

# Public health lessons from drinking water contamination disasters of utility and plumbing: Chemical spills, wildfires, and more

November 2022

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*Purdue University*

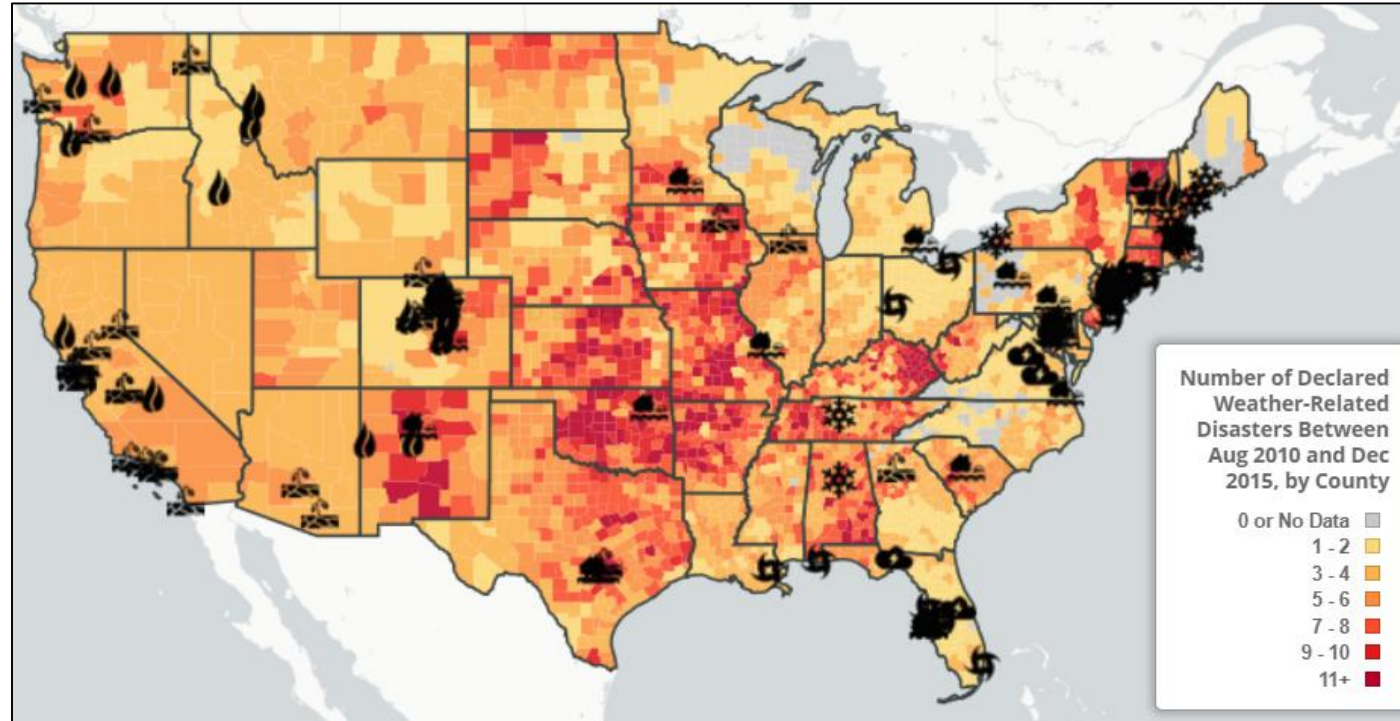


Club of  
Paradise,  
California





# *Safe drinking water and infrastructure are critical to the health, safety, and economic security*



Floods, Hurricanes  
Tropical Storms,  
Tornadoes, Snow, Ice,  
And Wildfires

1,000s of communities  
each year are affected  
prompting drinking water  
safety risks

## **Wildland Urban Interface (WUI)**

Human development intermingles with vegetative and wildland fuels  
Fastest growing land use  
46M+ residences in 70,000 communities

# Contaminants

Organic chemicals  
Inorganic chemicals  
Radionuclides  
Microorganisms

## A Few Examples

2021 (Marshall wildfire) Boulder Co., CO, Pop: 40,000

2021 (Chem spill) Pearl Harbor, HI, Pop: 93,000

2021 (Petroleum backflow) San Angelo, TX, Pop: 101,000

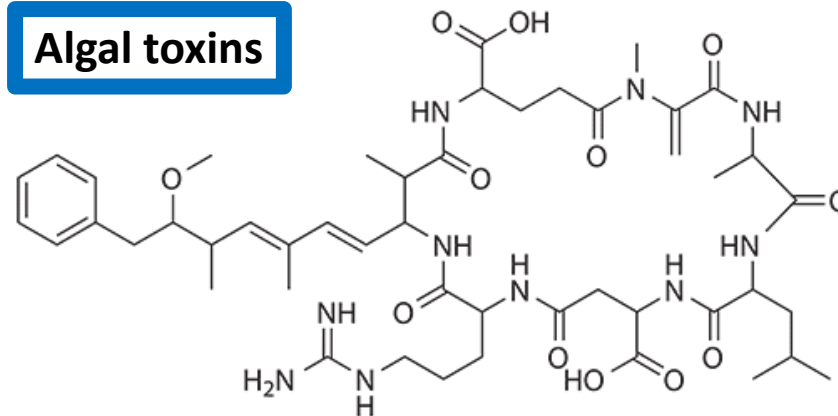
2020 (Naegleria fowleri), Lake Jackson, TX, Pop: 172,000

