PURDUE
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Mr. Reese Crenshaw, P.E.
State Water Resources Control Board
Division of Drinking Water (DDW)
364 Knollcrest Dr., Redding CA 96002

March 11, 2019

Dear Mr. Crenshaw and the State Water Resources Control Board:

I submit this Dissenting Opinion on the Camp Fire drinking water response as it relates to the recent Paradise Irrigation District (PID) domestic water supply permit amendment signed and issued March 8, 2019. This is an unfolding emergency situation. This opinion is based on my experience and the evidence I reviewed from the Camp Fire area.

My recommendations are:

A. Wide scan VOC testing with EPA Method 524.2 or equivalent (65 chemicals) should be used at a minimum for the water distribution system. This should include TBA, a volatile organic compound (VOC) that exceeded its California Drinking water limit in Santa Rosa after the Tubbs Fire, but has not been yet tested for by the PID or DDW in the PID water distribution system.

B. The same minimum standard to protecting public health of Californians' in Santa Rosa is needed for California's served by the PID where a 0.5 ppb or greater benzene level is unacceptable. This 0.5 ppb benzene threshold will institute a safety factor for the uncontrolled leaching that is likely underway in the water distribution system and premise plumbing.

C. The same minimum standard to protecting public health of Californians' in Santa Rosa where a 72 hour stagnation time was applied should be applied to Californian's served by the PID including from the water distribution system and premise plumbing.

D. Multiple samples should be taken from premise plumbing, not 1. The wide scan VOC testing method may not identify the potential health risks associated with premise plumbing in the Camp Fire area. A rapid study should be conducted to determine how to appropriately evaluate premise plumbing safety.

E. With regards to flushing, please recognize that because the extent and scale of VOC water contamination in the PID system is unknown and customers are drawing in water from that contaminated water distribution system, contaminated water may be drawn into customer buildings that may not previously have had such contamination or were deemed safe previously.

This opinion is informed by my 16 years of experience where I have personally examined VOC fate in water distribution systems and premise plumbing. I have specially reviewed water testing records of the DDW, PID, and Del Oro Water Company regarding VOCs in water distribution systems. I have advised the EPA, State of West Virginia, utilities and others on how to conduct testing following water contamination. I worked for 3.5 years at the US Army helping units downrange and in garrison address drinking water infrastructure contamination and decontamination challenges. In 2014, my colleagues and I identified a general roadmap for large-scale contamination and response. Every emergency has its own issues where details are all important. Thank you for the opportunity to share my concerns.

Sincerely,

Andrew Whelton, Ph.D.
Lyles School of Civil Engineering, Division of Environmental and Ecological Engineering

A. Wide scan VOC testing with EPA Method 524.2 or equivalent (65 chemicals) should be used at a minimum for the water distribution system.

DDW Position #1: "Based on historical data, the Division believes benzene is a sufficient indicator of VOC contamination."

Evidence and Observations for Dissent:

1. As of February 13, for the limited PID water testing results (35 VOC samples for a 173 mile long water distribution system), benzene was present in most abundance compared to other 30 or so listed and identified VOCs. **However, the PID has not characterized its water distribution system broadly because of the scale of damage, and its results are not yet representative chemically or geographically.** Most of the PID's VOC testing results are from their water mains, not the service lines which I expect to exhibit much greater degrees of contamination. It has been estimated that PID will need at least 20,000-50,000 water samples to characterize their water distribution system. Their current water testing data represent about 0.07% of what they believe is needed for characterization. It is my understanding that they are continuing to ramp up their water sampling activities.

2. As of February 13, the City of Santa Rosa holds 8,222 water chemical testing records for a 5.2 mile water distribution system generated after the 2017 Tubbs Fire. To my knowledge, the City of Santa Rosa was overseen by the DDW and conducted chemical testing of their drinking water distribution system which was impacted by the wildfire. **The City of Santa Rosa found a variety of VOCs in the water distribution system, not just benzene.**

3. Several of VOCs found in Santa Rosa's water distribution system had California drinking water MCLs and notification levels and those limits were exceeded. This includes naphthalene, styrene, *tert*-butyl alcohol (TBA), toluene, vinyl chloride as well as benzene.

