**. Water utilities should rate customer buildings to assess their potential for being a SOURCE of the contamination.
These can be **cross-connections**.

Data validated all 3 theories! Power loss, pressure loss, and contamination rendering infrastructure and water unsafe to use

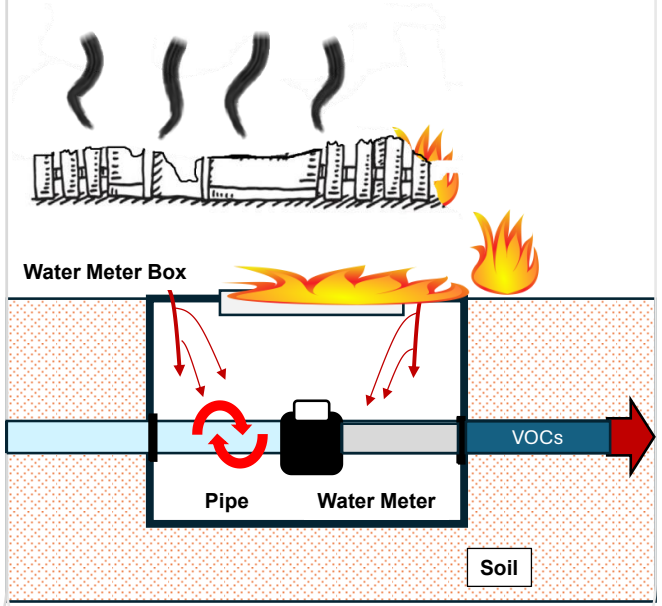
Burning or smoldering vegetation and other materials nearby traveling in ambient air



Burning or smoldering of structures traveling through the water service line



In-situ thermally degraded plastics due to fire effects



FREE to download: Zavodny & Whelton. 2026. Water utilities damaged by wildfire: Recovery lessons, mitigation, and research needs. *Utilities Policy.* https://www.doi.org/10.1016/j.jup.2026.102245

Exposure Routes

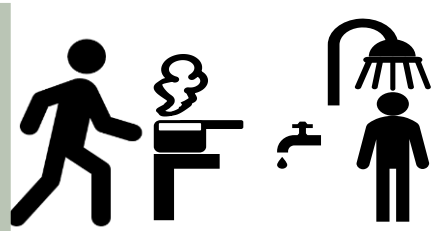
(i.e., Adults, children, infants, etc.)



Ingestion

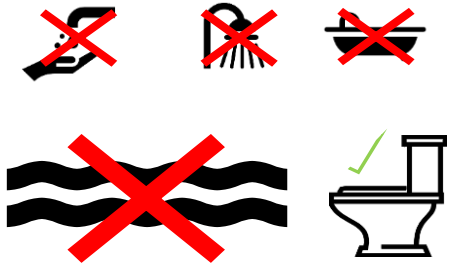


Dermal contact



Inhalation

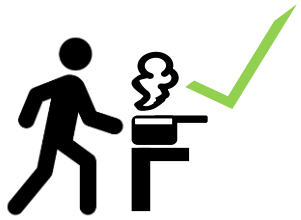
Water Use Warnings



Do Not Use (DNU)



Do Not Drink (DND)