2018 (Microcystins) Salem, OR, Pop: 199,000

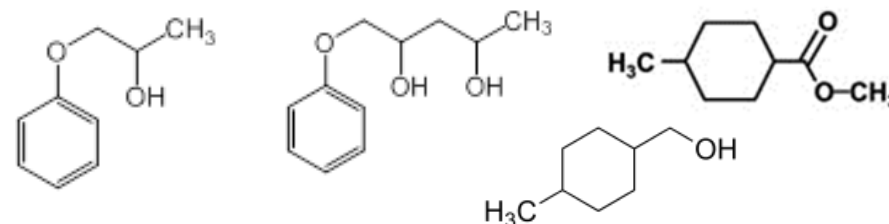
2017 (E. Coli), Puerto Rico, Pop: 100,000

2013 (Naegleria fowleri) St. Bernard, LA, Pop: 44,000

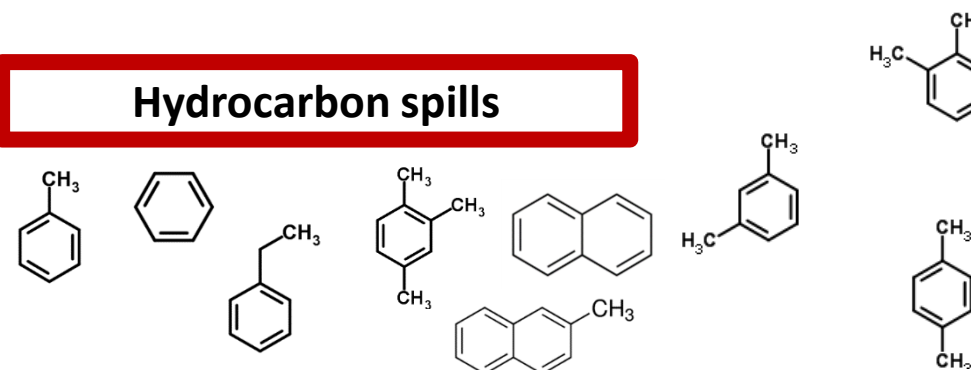
### Algal toxins



### Coal flotation liquid



### Hydrocarbon spills



<b>Max. Benzene</b>	<b>Wildfire Event / Location</b>	<b>Pop. Affected</b>	<b>System Name</b>	<b>Year</b>
221	Marshall Fire/ Colorado	20,319	City of Louisville	2021
5.1	Marshall Fire/ Colorado	300	East Boulder County Water District	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
1.8	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
38.3	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

Location	Year	Cause	Contaminant	Plumbing system decon method	Population affected	Health impacts	Duration, days
Nibley City, UT <sup>45</sup>	15	Truck spill	Diesel fuel	Flushing	5000	nr	1
Glendive, MT <sup>46</sup>	15	Pipe rupture, spill	Crude oil	Flushing	6000	Yes	5
Longueuil, QC, CN	15	Tank rupture, spill	Diesel fuel	None	230 000	No	2
Washington, D.C. <sup>47</sup>	14	Unknown	Petroleum product	Flushing	Est. 370	nr	3
Toledo, OH <sup>48</sup>	14	Algal bloom	Microcystins <sup>c</sup>	Flushing	500 000	No	2
Charleston, WV <sup>1</sup>	14	Tank rupture, spill	Coal chemical	Flushing	300 000	Yes	9 <sup>b</sup>
Jackson, WI <sup>49</sup>	12	Pipe rupture, spill	Petroleum product	nr	50	nr	30
Safed, Israel <sup>38</sup>	10	DS backflow	Diesel fuel	Flushing; surfactant	3000	nr	3
Boise, ID <sup>50</sup>	05	Unknown	TCE	Flushing	117	nr	nr
Stratford, ON, CN <sup>51</sup>	05	DS backflow	2-Butoxyethanol	Flushing	32 000	Yes	Up to 7
Northeast Italy <sup>52</sup>	02	New pipe install	Cutting oil	Flushing	4 bldgs	nr	Months
Guelph, CN <sup>53</sup>	97	DS backflow	Petroleum product	nr	48 000	nr	3
Charlotte, NC <sup>36</sup>	97	DS backflow	Fire suppressant (AFFF) <sup>d</sup>	Flushing	29 bldgs	No	nr
Tucumcari, NM <sup>32,54</sup>	95	DS backflow	Toluene, phenol, <i>etc.</i> <sup>a</sup>	Flushing	nr	Yes	nr
Uintah Highlands, UT <sup>32</sup>	91	DS backflow	TriMec; 2,4-D; dicamba	nr	2000 homes	Yes	nr
Hawthorne, NJ <sup>36</sup>	87	DS backflow	Heptachlor	Cl <sub>2</sub> flush; replacement	63	No	nr
Gridley, KS <sup>54</sup>	87	DS backflow	Lexon DF	nr	10 homes, 1 business	nr	nr
Hope Mills, NC <sup>36</sup>	86	DS backflow	Heptachlor, chlordane	Flushing	23 homes	No	3
Pittsburgh, PA <sup>54</sup>	81	DS backflow	Heptachlor, chlordane	Flushing; replacement	300 (23 bldgs)	No	27
Lindale, Georgia <sup>55</sup>	80	DS construction	Phenolic compounds	Super-chlorination	Hospital	Yes	nr
Montgomery Cnty, PA <sup>35</sup>	79	Tank rupture, spill	TCE	nr	500	Yes	nr