4. Specifically, benzene was sometimes "not-detected" (<0.5 ppb) when *tert*-butyl alcohol (TBA), a VOC, was found above its California drinking water notification level of 12 ppb. TBA is regulated in drinking water by the DDW. **Therefore, benzene did not indicate contamination for *all* regulated VOCs in Santa Rosa.**

5. The assertion that benzene is a sufficient indicator of VOC contamination in the PID water distribution system is not supported by Santa Rosa's water distribution system testing data. While benzene is itself a VOC, it's absence does not indicate the water is free of VOC contamination and that other chemicals present would not exceed drinking water health standards. Additional data discussion below.

6. The DDW requires that a public water system must notify their customers when a chemical exceeds its notification level (State of California Constitution below).

    a. DDW Notification Level Requirement https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/NotificationLevels.html.
    b. DDW List of Notification Levels: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/notificationlevels/notification_levels_response_levels_overview.pdf
    c. CALIFORNIA CONSTITUTION - HEALTH AND SAFETY CODE – HSC, DIVISION 104. ENVIRONMENTAL HEALTH [106500 - 119406], *Division 104 added by Stats. 1995, Ch. 415, Sec. 6.),* PART 12. DRINKING WATER [116270 - 117130], *(Part 12 added by Stats. 1995, Ch. 415, Sec. 6.),* CHAPTER 4. California Safe Drinking Water Act [116270 - 116755], *(Chapter 4 added by Stats. 1995, Ch. 415, Sec. 6.),* ARTICLE 5. Public Notification [116450 - 116485], *Article 5 added by Stats. 1995, Ch. 415, Sec. 6.)* 116455. (a) A public

water system shall comply with the requirements of this section within 30 days after it is first informed of a confirmed detection of a contaminant found in drinking water delivered by the public water system for human consumption that is in excess of a maximum contaminant level, a notification level, or a response level established by the department. http://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?sectionNum=116455.&lawCode=HSC

7. To my knowledge, as a condition of lifting the drinking water advisory in Santa Rosa, the DDW required that Santa Rosa test for multiple VOCs not just benzene. The plan that had to be submitted by Santa Rosa and was approved by the DDW can be found here: https://srcity.org/DocumentCenter/View/21682/Final---Plan-for-Lifting-the-Water-Quality-Advisory_09052018

8. To date, the PID's water testing has not included TBA as an analyte to examine among other chemicals detected in Santa Rosa. To my knowledge, the DDW has not included TBA testing in their own analyses. Public evidence reviewed from Del Oro Water Company's website indicates they too have not tested for this VOC during the Camp Fire response. It is my understanding that neither the DDW nor the PID know if TBA has been previously or is currently present in the PID's drinking water.

9. Most of PID's samples have thus far targeted the water mains and hydrants, not service lines. If the City of Santa Rosa's water testing data are helpful (they may or may not be, it is a different system/disaster), I suspect that the PID's service lines will have greater and more variable chemical contamination than their water mains. The numbers indicate a continued need for wide-scan VOC testing to fully understand the magnitude and extent of contamination in PID.

    a. In Santa Rosa, the maximum concentration *ever* measured in the water distribution sampling stations and hydrants (not service lines) was 6.98 ppb and all benzene values measured from the water distribution area 6 months after the incident and beyond were below 0.78 ppb.
    b. In Santa Rosa, the maximum concentration ever measured at a meter location (also represents the service line) was 40,000 ppb.
    c. In Santa Rosa, 7% of 29 hydrant samples taken in the period of 3-6 months after the incident were contaminated (≥0.5 ppb), while 12% of 3,227 samples taken at the water meter in this period were contaminated. (With a threshold of >1.0 ppb, the percentages of hits in this period are 0% and 9% for hydrant and meter, respectively.)
    d. This is in stark contrast to the PID's data, where 167 of 238 samples tested for benzene had concentrations above 1.00 ppb (source CalOES memo March 5, 2019).
    e. Thus, in the current period of recovery at PID, I expect a higher *magnitude* of contamination and a higher *percentage* of contamination than Santa Rosa, overall. I can also expect that this magnitude and percentage will increase when service lines/meters are targeted.

