Preliminary Results: Response of Large Water Utilities to the Marshall Fire and Scientific Needs

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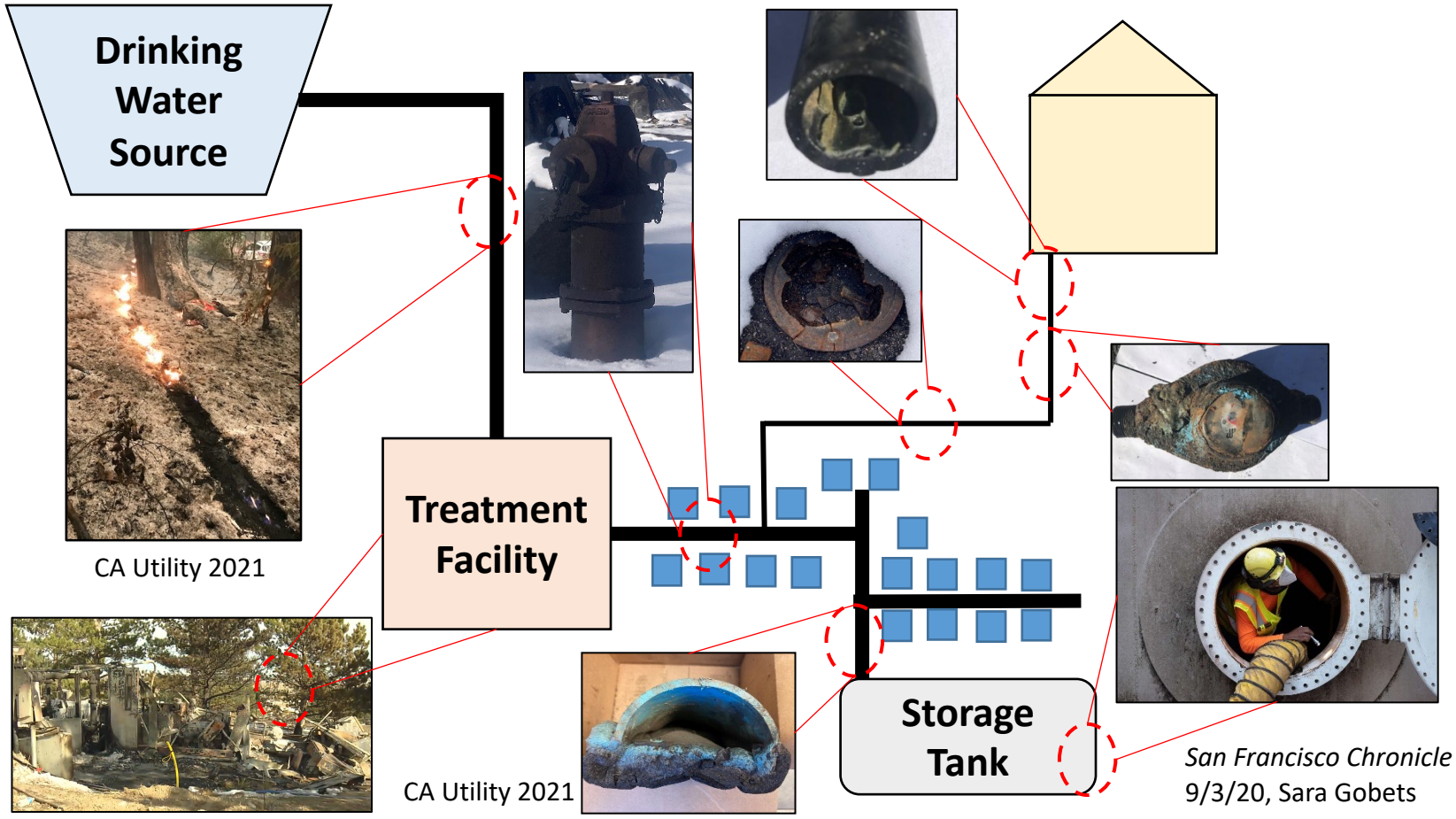
USGS 2009

Public water systems (PWS) supply ≥ 25 of the same people ≥6 months per year, and their assets are vulnerable to fire.