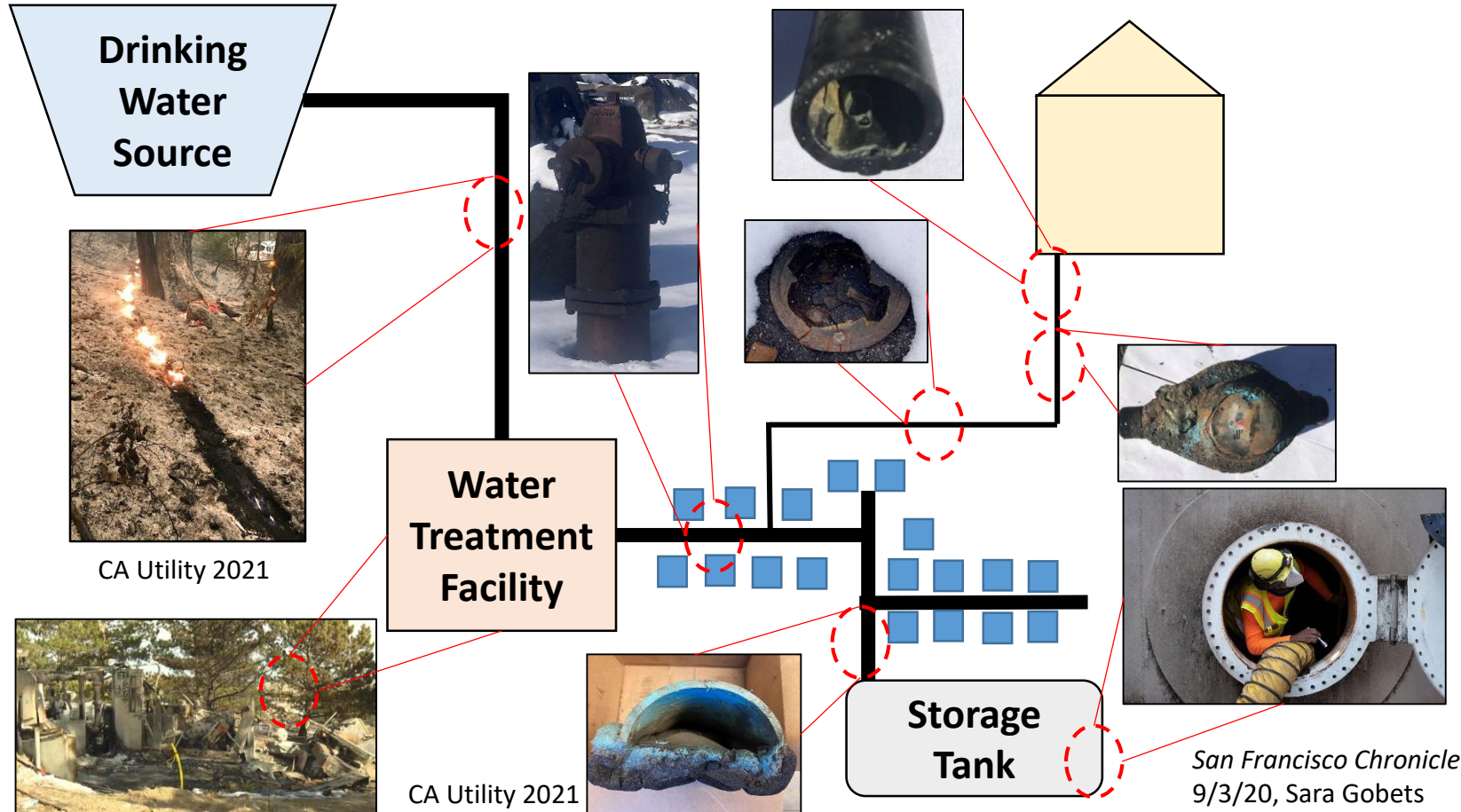
Casteloes et al. 2015. Decontaminating chemically contaminated residential premise plumbing systems by flushing. <https://doi.org/10.1039/C5EW00118H>.