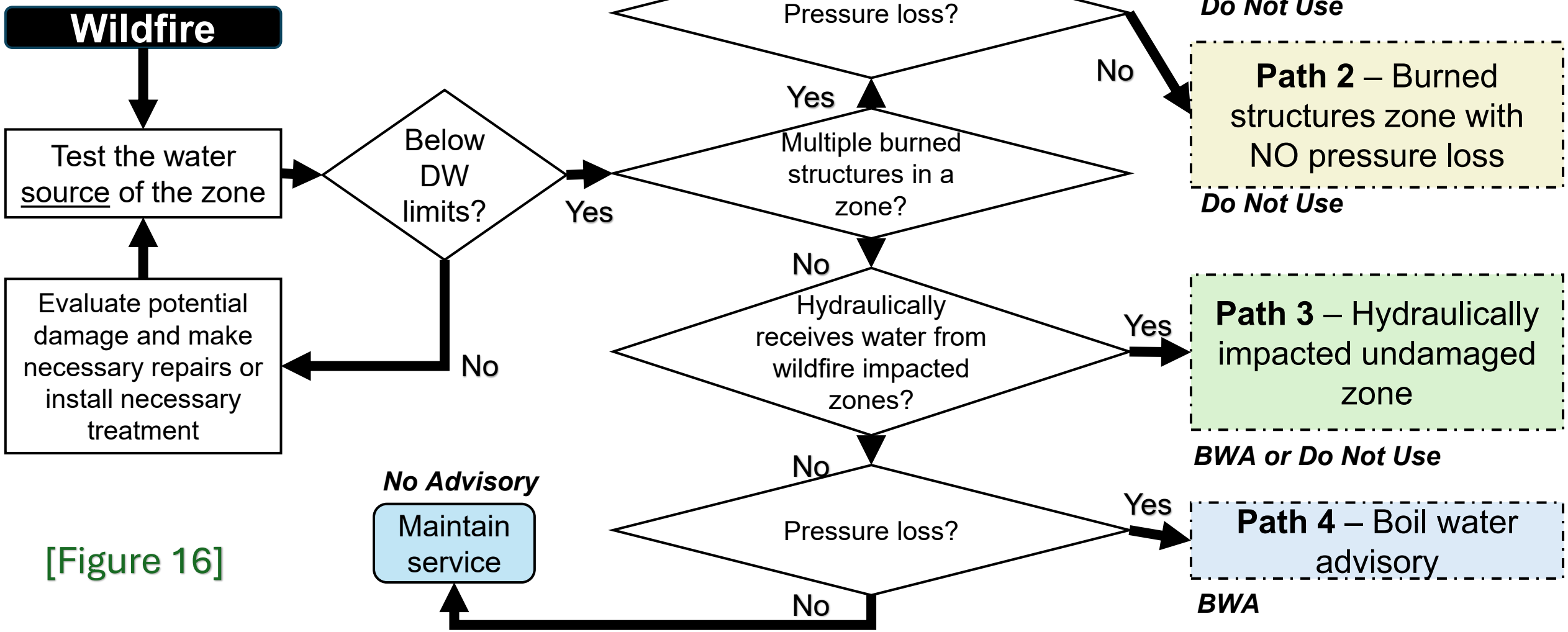


Boil Water Order

Water utilities should issue a drinking warning to customers ASAP, if necessary, (i.e., Boil Water Advisory, Do Not Use Order).
The WARNING **must be protective of the specific health threats**.

Overall Decision Flow Chart

No advisory v. Boil Advisory v. Do Not Use Advisory?



[Figure 16]

Testing water after a fire: What fires taught us

Protocols based on past fires in CA, CO, HI, NM, and OR



Screening sequence

1 Repressurize → **2** Measure disinfectant residual → **3** Screen for VOCs

Test the right things

- Use EPA Method 524.2 as the minimum
- Other methods must be sensitive enough and cover all fire-related chemicals
- Confirm your lab screens for what you need; labs differ

Be transparent and plan ahead

- Make data and methods publicly available
- Develop a plan to restore service and seek external resources