CA Utility 2021

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San Francisco Chronicle 9/3/20, Sara Gobets

Since 2017, fires have chemically contaminated ***at least 11*** California and Oregon *water distribution systems*

Proctor et al. 2020
https://doi.org/10.1002/aws2.1183
Odimayomi et al. 2021
https://doi.org/10.1007/s11069-021-04714-9

Contamination Sources

- Plastic degradation
- Building combustion
- Biomass combustion

The Large Water Utility Case Study

Parameter	2021 U.S.	2021 Marshall Fire	2018 Camp Fire
Median income	$62,843	$127,292	$51,566
Mean home value	$217,500	$576,800	$49,000
B.S. degree+	32.1%	76.3%	26.0%

Goal

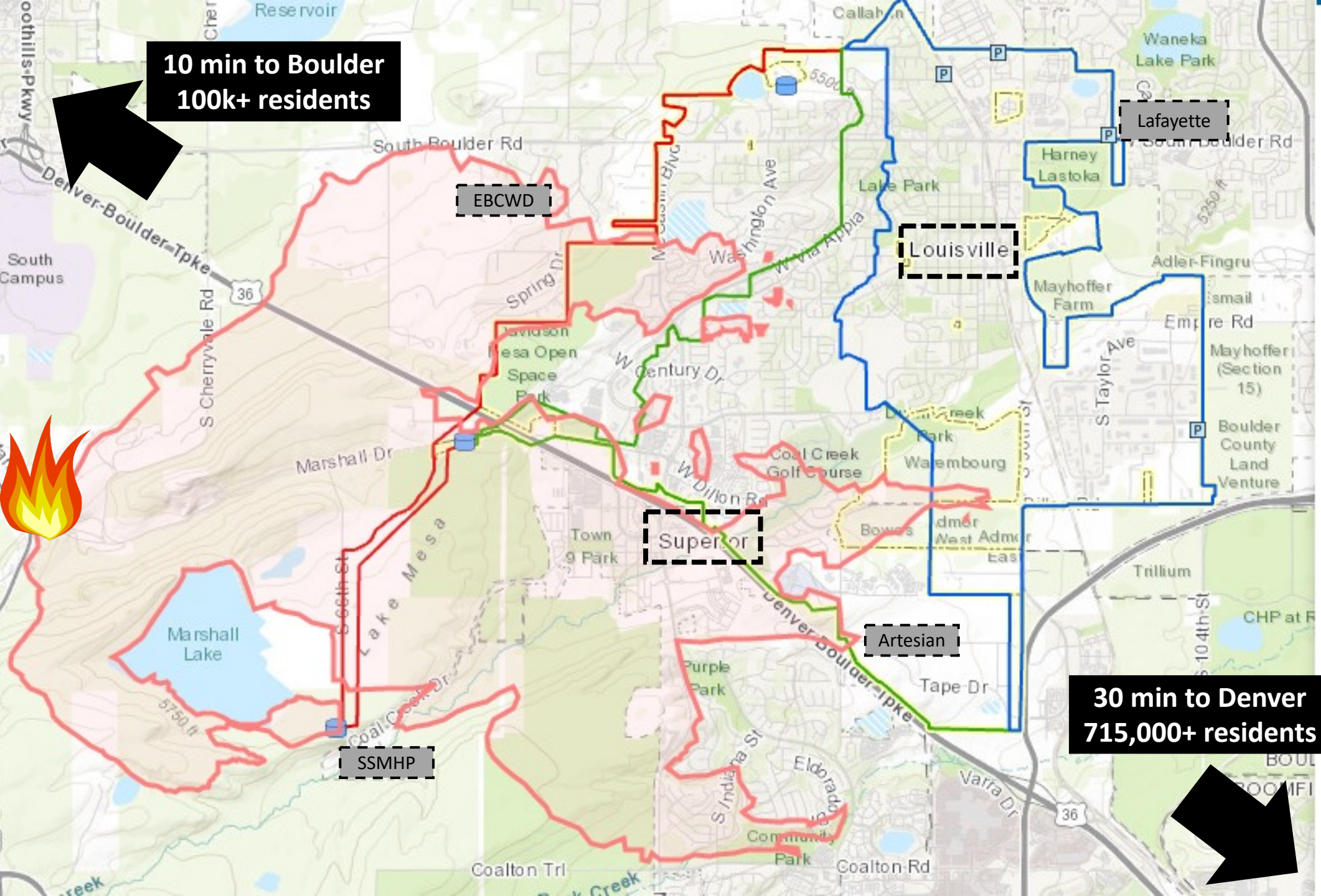
Identify key limitations during the drinking water contamination incidents as they pertained to decisions, resources, and expertise

