INVESTIGATION OF BENZENE IN DRINKING WATER FOLLOWING THE "CAMP FIRE" IN PARADISE, CA

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Foreword

This technical report was developed and published with the technical help and financial support of the members of the Plastics Pipe Institute (PPI). These members have shown their commitment to developing and improving quality products by assisting standards development organizations in the development of standards, and also by developing design aids and reports to help engineers, code officials, specifying groups, contractors and users.

The purpose of this technical report is to report on PPI's investigation into reports of benzene in drinking water following the "Camp Fire" in Paradise, CA.

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PPI intends to revise this technical report within five years, or sooner if required, from the date of its publication, in response to comments and suggestions from users of the document. Please send suggestions of improvements to the address below. Information on other publications can be obtained by contacting PPI directly or visiting our website.

The Plastics Pipe Institute, Inc.

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Table of Contents

Table of Figures

INVESTIGATION OF BENZENE IN DRINKING WATER FOLLOWING THE "CAMP FIRE" IN PARADISE, CA

1.0 INTRODUCTION

The **2018 Camp Fire** was the deadliest and most destructive wildfire in California history, and the most expensive natural disaster in the world, in terms of insured losses, that year. Named after Camp Creek Road, its place of origin, the fire started on November 8, 2018 in Northern California's Butte County. According to Cal Fire, the fire was ignited by a faulty electric transmission line in the Pulga area[1].

The unfortunate combination of strong winds, low humidity, and warm temperatures promoted this fire and caused extreme rates of spread, creating an urban firestorm in the densely populated foothill town of Paradise, with a population estimated at 26,800 before the fire.

The fire covered an area of **153,336 acres** (62,053 ha), destroyed roughly **19,000 structures**, and caused at least **85 civilian fatalities**, with most of the damage occurring within the first four hours. The fire travelled through the entirety of Paradise within 60 minutes. Temperatures are estimated by Cal Fire to have reached **1,600°F** (870°C). See **Figures 1, 2** and **3** for scenes from Paradise after the fire.

This Technical Report will explain PPI's investigation into reports of Benzene in drinking water following the Camp Fire in Paradise, CA.

Topics discussed in this document include:

- Section 2.0: Impacts of the Camp Fire to Water Quality
- Section 3.0: Current Situation – Water Quality in Paradise
- Section 4.0: PPI Investigation
- Section 5.0: PPI Findings
  - 5.1 Paradise before the Fire
  - 5.2 Effects of the Fire
  - 5.3 Impacts to Water Pipelines
- Section 6.0: Path Forward in Paradise
- Section 7.0: Conclusion

[1] CalFire (May 15, 2019) *CALFIRE Investigators Determine Cause of the Camp Fire* https://www.fire.ca.gov/media/5121/campfire_cause.pdf

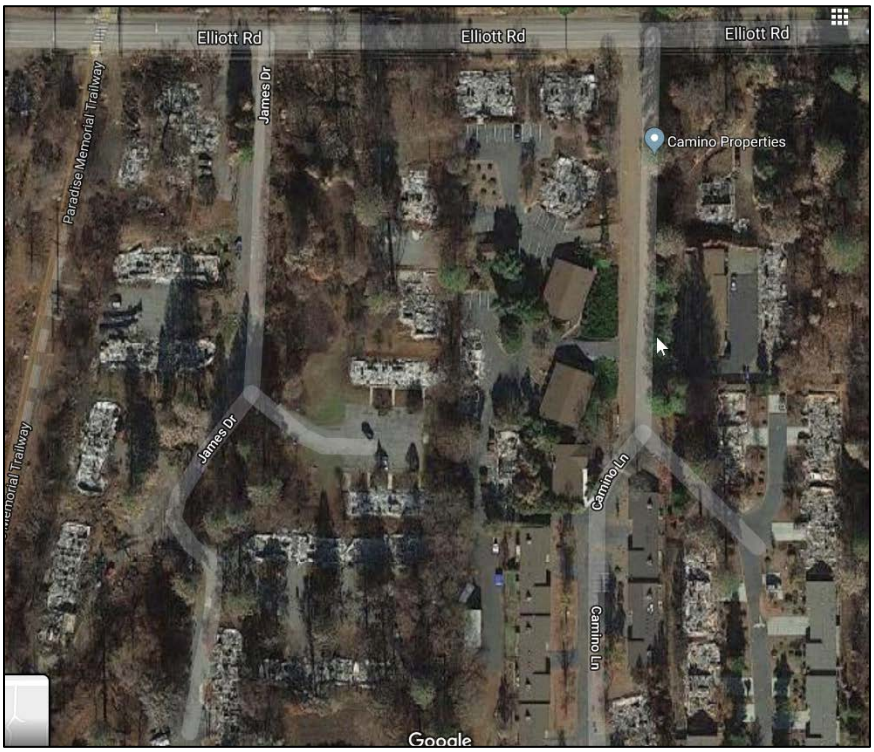

Figure 1: Google Maps image of a neighborhood in Paradise after the fire

Figure 2: Yard waste bins partially melted by radiant heat from nearby house fire

Figure 3: Site of a home after the fire; house debris and soil are removed

2.0 IMPACTS OF THE CAMP FIRE TO PARADISE WATER QUALITY

The uncontrolled fire that swept through Paradise spread toxic contamination throughout the region. Authorities had to coordinate the removal of nearly 3.7 million tons (3.4 million tonnes) of ash, metal, concrete, and contaminated soil from the county, twice the amount of material removed from the World Trade Center area in New York City after the 9/11 attacks.