Remember: The absence of benzene doesn't mean your drinking water is safe








WELCOME
to the
ZOO
ZONE 5






SOUTH
ENTRANC
WE HAVE A
RIDGE
BERKELEY

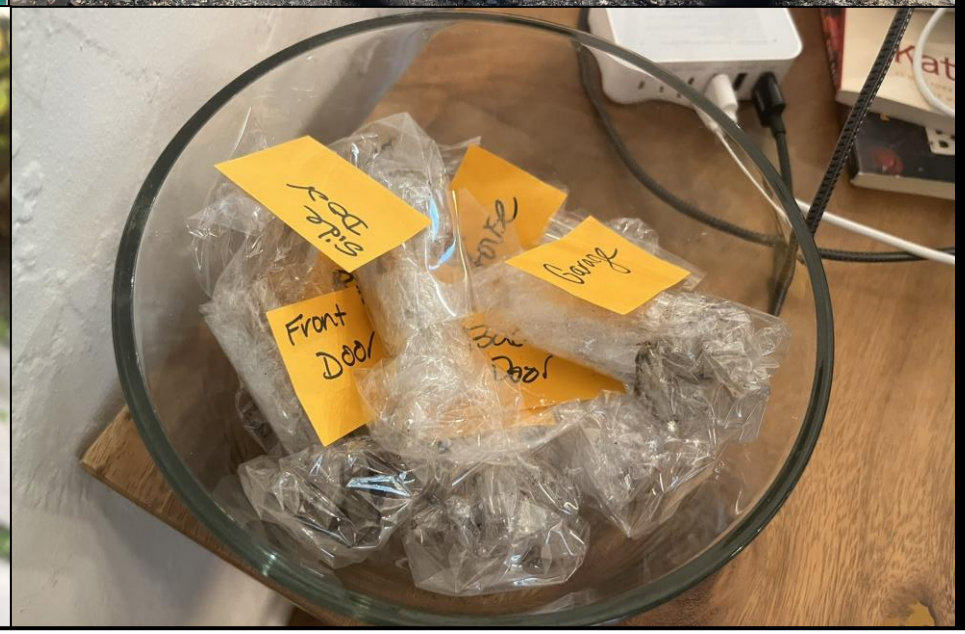






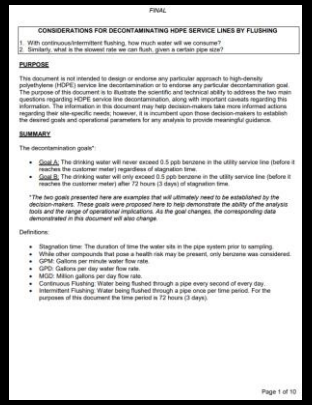





Front
Door

Making it Actionable

Post-Fire water sampling...


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 regarding their site-specific needs; however, it is incumbent upon those decision-makers to establish the desired goals and operational parameters for any analysis to provide meaningful guidance.

SUMMARY

The decontamination goals*:

- Goal A: The drinking water will never exceed 0.5 ppb benzene in the utility service line (before it reaches the customer meter) regardless of stagnation time.
- Goal B: The drinking water will only exceed 0.5 ppb benzene in the utility service line (before it reaches the customer meter) after 72 hours (3 days) of stagnation time.

*The two goals presented here are examples that will ultimately need to be established by the decision-makers. These goals were proposed here to help demonstrate the ability of the analysis tools and the range of operational implications. As the goal changes, the corresponding data demonstrated in this document will also change.

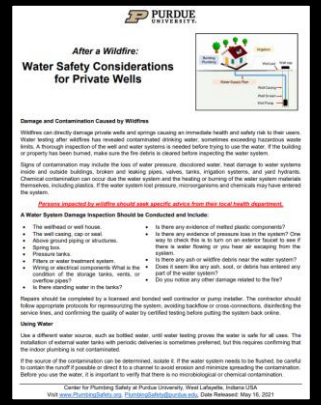
Definitions:

- Stagnation time: The duration of time the water sits in the pipe system prior to sampling.
- While other compounds that pose a health risk may be present, only benzene was considered.
- GPM: Gallons per minute water flow rate.
- GPD: Gallons per day water flow rate.
- MGD: Million gallons per day flow rate.
- Continuous Flushing: Water being flushed through a pipe every second of every day.
- Intermittent Flushing: Water being flushed through a pipe once per time period. For the purposes of this document the time period is 72 hours (3 days).

Page 1 of 10

2019

Private wells...


PURDUE UNIVERSITY

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, wells, 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 representing 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

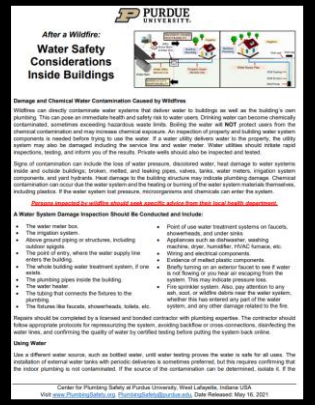
Use a different water source, such as bottled water, until water testing proves the water is safe for all uses. The installation of external water tanks with periodic deliveries is sometimes preferred, but this requires confirming that the indoor plumbing is not contaminated.