10. If PID only looks for benzene and the allowable limit is 1.0 ppb, based on Santa Rosa water testing data (if it applies at all due to differences between systems), PID may not detect the following 33 chemicals listed below. **TBA is highlighted because when benzene was not detected (< 0.5 ppb) in Santa Rosa, TBA violated the California State drinking water limit (notification level).** It should be noted that since the sources of PID's contamination are not known precisely, and since Santa Rosa's and PID's systems vary considerably in terms of size and materials, that a different suite of chemicals may be present in PID when benzene is not detected. This cannot be known until further testing takes place.

Chemicals Found in Santa Rosa Water Distribution System after the Tubbs Fire	Concentration Maximum, ppb
1,2,4-Trichlorobenzene	0.14
Vinyl chloride	0.16
1,1,1-Trichloroethane	0.25
Bromochloromethane	0.26
Carbon tetrachloride	0.34
Chloromethane	0.85
Carbon Disulfide	1.3
Isopropylbenzene	1.5
Methyl isobutyl ketone	2.3
Methyl tert-butyl ether (MTBE)	2.57
Ethylbenzene	2.61
Bromoform	3.68
o-Xylene	4.26
Xylenes (total)	4.3
Iodomethane	8.8
Acetonitrile	9.1
Naphthalene	9.4
m+p-Xylene	11.6
Acrylonitrile	14
Dibromochloromethane	14.6
Toluene	16
Styrene	26
Tert-Butyl Alcohol (TBA)	**29**
Methylene chloride	41
Bromodichloromethane	43
Ethanol	45
Trihalomethanes (total)	49
Chloroform	55.7
Total Trihalomethanes	66
Methyl ethyl ketone	230
Acetone	240
Tetrahydrofuran	1100

11. The DDW collected a water sample from the Lancaster Drive area of PID's service area and found very high levels of multiple VOCs (100s-1000s ppb). **This single DDW sample made clear that PID's limited data available as well as DDW's own limited data available were not representative of the system.**

RECOMMENDATION

Since the existing DDW and PID water testing results are not yet representative and a regulated VOC called TBA exceeded its California drinking water limit in Santa Rosa following the Tubbs Fire when benzene was not detected, it is my recommendation that wide scan VOC testing be continued for the PID. Evidence shows multiple VOCs with health-based drinking water limits can be present (Santa Rosa data and PID data) and VOCs can exceed health based limits even when benzene was non-detect (Santa Rosa). Reliance on benzene only testing may permit Californians to be exposed to other VOCs at unacceptable levels. As written, DDW's permit amendment would prevent PID, DDW, and ultimately the public from knowing that this exposure was taking place.

B. The same minimum standard to protecting public health of Californians' in Santa Rosa is needed for California's service by the PID where a 0.5 ppb or greater benzene level is unacceptable.

DDW Position #2: Benzene found at 1.0 ppb or greater in a water sample during recovery where plastics and other materials are leaching benzene into drinking water is unacceptable.

Evidence and Observations for Dissent:

1. Benzene has a California MCL of 1.0 ppb (https://oehha.ca.gov/water/chemicals/benzene). The City of Santa Rosa, who experienced widespread VOC water distribution system contamination after the Tubbs Fire, required that if any benzene was detected at or above 0.5 ppb, the infrastructure was concluded to be chemically contaminated. Santa Rosa believed that any benzene greater than or equal to 0.5 ppb concentration was not permissible in the water distribution system. This approach was overseen by the DDW and EPA. The concern at that time was that if 1.0 ppb benzene was the permissible level in the water distribution system undergoing decontamination, which was subject to VOC leaching, a discrete water sample detection of benzene slightly below 1.0 ppb could indicate, after leaching a few more hours or days, the benzene concentration would exceed 1.0 ppb. **Therefore, a margin of safety between when benzene was detected (0.5 ppb) and the level at which is posed a health risk (1.0 ppb) was built into their acceptance criterion.**

2. If the 0.5 ppb benzene target concentration was increased to 1.0 ppb benzene in Santa Rosa, 95 (24%) out of their 394 "contaminated locations" would have been deemed "clear" instead of "contaminated" based on the maximum found at each location in all testing rounds.