Objectives

1. Summarize the response of the public water systems impacted
2. Describe the difficulties faced including resources, staffing, perceived or actual health risks encountered
3. Identify future policy and research needs that can better limit system vulnerability and prepare communities for response and recovery

Audience

Water, public health, and government sectors for improving their decision-making processes during incident response and recovery


10 min to Boulder
100k+ residents
EBCWD
Louisville
Lafayette
Superior
Artesian
SSMHP
30 min to Denver
715,000+ residents
Wildfire Perimeter
Wildfire Perimeter Fill
Water Layers
Pump Station
Water Tank
Water Pressure Zone
High
Medium
Low
City Boundary
City Limit

6 Public water systems were damaged affecting about 60,000 people

Public Water System (population)	Damaged/ Destroyed Properties	Water Mains, miles	Hydrants	Finished Water Storage, MG	Raw Water
Louisville (20,319)	593 of 7,339	120	1,200	7.5	Surface water
Superior (17,170)	436 of tbd	50	430	3.4	Surface water
Lafayette (28,700)	22 of 9,700	177	900	14	Surface water
EBCWD (300)	72 of 137	8	40	0.1	Lafayette
Eldorado Artesian Spring (259)	tbd	tbd	tbd	tbd	2 Wells, 1 Spring
S.S. Mobile Home Park (150)	3 of 61, wind	<1	None	None	1 Well

Louisville: VOC contamination confirmed (benzene 221 ppb + others), decon underway

Superior: Smokey – ash tray drinking water odor, no VOC contamination so far, testing underway

Lafayette: Testing underway (1 month stagnation, then sampled)

EBCWD: Paint thinner water odor, VOC contamination confirmed (benzene 5.1 ppb + others), decon underway

Number of leaks increasing

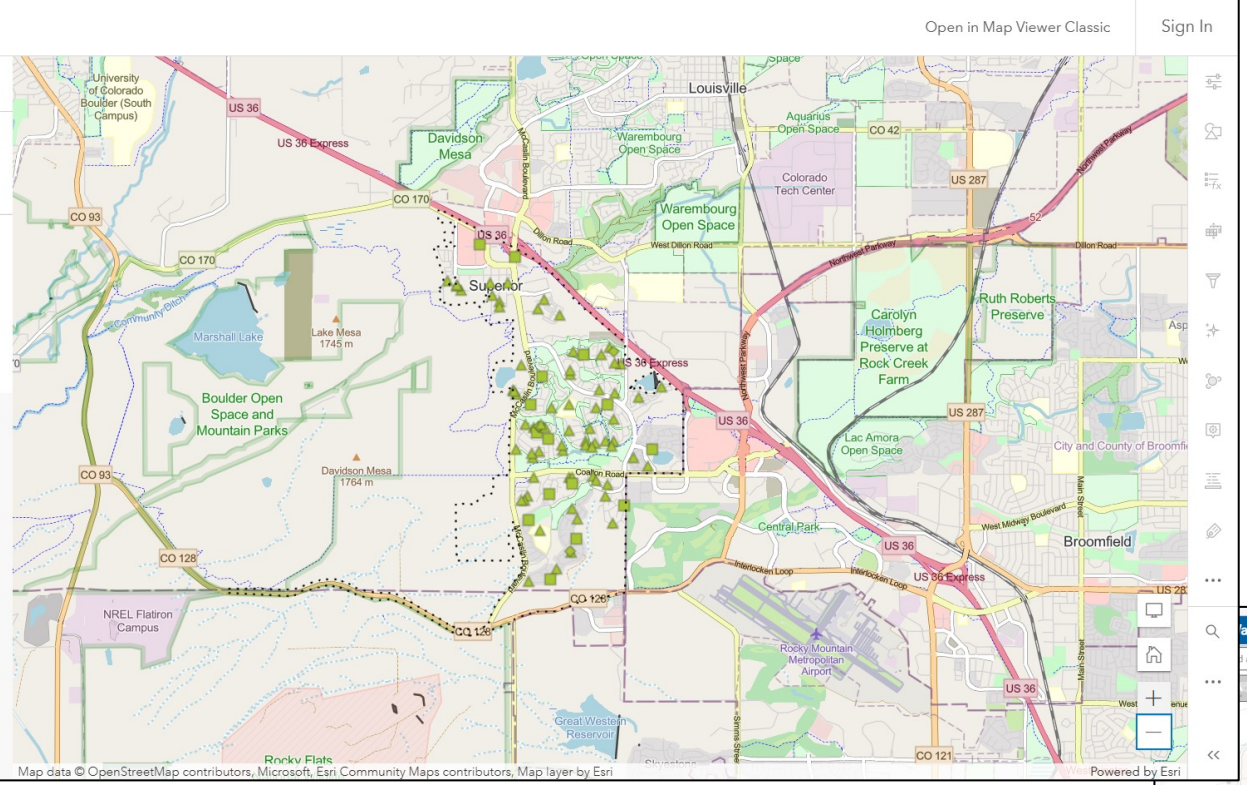
Dec 30	11 am	**Fire detected:** 70 mph sustained, 100 mph gusts
	11-12	Fire in Superior
	12	Evac order for 35,000+ in Boulder County
	12-1 pm	Fire enters Louisville treatment plant property, power loss
	4-8	Superior unable to produce water (no natural gas power, generator destroyed)
	4	Louisville provides water to Superior with interconnect
	5	Fire reaches 1,600 acres
	6-7	**Widespread pressure loss imminent,** Louisville shuts interconnect, sends untreated lake water into the water distribution system
	9	Lafayette sending water hydrant-to-hydrant by hose to Louisville
	10	Xcel Energy drove into firezone to feed natural gas and restart Louisville treatment plant
	Evening	CDPHE issues boil water advisories for 5 water systems
Dec 31	12-5am	Staff shutoff water to properties and areas. Used pipe network maps predownloaded to phones and tablets for navigation.
	10 am	Fire at 6,021 acres
	Evening	Snowfall and fire containment
	Evening	Building plumbing pipes froze, broke, and leak
Next…	All day	Reached out to CDPHE, the community, CU Boulder, Purdue, and Oregon State for help. Repressurize, flushing, bacteria and chlorine testing; VOC and SVOC testing…