USGS 2009

# *Public and private drinking water systems are vulnerable to contamination*

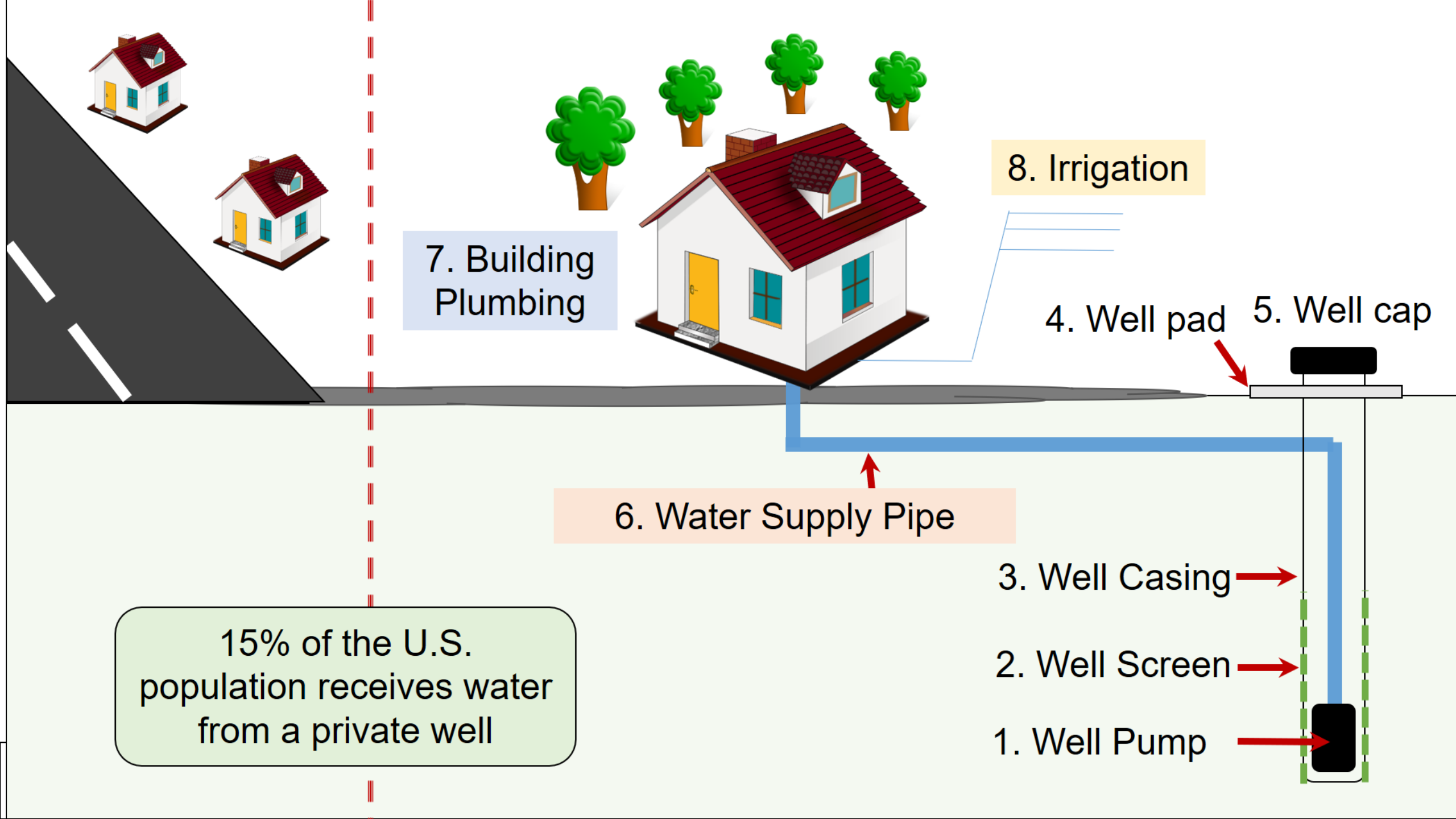


## Assets

Water source  
Treatment  
Distribution  
Plumbing

## Damage

Loss of water pressure  
Water contamination  
Infrastructure contam.  
Plumbing contam.









# Water Systems Face Multiple Challenges During Response

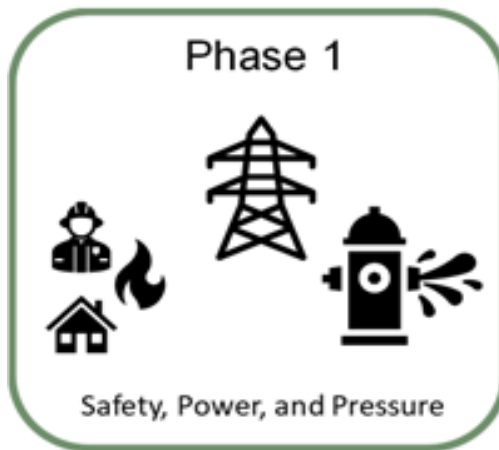
**Pressure, utility network and building plumbing:** Leaking, destruction

**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

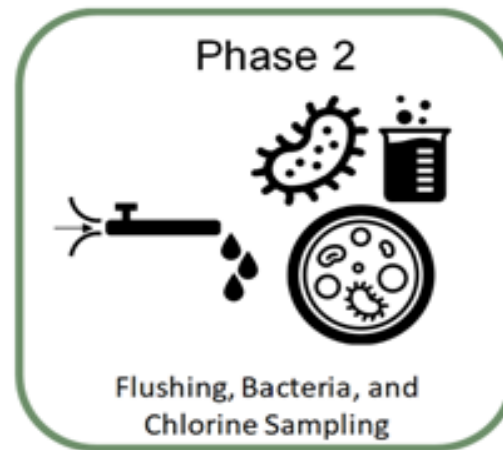
**Personnel:** Hazard situations, unable to respond due to staff availability

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

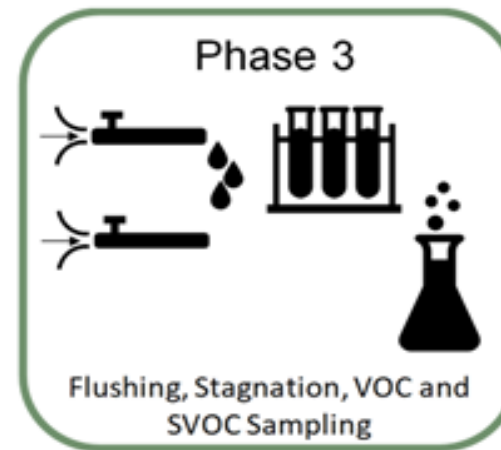


Support firefighting  
Isolate damage  
Maintain pressure

**Water use warnings**



Personnel surge  
Restore control, pressure  
Repeated sampling  
Laboratories



Personnel surge  
Repeated sampling  
Laboratories  
Decon, remove, replace

**Resilience:**  
*The ability to  
bounce back  
from misfortune  
or change*

## Exposure Routes

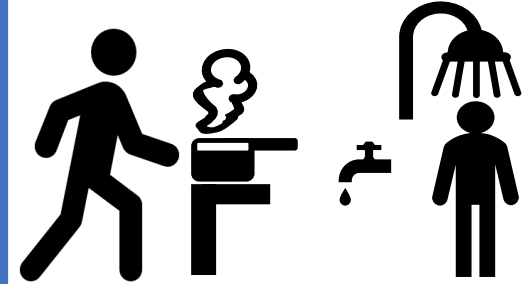
(i.e., Adults, children, infants, etc.)