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.

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

2021

Buildings plumbing...


PURDUE UNIVERSITY

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 representing 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.

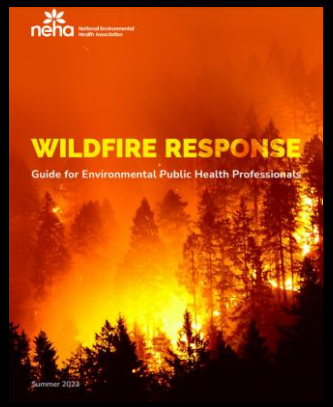
Using Water

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

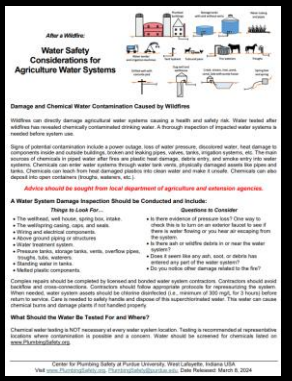
2021

Environmental health basics...



2023

Ag water systems...


After a Wildfire:

Water Safety Considerations for Agriculture Water Systems

Damage and Chemical Water Contamination Caused by Wildfires

Wildfires can directly damage agricultural water systems causing a health and safety risk. Water tested after wildfires has revealed chemically contaminated drinking water. A thorough inspection of impacted water systems is needed before system use.

Signs of potential contamination include a power outage, loss of water pressure, discolored water, heat damage to components inside and outside buildings, broken and leaking pipes, valves, tanks, irrigation systems, etc. The main sources of chemicals in piped water after fires are plastic heat damage, debris ash, and smoke entry into water systems. Chemicals can enter the water systems through water tank vents, physically damaged assets like pipes and tanks. Chemicals can leach from heat damaged plastics into clean water and make it unsafe. Chemicals can also deposit into open containers (troughs, waterers, etc.).

Advice should be sought from local department of agriculture and extension agencies.

A Water System Damage Inspection Should be Conducted and Include:

Things to Look For...

- The wellhead, well house, spring box, intake.
- The well/spring casing, caps, and seals.
- Wiring and electrical components.
- Above ground piping or structures
- Water treatment system.
- Pressure tanks, storage tanks, vents, overflow pipes, troughs, tubs, waterers.
- Standing water in tanks.
- Melted plastic components.

Questions to Consider

- Is there evidence of pressure loss? 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 ash or wildfire debris in or near the water system?
- Does it seem like any ash, soot, or debris has entered any part of the water system?
- Do you notice other damage related to the fire?

Complex repairs should be completed by licensed and bonded water system contractors. Contractors should avoid backflow and cross-connections. Contractors should follow appropriate protocols for representing the system. When needed, water system assets should be chlorine disinfected (i.e., minimum of 300 mg/l, for 3 hours) before return to service. Care is needed to safely handle and dispose of this superchlorinated water. This water can cause chemical burns and damage plants if not handled properly.

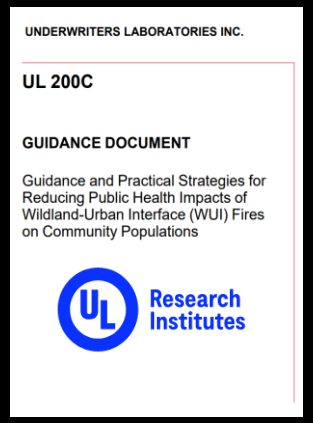
What Should the Water Be Tested For and Where?

Chemical water testing is NOT necessary at every water system location. Testing is recommended at representative locations where contamination is possible and a concern. Water should be screened for chemicals listed on www.PlumbingSafety.org.

Center for Plumbing Safety at Purdue University, West Lafayette, Indiana USA
Visit www.PlumbingSafety.org. PlumbingSafety@purdue.edu; Date Released: March 5, 2024

2023

Public health basics...


UNDERWRITERS LABORATORIES INC.