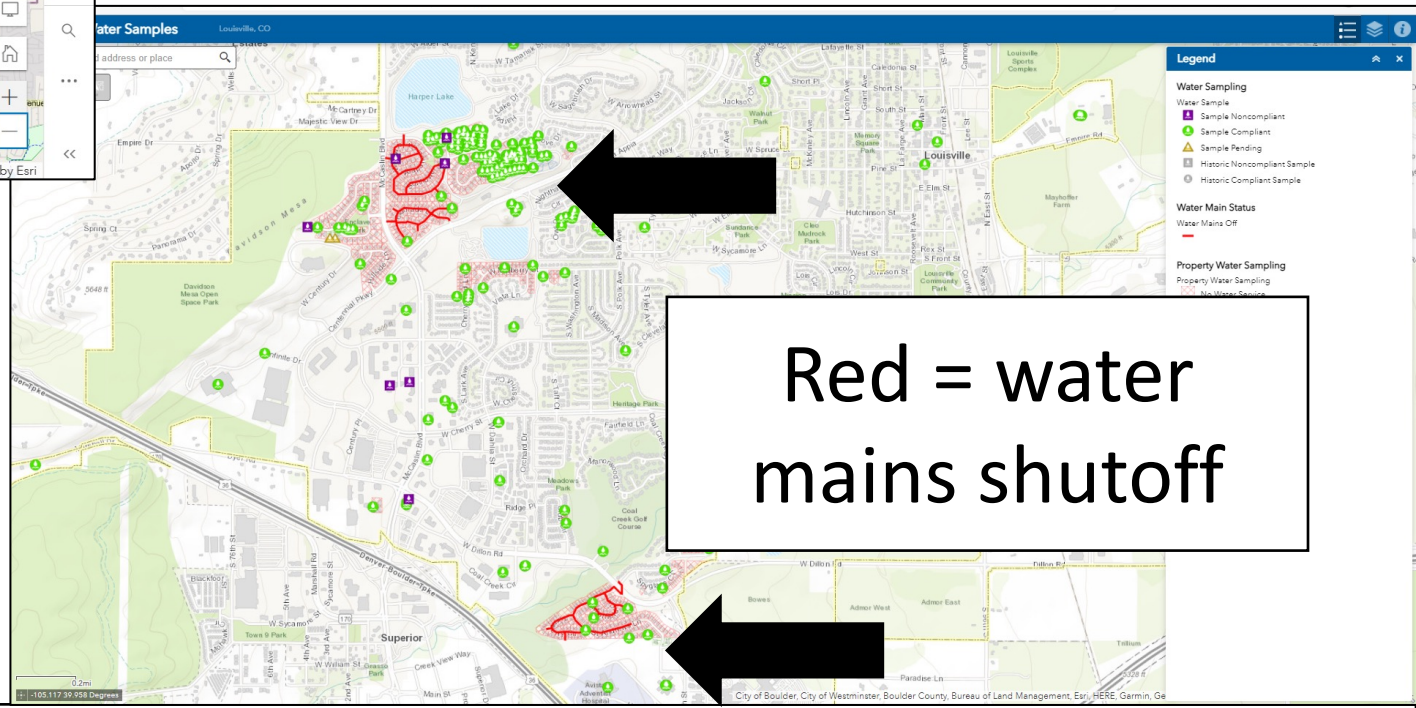
Internal leadership, exceptional staff, and requests for aide helped Louisville and Superior utilities stabilize