Following the fire, the Paradise Irrigation District (PID)[2], the local water utility, focused on restoring the delivery of safe drinking water to the remaining structures within the town.

During water quality testing that was above and beyond California state regulations, the contaminant Benzene (C_6H_6), a known carcinogen, was detected at levels well above allowable state and US EPA levels in various locations. This included some of the water mains, some of the service lines going to standing buildings, and to approximately 30% of burned-out lots tested.

Several investigations have been conducted to determine the source of benzene. PID obtains its surface water from a lake several miles away from the fire site, and it was not contaminated with benzene.

It is established that benzene is produced from the burning of various types of trees, as well as from other materials that were present within the thousands of structures burned.[3]

[2] Paradise Irrigation District (PID) https://pidwater.com/
[3] Urbanski, Hao, and Baker, *Chapter 4 Chemical Composition of Wildland Fire Emissions*.

Many other chemicals, including several Volatile Organic Compounds (VOCs), were also generated during the burning of millions of pounds of materials consumed during the fire[4].

It has been alleged that heat from the fire created a chemical reaction in buried plastic water pipes which generated benzene from within the pipes themselves. The allegation doesn't provide any evidence that this theoretical reaction actually occurred, or identify exactly which pipe material is involved with this reaction.

Unfortunately, wildfires continue in California and across North America, and accurate data is critical when working towards solutions. PPI and our members have been following the situation carefully, and collecting evidence and data to share with interested parties.

3.0 CURRENT SITUATION – WATER QUALITY IN PARADISE

As of March 2020, over a year after the fire, PID had performed over 3,500 water quality tests at great cost to the utility. Approximately 8.5% of those tests had positive detections of benzene and/or other VOCs. Typical detected levels ranged from 0.5 to 15 µg/l (micrograms per liter, equivalent to parts per billion, or ppb).

Note: Like with most utilities, PID is responsible only for the service lines up to the customer's connection, typically at the curb box/water meter. Customers are responsible for testing water quality after that connection point.

PID has successfully flushed mains to remove benzene contamination.

For water service lines for standing structures, 95% are found to be in compliance, as of Nov. 2019. Where extensive flushing has not worked to restore safe water to standing buildings, PID has replaced water service lines to affected buildings, typically using high-density polyethylene (HDPE) PE4710 water service pipe material produced in accordance with AWWA Standard C901. Approximately 290 service lines have been replaced, with more scheduled for replacement. As destroyed homes are rebuilt, PID intends to replace all service lines with HDPE pipe.

As of February 2020, the majority of the remaining drinking water service connections in Paradise supplied by PID have tested safe, according to EPA and State guidelines. Of the 1,543 water services tested, only 26 (1.6%) were contaminated at levels above California's regulatory limit. Work continues to replace damaged or contaminated water lines.

[4] Quartz (Nov. 17, 2018) *California's air was among the world's worst this week. Climate change will make it the new normal.* https://qz.com/1466111/californias-air-was-among-the-worlds-worst-this-week-climate-change-makes-that-the-new-normal/

4.0 PPI INVESTIGATION

PPI has been following the investigations related to water quality in Paradise throughout 2019, monitoring published reports, and tracking media publications. PPI has been contacted by media outlets several times, with comments published in the *Sacramento Bee*[5] and *Plastics News*[6].

PPI staff members have been in direct contact with Paradise Irrigation District officials, as well as researchers in California who are employed by PID or the State, to help investigate the source of benzene and other chemicals persistent in the drinking water. PPI has endeavored to help determine what role plastic pipes, if any, may have played in the overall situation, and how to best utilize plastic piping materials as part of the solution.

5.0 PPI FINDINGS

Based on reviews of numerous reports from multiple agencies, interviews with local officials, and a site visit of PPI staff in November 2019, PPI's findings of the situation, with respect to water quality and the role of pipelines, are listed below.

5.1. Paradise before the Fire

Before the Camp Fire, Paradise Irrigation District had approximately **170 miles** of underground water mains arranged in seven pressure zones to accommodate elevations throughout the coverage area.