UL 200C

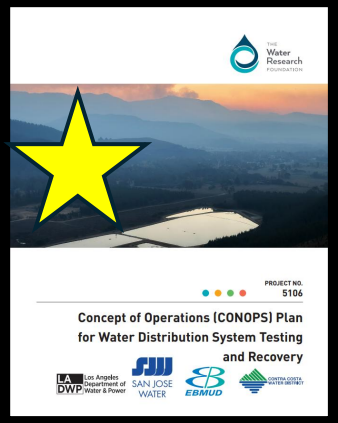
GUIDANCE DOCUMENT

Guidance and Practical Strategies for Reducing Public Health Impacts of Wildland-Urban Interface (WUI) Fires on Community Populations

UL Research Institutes

2024

Post-fire utility and health decisions


The Water Research Foundation

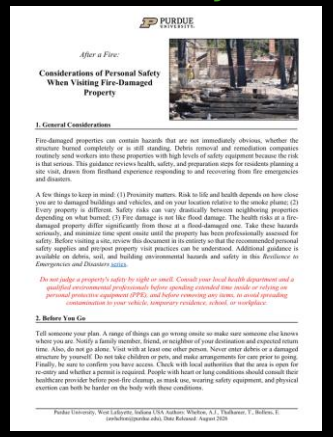
PROJECT NO. 5106

Concept of Operations (CONOPS) Plan for Water Distribution System Testing and Recovery

Los Angeles Department of Water & Power · SAN JOSE WATER · EBMUD · CONTRA COSTA WATER DISTRICT

2024

Visiting properties safely


PURDUE UNIVERSITY

After a Fire:

Considerations of Personal Safety When Visiting Fire-Damaged Property

1. General Considerations

Fire-damaged properties can contain hazards that are not immediately obvious, whether the structure burned completely or is still standing. Debris removal and remediation companies routinely send workers into these properties with high levels of safety equipment because the risk is that serious. This guidance reviews health, safety, and preparation steps for residents planning a site visit, drawn from firsthand experience responding to and recovering from fire emergencies and disasters.

A few things to keep in mind: (1) Proximity matters. Risk to life and health depends on how close you are to damaged buildings and vehicles, and on your location relative to the smoke plume; (2) Every property is different. Safety risks can vary drastically between neighboring properties depending on what burned; (3) Fire damage is not like flood damage. The health risks at a fire-damaged property differ significantly from those at a flood-damaged one. Take these hazards seriously, and minimize time spent onsite until the property has been professionally assessed for safety. Before visiting a site, review this document in its entirety so that the recommended personal safety equipment and pre/post procedures can be understood. Additional guidance is available on debris, soil, and building environmental hazards and safety in this Resilience to Emergencies and Disasters series.

Do not judge a property's safety by sight or smell. Consult your local health department and a qualified environmental professionals before spending extended time inside or relying on personal protective equipment (PPE), and before removing any items, to avoid spreading contamination to your vehicle, temporary residence, school, or workplace.

2. Before You Go

Tell someone your plan. A range of things can go wrong onsite so make sure someone else knows where you are. Notify a family member, friend, or neighbor of your destination and expected return time. Also, do not go alone. Visit with at least one other person. Never enter debris or a damaged structure by yourself. Do not take children or pets, and make arrangements for care prior to going. Finally, be sure to confirm you have access. Check with local authorities that the area is open for re-entry and whether a permit is required. People with heart or lung conditions should consult their healthcare provider before post-fire cleanup, as mask use, wearing safety equipment, and physical exertion can both be harder on the body with these conditions.

Purdue University, West Lafayette, Indiana USA. Authors: Whelton, A.J., Thalhamer, T., Bellens, E. (awhelton@purdue.edu); Date Released: August 2026

2026

Debris removal and soil restoration


PURDUE UNIVERSITY

After a Fire:

Considerations for Residential Property Soil Testing and Restoration

1. Damage and Soil Contamination Caused by Fires

Fires can leave hazardous chemical residues in soil around burned structures and vehicles, posing an immediate and long-term health risk to property users. When structures, vehicles, and personal items burn, they release and deposit toxic materials into the surrounding ash and soil. Common contaminants include asbestos, metals, and organic compounds such as polycyclic aromatic hydrocarbons (PAHs), dioxins, furans, and per- and poly-fluoroalkyl substances (PFAS/PFOS). Burned vehicles and battery storage systems (including lithium-ion batteries) are among the most hazardous materials, often containing elevated levels of lead, lithium, cobalt, nickel, and other metals. Not all contamination is visible; most metal and organic contamination cannot be seen.