Ingestion

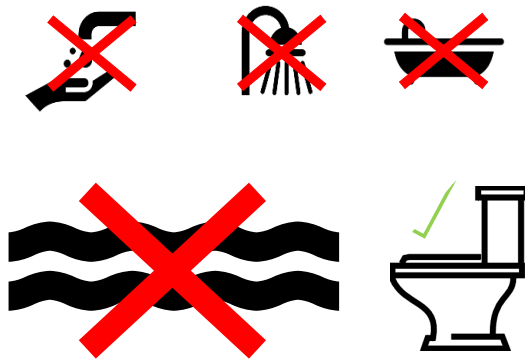


Dermal contact



Inhalation

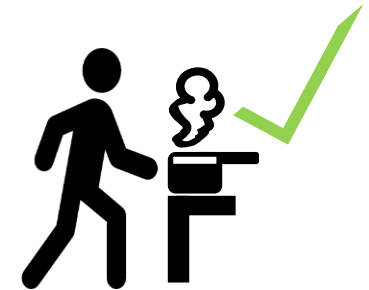
## Water Use Warnings



Do Not Use (DNU)



Do Not Drink (DND)



Boil Water Order

*If you do not know the range of contamination, it is not advisable to use in-home water treatment devices. Those are NOT rated to make acutely contaminated water safe.*



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

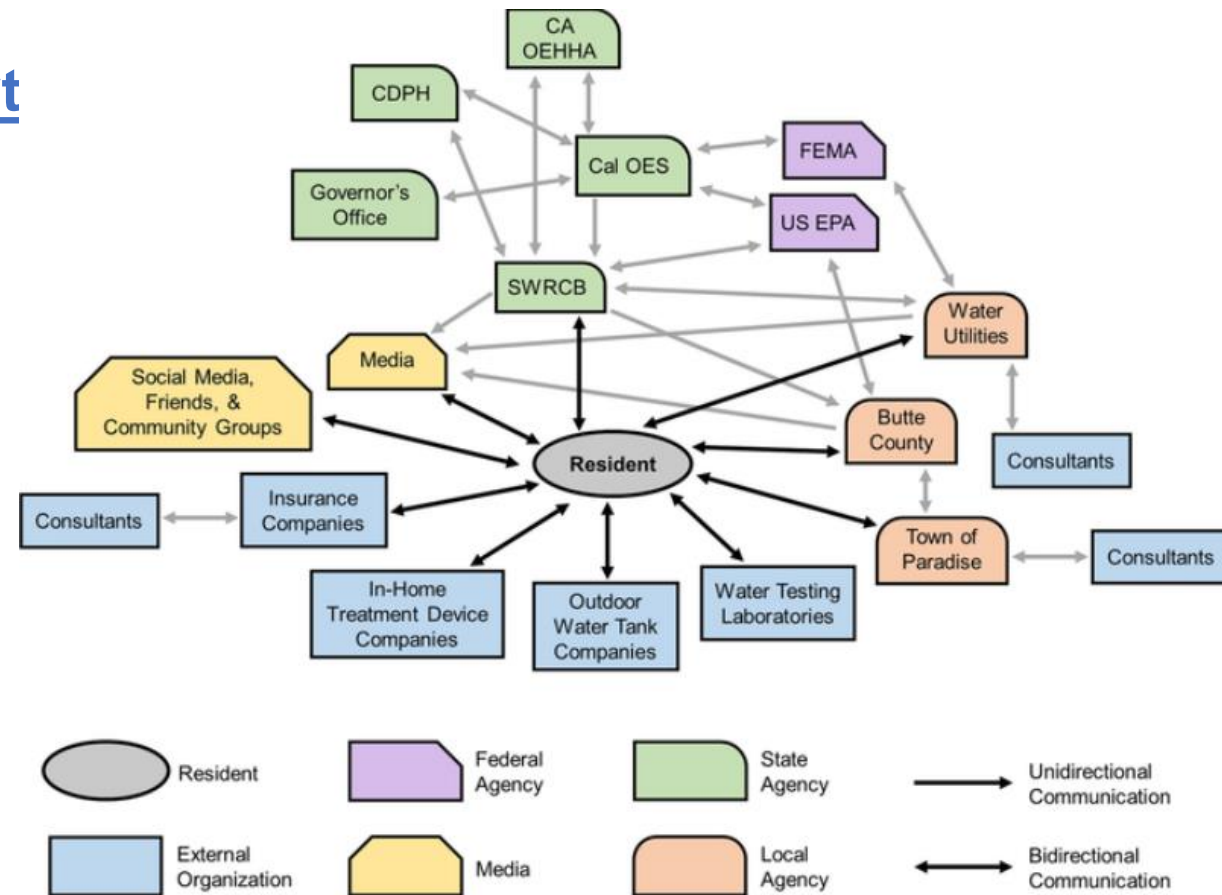
***Natural Hazards, Published May 2021***

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

## Household Public Health Support Not (yet) Based on Science

- 1) Water use restrictions
- 2) Plumbing sampling and testing
- 3) Plumbing decon and validation
- 4) Water tank selection and maintenance
- 5) In-home treatment device selection and maintenance

### *Rural communities are especially impacted*



# 1 Example: A State primacy agency told a population they should use in-home activated carbon filters 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