3. It is my opinion that a single result with an acceptance threshold of 1.0 ppb benzene would not be health protective during the continued response and recovery. A lower acceptance threshold of 0.5 ppb benzene should be implemented like applied in Santa Rosa. For example, Santa Rosa conducted repeated sampling at single locations. Here, you can compare their results against 0.5 ppb benzene or 1.0 ppb benzene level thresholds.
    - Of their 394 contaminated locations, at least 49 locations did not exhibit strict decreases of benzene levels with repeated testing.
    - **For at least 12 locations, benzene concentrations dropped below 1.0 ppb and then *rose above* 1.0 ppb.** Eight notable examples are shown below, where initial benzene test results would deem the asset safe with the 1.0 ppb (**red**) limit and with the 0.5 ppb (black) limit. But, then as evidence shows, water had an unacceptable amount of benzene in a follow-up sample. Using 1.0 ppb as an acceptance criterion is not advisable.

Location	Initial	Max after
61 [valve]	**0.53**	**8.72**
3050 [meter/service line]	**0.72**	**1.41**
105 [meter/ service line]	**0.56**	**1.01**
65 [valve]	0	8.4
67 [valve]	0	5.44
64 [valve]	0.16	1.9
79 [valve]	0.1	1.38
81 [valve]	0.48	1.04

    - The maximum benzene concentration measured at a location after a 'non-detect' at that location was at least 8.4 ppb.

- Other VOCs were found above drinking water health limits in Santa Rosa and included naphthalene, styrene, TBA, toluene, and vinyl chloride. Several of these compounds have been detected in PID's water for the limited number of samples they have collected (35) as of February 13.

4. Unlike Santa Rosa, 100s of standing buildings are in the PID service area. **If those buildings contain any benzene which leaches from their plumbing, benzene would be added to water after the water exits the water distribution system and is inside premise plumbing** (service line, water heater, shower, kitchen sink, bathroom sink, etc.). My concern is that this benzene addition could cause water to exceed 1.0 ppb concentration in the building. The magnitude of the in-building exceedance (+200 ppb benzene vs. 0.8 ppb benzene vs. +other concentration) remains unknown because there is no representative building water testing data. Moreover, if stagnation ever exceeded the stagnation period used in the mandated DDW test (i.e., at a sink that is not used often, inhabitant gone away for weekend, or vacation), using available evidence I would expect the benzene concentration at the tap could exceed 1.0 ppb. Plumbing is not a typical source for benzene, but in the PID area some plumbing systems likely have and are contributing benzene as a source. **A 0.5 ppb benzene concentration limit, like used in Santa Rosa, would incorporate a safety factor that can help account for this source before water reaches the faucet.**

RECOMMENDATION

It is my recommendation that the same minimum standard to protecting public health of Californians' in Santa Rosa be applied to California's served by the PID. A water sample with a 0.5 ppb or greater benzene level should be unacceptable. This will institute a safety factor for the uncontrolled leaching that is likely underway in the water distribution system and also in premise plumbing.

C. A 72 hour stagnation time (soak time) should be applied before collecting a first-draw water sample, including from the water distribution systems and premise plumbing.

DDW Position #3: A 48 hour infrastructure soak time for service lines and 12 hour infrastructure soak time for premise plumbing (or less) before water sample collection is acceptable.