Persons impacted by wildfire should seek advice from their local health department and qualified, board-licensed professionals (e.g., professional engineers or professional geologists). The property should not be entered without proper safety equipment.

2. Site Assessment and Debris Removal

Restoring soil to safe use on properties with destroyed structures is a phased process: (1) site assessment and removal of large hazardous waste and physical hazards (i.e., propane tanks, batteries, household hazardous waste, damaged vehicles, etc.), (2) general debris and hazardous ash removal, typically including excavation of 3 to 6 inches of soil beneath the ash, concrete slab, foundation, and (3) confirmatory soil sampling and analysis to confirm that health hazards have been removal. Properties are NOT safe for reentry or rebuilding after Phase 1 or after initial soil scraping alone. Confirmation sampling is required.

3. Who Should Conduct Soil Testing?

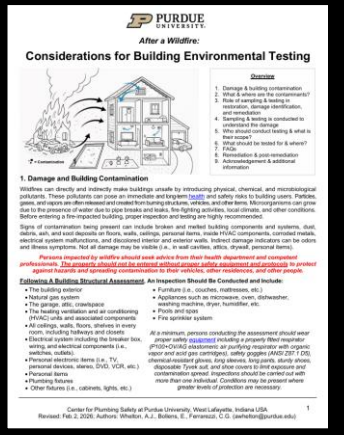
Property owners should retain qualified, board-licensed professionals such as professional engineers (P.E.) or professional geologists (P.G.) with relevant experience to design and conduct environmental sampling, following appropriate ASTM, U.S. EPA, and equivalent practices. Holding a general engineering, science, safety, or industrial hygiene credential does not qualify an individual for this work. Samples should be analyzed by a certified laboratory, preferably accredited under the National Environmental Laboratory Accreditation Program (NELAP). Local health departments or state environmental agencies (the Authority Having Jurisdiction, AHJ) should review and approve residential soil sampling plans. Properties should not be issued rebuild permits until proof of soil safety.

4. What Should Be Tested for and Where?

Soil sampling after debris removal is called "confirmation sampling." This confirms remaining soil does not pose a health risk. Analytical results determine whether additional excavation is required before a property can be cleared for rebuilding. The property (building/vehicle footprint plus a buffer) is divided into "decision units (DUs)." For smaller or irregular footprints (100 to 1,000 ft²), the five-point "DUU" model is used. This involves collecting five samples per DU that

2026

Home environmental testing...


PURDUE UNIVERSITY

After a Wildfire:

Considerations for Building Environmental Testing

Overview

1. Damage & building contamination
2. What & where are the contaminants?
3. Role of sampling & testing in restoration, damage identification, and remediation
4. Sampling & testing is conducted to understand the damage
5. Who should conduct testing & what is their scope?
6. What should be tested for & where?
7. FAQs
8. Remediation & post-remediation
9. Acknowledgement & additional information

1. Damage and Building Contamination

Wildfires can directly and indirectly make buildings unsafe by introducing physical, chemical, and microbiological pollutants. These pollutants can pose an immediate and long-term health and safety risks to building users. Particles, gases, and vapors are often released and created from burning structures, vehicles, and other items. Microorganisms can grow due to the presence of water due to pipe breaks and leaks, fire-fighting activities, local climate, and other conditions. Before entering a fire-impacted building, proper inspection and testing are highly recommended.

Signs of contamination being present can include broken and melted building components and systems, dust, debris, ash, and soot deposits on floors, walls, ceilings, personal items, inside HVAC components, corroded metals, electrical system malfunctions, and discolored interior and exterior walls. Indirect damage indicators can be odors and illness symptoms. Not all damage may be visible (i.e., in wall cavities, attics, HVAC components, personal items).