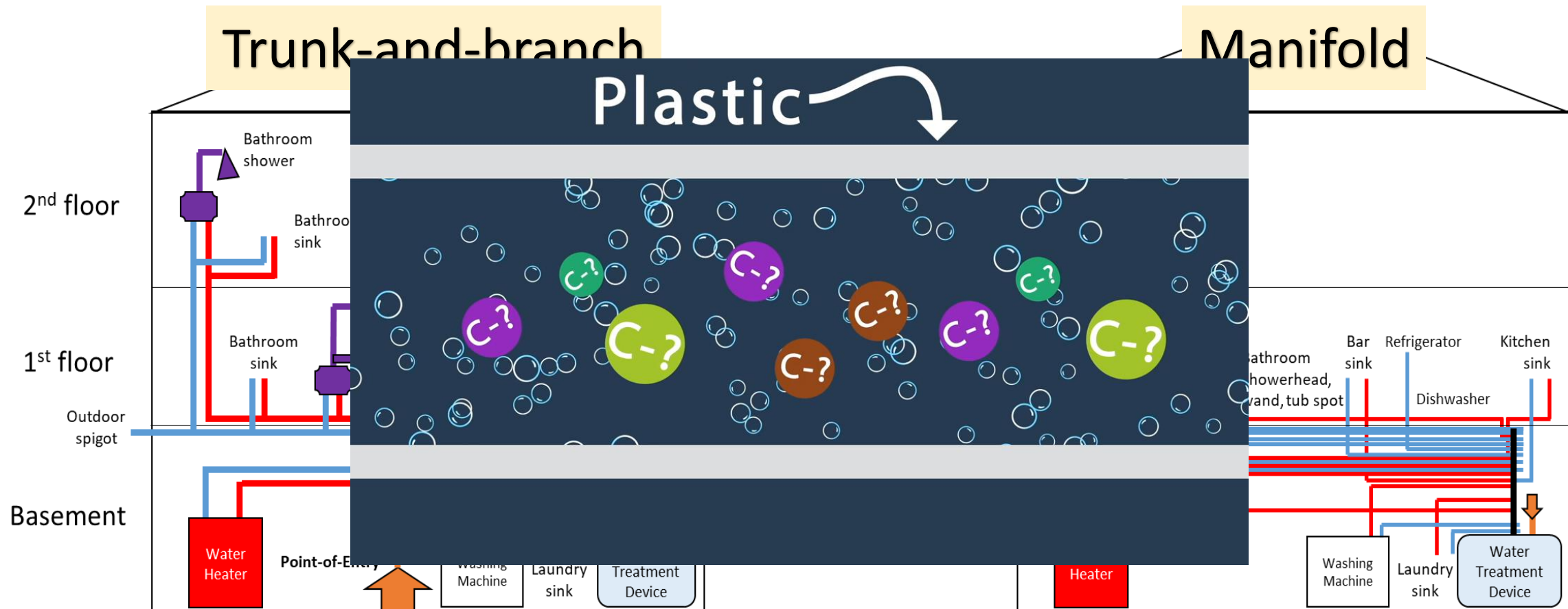


The devices are NOT designed for this.  
The range of contamination must be known + testing.

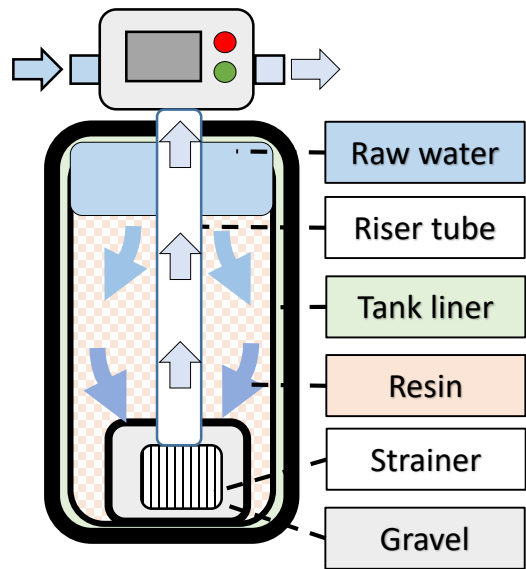
*In 2019, CA OEHHA concluded that short-term 26 ppb benzene exposure would prompt an increased risk of blood effects in children such as a decrease in lymphocytes and white blood cells; Benzene has a 5 ppb Federal MCL, 1 ppb CA MCL*



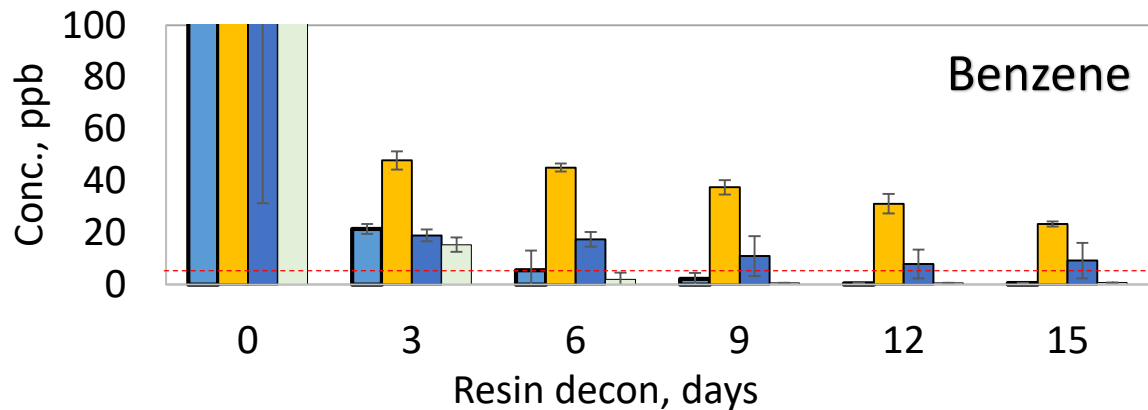
# Sampling buildings and decontamination activities needs to take into considerations the plumbing



# Hydrocarbon Contamination and Decontamination of Water Softeners



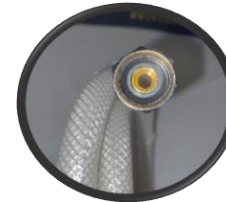
**Surface area**  
 Resin: 2,800,000+ cm<sup>2</sup>  
 Liner: 9,300 cm<sup>2</sup>  
 Gaskets: 32 cm<sup>2</sup>