Evidence and Observations for Dissent:

1. It is my understanding that the City of Santa Rosa, which experienced water distribution system contamination after the Tubbs Fire, required a 72 hour "soak time" of all infrastructure before water was sampled. It is also my understanding that this 72 hour soak time approach was overseen by the DDW and EPA during support to Santa Rosa. The concern at that time was that if a shorter soak time was permitted, any VOCs that were present in the plastics, including benzene (and others which were present), would not have enough time to leach from plastics into water for detection. The concern was that Santa Rosa would be unable to find all the contaminated water distribution system components if a shorter soak time was applied. If the contaminants were not detected in soak water because of a short soak time, and the contaminated components were placed back into service, VOCs may then exceed allowable drinking water exposure limits.

2. The PID, at the recommendation of the City of Santa Rosa and with the consent of the DDW, has applied a 72 hour soak time for their water distribution system components in the aftermath of the Camp Fire for 4 months. Under these circumstances they have detected benzene in excess of 0.5 ppb in their limited water testing results. They are continuing to use this approach.

3. As reiterated by Dr. Levi Haupert from EPA Office of Research and Development March 4, 2019 on the *VOC Fate in Water Systems* conference call, **stagnation time (soak time) is one factor that influences VOC leaching from contaminated plastics into water.** As such, reducing the soak time from 72 hours to any time less than this duration will decrease the amount of VOC that leaches into water, and therefore the chance chemically contaminated plastics will be discovered.

4. Our own testing of VOC contamination and leaching for plastic service lines and plumbing drinking water pipes has shown that a 3 day stagnation time (soak time) enables VOC leaching from copper and several plastic service line / plumbing pipes (*Journal of Hazardous Materials*, 2017, https://doi.org/10.1016/j.jhazmat.2017.06.015). Our study was limited by the initial organic contaminant exposure concentrations (determined by the petroleum product composition/dilution we used), only examined room temperature conditions, and the pipe's contaminated water exposure period was only 3 days. As Dr. Haupert from EPA underscored during his presentation, prolonged exposure to water that contains VOCs can allow a greater mass of VOCs to penetrate the plastics and more equally distribute inside the plastics. Therefore, I continue to recommend the 72 hour exposure period to provide time for VOCs to leach out.

5. I am not aware of any water or materials testing data that have been developed since the 2017 Tubbs Fire for water distribution systems or premise plumbing that shows the shorter soak time (48, 12 hours, or less) will result in equal or greater amount of VOCs in water from infrastructure materials, including plastics, as would be found for a 72 hour soak time.

RECOMMENDATION
The same minimum standard to protecting public health of Californians' in Santa Rosa where a 72 hour stagnation time was applied should be applied to Californian's served by the PID including from the water distribution systems and premise plumbing.

D. Multiple samples should be taken from premise plumbing, not 1. The wide scan VOC testing method may not identify the potential health risks associated with premise plumbing in the Camp Fire area. A rapid study should be conducted to determine how to appropriately evaluate premise plumbing safety.

DDW Position #4: In-building water is only to be tested at the most used drinking location (proposed as cold water kitchen sink) for benzene only, and samples should not come from locations subject to treatment.

Evidence and Observations for Dissent:

1. The intent of premise water sampling should be to determine if plumbing is safe including the customer's premise (property) service line. Testing should be conducted to determine whether or not building inhabitants may or may not encounter contaminated water that can prompt short- or long-term adverse health effects. A single benzene only water sample inside a building will not be representative of the safety of the entire plumbing or the customer's service line. If and when the PID or DDW provides this testing data to building inhabitants, they are likely to falsely interpret the results as indicative of their premise plumbing's safety.

2. It is well-known that VOC exposure can occur by not only ingesting drinking water, but also dermal contact and inhalation exposure. The DDW permit amendment for water sampling does not address these valid exposure routes to include showers and baths.

3. A single water sample for benzene only at a single drinking water (cold) location in the building does not address contamination elsewhere in the cold water lines and hot water system contamination, even at the kitchen sink.