Persons impacted by wildfire should seek advice from their health department and competent professionals. The property should not be entered without proper safety equipment and protocols to protect against hazards and spreading contamination to their vehicles, other residences, and other people.

Following A Building Structural Assessment, An Inspection Should Be Conducted and Include:

- The building exterior
- Natural gas system
- The garage, attic, crawlspace
- The heating ventilation and air conditioning (HVAC) units and associated components
- All ceilings, walls, floors, shelves in every room, including hallways and closets
- Electrical system including the breaker box, wiring, and electrical components (i.e., switches, outlets)
- Personal electronic items (i.e., TV, personal devices, stereo, DVD, VCR, etc.)
- Personal items
- Plumbing fixtures
- Other fixtures (i.e., cabinets, lights, etc.)
- Furniture (i.e., couches, mattresses, etc.)
- Appliances such as microwave, oven, dishwasher, washing machine, dryer, humidifier, etc.
- Pools and spas
- Fire sprinkler system

At a minimum, persons conducting the assessment should wear proper safety equipment including a properly fitted respirator (P100+OV/AG elastomeric air purifying respirator with organic vapor and acid gas cartridges), safety goggles (ANSI Z87.1 D8), chemical-resistant gloves, long sleeves, long pants, sturdy shoes, disposable Tyvek suit, and shoe covers to limit exposure and contamination spread. Inspections should be carried out with more than one individual. Conditions may be present where greater levels of protection are necessary.

Center for Plumbing Safety at Purdue University, West Lafayette, Indiana USA.
Revised: Feb 2, 2026. Authors: Whelton, A.J., Bellens, E., Ferrarezi, C.G. (awhelton@purdue.edu)

2026

PURDUE UNIVERSITY



Evidence-based decisions for public safety & public health

DONE, AVAILABLE NOW

- ✓ Public drinking water systems (CONOPS!)
- ✓ Safely visiting properties with destroyed structures
- ✓ Private wells
- ✓ Ag water systems
- ✓ Building plumbing water
- ✓ Residential fire debris removal and soil restoration
- ✓ Indoor environmental testing

IN THE WORKS

- Swimming pool testing and restoration
- Septic systems
- Gardens
- Agriculture
- Stormwater
- Electric vehicles
- Commercial fire debris and soil
- And more…