## .... of Water Supply Connectors

*After the 2014 West Va. chemical spill, the Health Department recommended discarding tubing at restaurants*

Dishwasher connector – PVC



Multipurpose tubing – PVC



Softener connector – PVC



Faucet supply line – PVC



Ice-maker tubing – PE



Ice-maker tubing – PEX

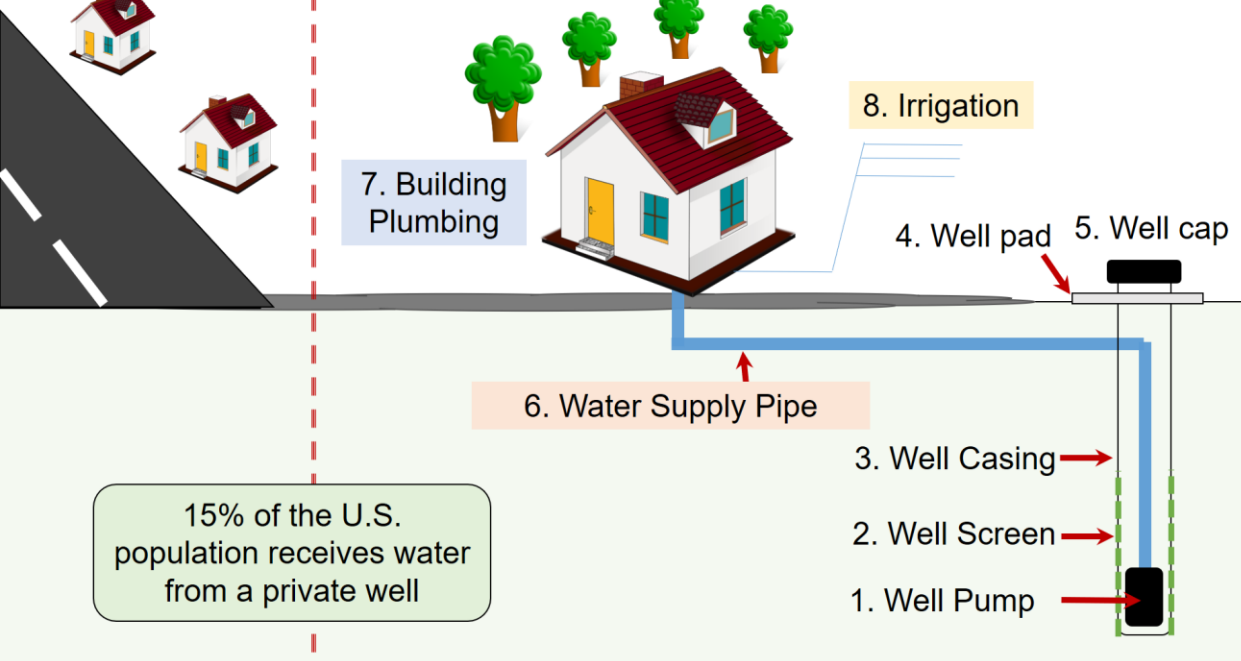


Washing machine hose – EPDM

All plastics sorbed 93-100% of the BTEX in 24 hr

9 of 11 materials still exceeded the benzene MCL after 9 days of decon





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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 to 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 tanks.
- 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 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](http://www.PlumbingSafety.org), [PlumbingSafety@purdue.edu](mailto: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 cleaned 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 to 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 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**

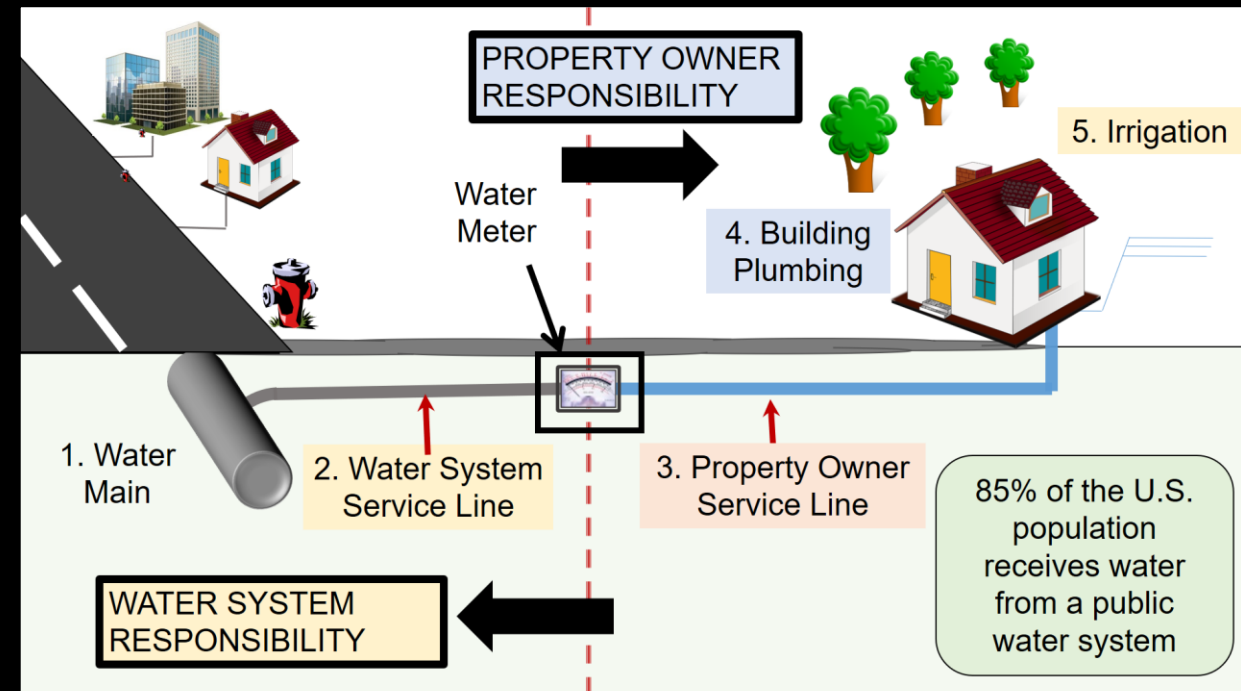
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Center for Plumbing Safety at Purdue University, West Lafayette, Indiana USA  
Visit [www.PlumbingSafety.org](http://www.PlumbingSafety.org), [PlumbingSafety@purdue.edu](mailto:PlumbingSafety@purdue.edu), Date Released: May 16, 2021