4. In 1970s and 1980s, the pesticide chlordane entered water distribution systems and premise plumbing. Do not use drinking water orders were issued. When contaminated water entered building plumbing, plastic components were especially susceptible to chemical contamination and the hot water systems were more grossly contaminated than the cold water systems. In one example, 0.3 mg/L was found in building hot water while 0.03 mg/L was found in building cold water. Water heaters were irreparably damaged and required replacement. The investigators concluded contaminants sorbed into plastics, became sequestered in plumbing sediment and corrosion products. The DDW permit ammendment allows building inhabitants to continue to be exposed to potentially unsafe levels of VOCs in hot water plumbing. While water use after the disaster likely varied from that in the pesticide disasters above, we cannot know or understand the extent of hot water contamination until representative samples are taken.

   Reference: R. M. Moser, Purposeful Contamination of Distribution System with Chlordane Affecting 10,000 People, Proc. AWWA Water Security Conference, Denver, CO USA, 2005

5. The DDW and PID have detected multiple VOCs in water that have health based drinking water limits. Each VOC has different henry's law constant or volatility from water. The testing approach does not consider building inhabitants may be exposed to multiple VOCs in air when using water (showering, washing clothes, dishwasher, etc.). No hot water testing is considered. Inhalation exposure for the chemical mixture that has been found in drinking water by DDW and PID does not seem to have been considered in the DDW permit amendment. Models are available to estimate inhalation exposure. Models for the prediction of chemical exposures for building water safety should be applied.

6. The lack of hot water testing prevents the PID from lifting its hot water use ban. Kitchen sink cold water is not representative of the shower, or bath, or elsewhere in the building. I, and many others have previously shown, shower water enters a water heater and both chemical quality and stagnation time at this location can differ quite dramatically from the kitchen sink and between buildings. As I have reiterated, cold water and hot water are not chemically equal. Further, cold and hot water systems can be affected differently by contaminated water. For one example, some water heaters contain plastic dip tubes susceptible to VOC contamination. A single water sample for cold water likely will not be chemically representative of the entire building hot water system.

7. Excluding water samples from points that receive treatment may exclude entire homes where homeowners have installed treatment devices without advice or guidance from authorities. It may be those devices do not work or they are receiving excessive amounts of contaminants in the water (i.e., see DDW Lancaster Drive water sample). To my knowledge, there has been no public health oversight for building water treatment systems or plumbing contamination. Therefore, even if a device is installed, is in failure, and persons are being exposed to contaminated water, the DDW directs the PID not to test at that location. For these homes, drawing samples from outside the home, as recommended in the permit amendment, is not health-representative. Plumbing fixtures outside the homes do not often have certified drinking water fixtures. They may also have experienced heat damage to gaskets, experience unusual environmental conditions compared to indoor plumbing, and further may not represent drinking water inside the building.

8. Allowing limited, non-representative building water testing will give those affected a false-sense of the contamination levels in their homes. It also may prevent people from finding out that their being exposed to unsafe water. Looking forward, it may allow for the sale of contaminated homes to others who unknowingly think the DDW mandated testing was to determine if the home plumbing was or was not safe.

RECOMMENDATION

A rapid home testing study should be initiated to determine how sampling should be conducted to identify if plumbing poses a health risk due to chemical contamination and damage.

Multiple samples from both premise plumbing cold and hot water systems should be collected from locations where water use and stagnation are experienced inside the building.

The wide scan VOC testing method may not identify the potential health risks associated with premise plumbing in the Camp Fire area.

E. By promoting flushing, DDW may be permitting the spread of VOC contaminated water throughout the water distribution system whereby it enters buildings that may not have previously had contamination or were deemed safe previously.

DDW Requirement #5: "…flushing until 'chlorine residual is achieved' once monthly."

Evidence and Observations:

1. I assume the act of flushing is intended to remove contaminated water from the water distribution system.

2. Many parts of PID's system are still VOC contaminated, have not undergone testing (so the scale of contamination/damage remains unclear), and will remain that way for an extended period (months or >year). In Santa Rosa, for the only 5.2 miles of water distribution system impacted some samples from fire hydrants were contaminated (>0.5 ppb benzene) for over 6 months into the incident. As stated previously, Santa Rosa had a much smaller area affected and to a much smaller magnitude and potential damage than the 173 miles PID water distribution system. Thus, I expect that the PID will continue to have contamination in the water mains for an extended period of time.