Relationships between neighboring towns helped in asking for help during and after the fire.

Boulder, Ft. Collins, Erie, Westminster, South Adams County, Broomfield, Longmont, more…

Technology was very important to Louisville and Superior in finding valves, isolating systems, flushing, and identifying sampling locations to restore service





Red = water mains shutoff

Each moving at a different pace with different challenges

1st focus: Bacteria and chlorine

Next: Fire caused VOCs

And then: Fire caused SVOCs

Chemical contamination found above safe drinking water exposure limits in isolated, shutoff sections of Louisville

Sample → Flush → Sample → Stagnate 72 hr → Sample → Repeat

Chemical	Max	>Limit?	Odor?
Benzene	**221**	**Y**	
Toluene	511		**Y**
Ethylbenzene	160		**Y**
Xylenes	5		
Styrene	**1,900**	**Y**	**Y**
Naphthalene	11		**Y**
Acrolein	24		**Y**

3 different EPA Methods (524.2, 524.4, and 8260C) and >4 laboratories used

Locations with VOC exceedances were not returned to service until results were below health limits

Majority of samples had no detections

Others: 1,1-DCP, 1,2,4-TMB, 1,2-Dichloroethane, 4-Chlorotoluene, Acetone, Acetonitrile, Acrylonitrile, DEHP, Carbon disulfide, Chlorobenzene, Chloromethane, IPB, MEK, MTBE, *N*-Butylbenzene, *N*-Propylbenzene

Smoky, Ash Tray, Camp Fire Flavored Wa

Superior received 300+ complaints in a day

Community concerns:
- ✓ Present at 1 household and not the neighbors
- ✓ Present in hot water only, not cold water
- ✓ Water heaters were contaminated
- ✓ The depressurized system sucked in chemicals
- ✓ Contamination was trapped in parts of the system

Smoke flavor after ‘03, ‘13, ‘16 wildfires assumed to be caused by drinking water source ash contamination.

Food science literature: Caused by phenols, *o*-cresol, *p*-cresol, *m*-cresol, guaiacol

CSU Dr. Omur-Ozbek confirmed the flavor was originating from the source water (lake) –*and*– in the treatment plant –*and*– in the water distribution system

CU Boulder Dr. Thurman, Dr. Ferrer, and Corona identified and attributed a tricarboxylic benzoic acid and a dicarboxylic benzoic acid as the “smoky flavor” agents at ppb (Ferrer et al. 2021)

They stated chemicals identified were not known to be a health risk at levels found

For this study…

Ongoing

- Reviewing and analyzing VOC and SVOC water sampling data
- Documenting the timeline and challenges associated with resource procurement and decisions

Where may this go? Lessons for public works and utilities nationwide

- Explicit concept of operations plan (CONOPS) needed for drinking water contamination response for utilities ….. and state agencies
  - Decision responsibilities
  - 'Fire package' water analysis
  - Testing SOPs for mains, service lines, and buildings
  - Advisories and Orders
- Identification of response training and resources needed
- System design considerations to better respond (e.g., isolation valve locations, e-meters, etc.)
- Identification of chemical contamination source(s) and most vulnerable assets
- Rapid mechanism for scientific support post-disaster
  - What if Louisville didn't call?
  - What if CU Boulder and CSU weren't nearby?
  - What if community volunteers didn't have the necessary expertise?

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