We created two 1 page inspection and water testing guidance sheets for private wells and building water systems

Access here → [\[Click\]](#)



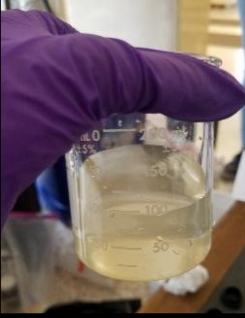
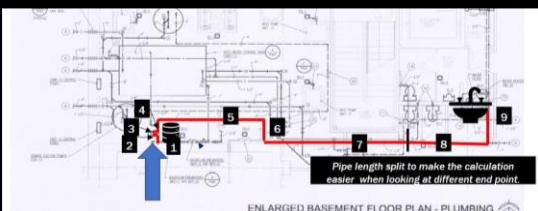
# Learn about 'Building Water Essentials' 10 Hour, Online Self-Paced Short-Course

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](mailto:awhelton@purdue.edu)  
Info and registration: <https://cutt.ly/Sg4RXJv>





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More Lessons Coming Soon  
[www.PlumbingSafety.org](http://www.PlumbingSafety.org)

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PURDUE / ENGINEERING / PLUMBING SAFETY / RESOURCES

### Resources

- Plumbing 101
- Flushing Plans
- Plumbing Demonstrations - Camp Fire
- Video / Audio
- Presentations / Reports
- Peer-Reviewed Publications
- Water Quality Risk Tools
- Hawaii Response
- Wildfire Response
- Survey - Camp Fire
- FAQs - General Plumbing
- FAQs - Camp Fire Response

## Response and Recovery to Wildfire Caused Drinking Water Contamination

Wildfires can damage buried drinking water systems as well as private drinking water wells and building plumbing, making them unsafe to use. Since 2017, a growing number of wildfires have prompted chemical drinking water contamination in the United States. Levels found in some water systems have exceeded hazardous waste limits and posed an immediate health risk. To help households and building owners understand key wildfire drinking water contamination public safety issues, resources were compiled below. These resources will also be of interest to public health officials, water providers, municipalities, emergency management, insurance companies, nonprofit agencies, elected officials, and consultants.

- Questions can be directed to Dr. Andrew Whelton at [awhelton@purdue.edu](mailto:awhelton@purdue.edu).

### Marshall Fire Homeowner Support

[Letter to Homeowners Affected by the Marshall Fire in Unincorporated Boulder County](#) (January 2022)

### Resources for Households, Private Well Owners, and Public Health Officials

Here is a list of chemicals to test for (as of May 2022) to find chemical contamination in wildfire impacted drinking water systems:

- [List of Chemicals in Wildfire Impacted Water Distribution Systems](#) [May 2022]

These 1 page information sheets provide households and public health officials considerations for water system, inspection, testing, and potential safe drinking water options when the plumbing is unsafe. These documents were developed based on firsthand experience investigating contamination after wildfire, building plumbing, sampling, decontamination, and advising local, county state, and federal agencies. Information in these documents is partly based on practices from several health departments who have responded to wildfire caused drinking water contamination disasters and also influenced by our firsthand experiences and testing.

- [After a Wildfire: Water Safety Considerations for Private Wells](#) [May 16, 2021, Prepared by the Center for Plumbing Safety]
- [After a Wildfire: Water Safety Considerations Inside Buildings](#) [May 16, 2021, Prepared by the Center for Plumbing Safety]
- Attention: Persons impacted by wildfire should seek specific advice from their local health department.**

### Resources for Emergency Management, Water Utility, Public Health, and Elected Officials

This video helps prepare officials for water system damage scenarios. Wildfires can damage water distribution system infrastructure both physically –and– chemically. Some damage may not be visible. Hazardous waste scale drinking water chemical contamination can be caused. This presentation does not cover all situations, but instead provides an introduction for the viewer. More information and help can be obtained by contacting the Center for Plumbing Safety.



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

Additional Slides

## Well testing after the Marshall Fire: *Evidence is lacking to inform decision making*

No published data

**20** different U.S. guidance documents: AK, AZ, CA, CO, KS, MN, NM, MT, OR, WA, CDC, and 2 universities (CO, IN)

- ✓ *Microorganisms (20)*
- ✓ *Nitrate (8), Heavy metals (6)*
- ✓ *VOC: 9 (most said BTEX only)*
- ✓ *SVOC: 4 (some said PAH only)*

Guidance also varied across Canadian agencies

*To address this gap, we helped Boulder County and CDPHE after the 2021 Marshall Fire... but more to be done.*







**Plastic** water system materials can be primary and secondary sources of hazardous waste scale drinking water contamination, sometimes requiring weeks to months to decontaminate.

[Proctor et al.](#); [Hauptert and Magnuson](#); [Isaacson et al.](#); [Draper et al.](#)