3. If contaminated water is drawn out from service lines into the mains through flushing, VOC contaminated water may be spread through the water distribution system (mains, hydrants, etc.). This may result in plastic components in the main system becoming a secondary source of VOC contamination.

4. By flushing, contaminated water may also spread to portions of the water distribution system that had not had such contamination.

5. Contaminated water may also be drawn into buildings that may not have previously had contamination or were deemed safe previously. This drawn-in water may contain contaminants that exceed 1-day and 10-day US EPA health advisories. Lack of testing data inhibit a more evidence based understanding of the potential exposures in buildings.

6. If VOC decontamination of water mains is the primary goal, a monthly flush is likely not the most effective way to decontaminate a pipe. As explained by Dr. Haupert from EPA on March 4, the rate limiting step for decontamination of VOC contaminated plastics is likely diffusion through the solid plastic. Therefore, increasing the frequency of flushing, rather than length of flush, is more likely to result in faster decontamination of plastics. Requiring flushing at every service line may be too onerous and costly for PID currently to manage.

7. Because flushing will be conducted both the PID and DDW will not have the best record where the greatest degree of chemical contamination was in the water distribution system. This limitation should be considered when reviewing water testing results. Much higher chemical concentrations may be flushed away or drawn into buildings, whereby subsequent PID water testing does not find them.

8. The absence of VOCs in a water sample does not mean the system is clear, it means that the chemicals targeted in that single water sample were not detectable. Continued water sampling of assets is needed to confirm whether or not contaminated water remains in the system as well as contaminated infrastructure. Contaminated water will likely continue to move around the PID system because of flushing activities, stagnation at unused service lines, and possible leaks.

RECOMMENDATION

This is a comment about the potential unintended consequences of general flushing when the extent and scale of VOC water contamination is unknown and customers are drawing in water from that contaminated water distribution system. Please note that by promoting flushing, DDW may be permitting the spread of VOC contaminated water throughout the water distribution system whereby it enters buildings that may not have previously had contamination.

APPENDIX

Table A-1. Volatile organic chemicals (VOC) scanned for and detected by Santa Rosa after the 2017 Tubbs Fire that have not been tested for by the PID. To my knowledge, the PID has not been directed to test for these chemicals by the DDW. TBA exceeded its California drinking water notification level in Santa Rosa.

Chemical Name
Acetone
Acetonitrile
Acrylonitrile
Carbon disulfide
Ethanol
Iodomethane
Methyl ethyl ketone (MEK)
Methyl isobutyl ketone (MIBK)
Tert-Butyl alcohol (TBA)
Tetrahydrofuran (THF)

Attachment A – Webinar presentation for the USEPA Homeland Security Research Program. *Removal of Organic Contaminants from Polyethylene Drinking Water Pipes by Flushing.* Presenters: L. Haupert, M. Magnuson, 26 September 2018. USEPA ORD. Cincinnati, OH.

Attachment B – Peer-review research study. Crude oil contamination of plastic and copper drinking water pipes. Published in the *Journal of hazardous materials*. 2017 Jun 17;339:385-394. doi: http://www.doi.org/10.1016/j.jhazmat.2017.06.015. Huang X., Andry S., Yaputri J., Kelly D., Ladner D.A., Whelton A.J.

Attachment C – Peer-review research study. Case study: the crude MCHM chemical spill investigation and recovery in West Virginia USA. Published in the journal *Environmental Science Water Research & Technology*. 3, 312. Doi: http://www.doi.org/10.1039/c5ew00294j. A. J. Whelton, L. McMillan, C. L.-R. Novy, K. D. White, X. Huang

Attachment D – Conference paper about a research study. Tap water and indoor air contamination due to an unintentional chemical spill in source water. Published in *Interaction between Theory and Practice in Civil Engineering and Construction* (eds Komurlu, R., Gurgun, A. P., Singh, A., Yazdani, S.). 2016, 597-602. P. Omur-Ozbek, D. Akalp, A. Whelton