More coming: eight efforts to improve post-fire recovery

HEART

Safely restoring homes after a fire

ASHES

Returning property soil to pre-fire condition

REBUILD

Survey of household needs: housing, testing, insurance

Fire Pools

Restoring impacted swimming pools

CRIBS

Handling baby products exposed to VOC-contaminated water

MITIGATE

Reducing impacts and speeding recovery for water utilities

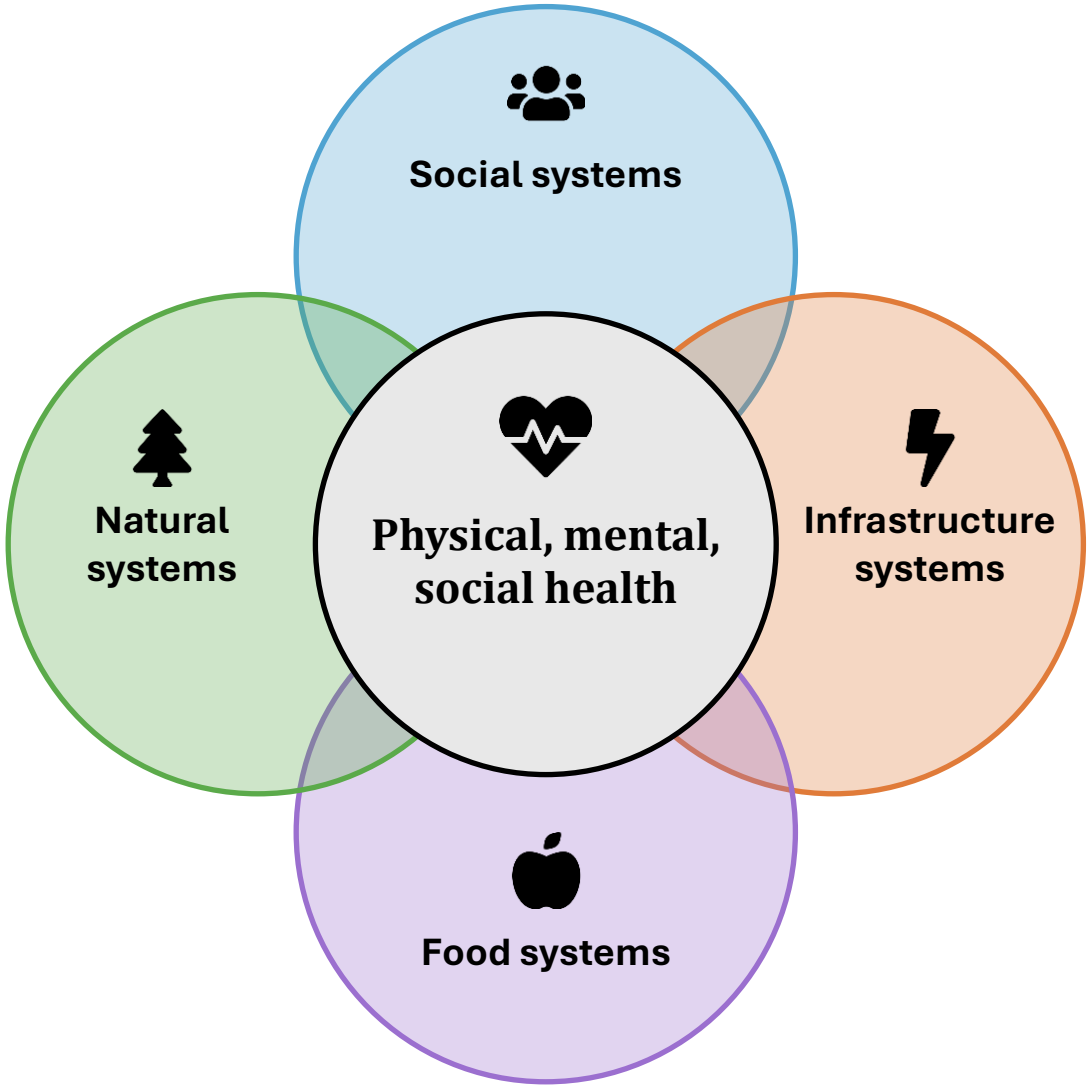
- Electric vehicle burns and ash toxicity
- Structure fire burns and water system contamination

HARVEST

Fruit and garden safety after fires

FIRE-NET: Science and Solutions for Post-Fire Building Contamination
Research gaps, remediation challenges, opportunities for innovation, and pathways to better recovery

Collaborators and partners Community groups | Property owners | Parents | Water utilities | Universities | Companies | Foundations

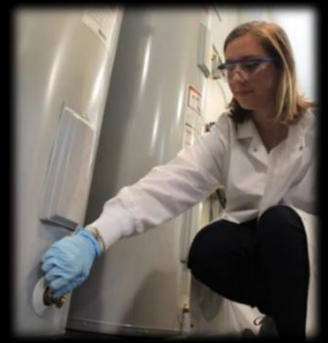


Recovery touches every system

This all started in California.

Santa Rosa, Butte County, PID, and the people affected wanted to transform how other communities recover.

Questions?



Wildfire response and recovery resources page
www.PlumbingSafety.org
(new redirect site coming soon)

University Courses:

- **Disasters & Emergencies**
- **Water & Infrastructure Resilience: Public Health & Extreme Events**



- ✓ Brief videos for emergency managers and health officials
- ✓ Guidance for public health, public works, and property owners
- ✓ Links to freely available studies themselves
- ✓ FEMA mitigation guidance
- ✓ Other training resources

Support from…

The Spanicciati Family
Lightbox
Rotary Club of Paradise, California
NSF
United States Environmental Protection Agency
The Water Research Foundation
R&S KAYNE FOUNDATION
Private donors
Andrew Whelton's Wallet

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