Materials used for water mains included PVC (35%), Steel (33%), Ductile Iron (19%), Asbestos Cement (10%), and Cast Iron (6%) [estimates][7]. Burial depths of 36 to 48 inches are typical[8].

The majority of houses in Paradise were built in the 1960s, 1970s, and 1980s. The median age of houses in Paradise was 43 years, with less than 15% having been built since 1990[9].

Water service lines primarily used steel, polybutylene (PB), copper, and PVC pipes; some more recent lines used HDPE[7,8].

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[5] Sacramento Bee (April 26, 2019) *Paradise Fire Contaminates City's Water Supply* https://backflowpreventionjournal.org/2019/04/26/paradise-fire-contaminates-citys-water-supply/

[6] Plastics News (June 5, 2019) *Towns reeling from wildfires now face contaminated water* https://www.plasticsnews.com/news/towns-reeling-wildfires-now-face-contaminated-water

[7] Whelton et al, *VOC Fate in Water Systems*, Purdue University & Manhattan College, March 4, 2019. It is noted that the total exceed 100% and is assumed to be the result of rounding by the authors.

[8] Personal Correspondence, Michael Lindquist, Water Works Engineers LLC, November and December 2019

[9] Paradise, California Housing, accessed July 14, 2020, https://www.bestplaces.net/housing/city/california/paradise

Plumbing materials for hot- and cold-water distribution within houses were predominantly copper, with some galvanized steel and polybutylene (PB). Newer piping materials such as crosslinked polyethylene (PEX) and chlorinated polyvinylchloride (CPVC) would have been rare, based on the age of the houses[8].

Backflow prevention devices were installed at commercial connections, but not at most residential connections[8].

5.2. Effects of the Fire

The Camp Fire destroyed roughly 18,000 of 20,000 buildings in the Town of Paradise. The uncontrolled burning of vegetation, buildings, stored household and industrial chemicals, and vehicles always has the potential to create toxic chemicals.

Under the extreme conditions of the Camp Fire, the environment and atmosphere would have been filled with many types of toxic substances. This is evidenced by the nearly 3.7 million tons of contaminated material removed from the town in the year following the fire.

5.3. Impacts to Water Pipelines

It is reported that a negative pressure event occurred during the fire in the municipal water system, resulting in exposed empty pipes into which toxic smoke and debris was siphoned. The negative pressure was due to the intense consumption of water by firefighting efforts.

Damage to multiple points of the municipal system (curb boxes, house risers or plumbing systems) occurred as the fire consumed buildings, exposed piping and connections, and damaged some water meters. See **Figure 4**. Some pipelines are reported to have been open to the atmosphere for several weeks after the fire.

Figure 4: Damaged water meter

The intensity of the heat damaged both exposed metal and plastic pipes, as well as water meter boxes buried on-grade, with evidence of melted brass connections and corroded steel pipes. **See Figures 5** and **6.**

Figure 5: Partially melted meter box

Figure 6: Brass water valve that is partially melted

Pipes buried 12 inches (30 cm) or deeper below grade were not exposed to significant heat, so water mains and most parts of service lines were not affected by the heat. Service line damage was principally at the water meter/curb box and above ground, where connecting to houses.

Plastic curb boxes frequently melted and may have ignited, dripping on components below, and particularly onto meters, possibly igniting the meter and/or other components within the curb box. Seats/seals of brass valves were damaged.

Some HDPE service lines had melted material deposits left within them from other materials; see **Figure 7**. It is presumed that these deposits were from a nearby fitting, meter or curb box. Where exposed to direct heat/fire, some plastic lines melted or burned.

Figure 7: HDPE water pipe with melted material deposits

Hydrocarbon contamination of mains and water services appears random, with neighboring houses showing different results.

- Benzene contamination of water mains was not material-specific, and was found in segments buried deep in the ground, and not subjected to the heat of the fire
- Benzene contamination of service water was found in both metal (e.g., steel, copper) and plastic service laterals
- There has been no clear correlation of cause-effect, with regards to the presence of benzene contamination, related to the location of pipelines or the material of pipelines (i.e. contamination follows no patterns of materials or installation type)

Following flushing of the water mains, no detectable contamination was observed (or observable) in flushed water mains following state and federal guidelines. It is possible that some of the service lines adsorbed contaminants during the fire, and are slowly releasing those contaminants back into the water. No evidence was found that the heating or burning of plastic pipes of any material is specifically responsible for the contamination of the water system.

6.0 PATH FORWARD IN PARADISE

As the Town of Paradise rebuilds and more residents return, PID is replacing all water service lines using high-density polyethylene PE4710 water service pipe material produced in accordance with AWWA Standard C901 due to their previous experience with HDPE pipe and comfort level with installation practices[8].

Residential connections are being installed with backflow prevention devices to protect PID-owned service lines and water mains against contamination from exposed or empty service lines, should a similar event occur in the future.

7.0 CONCLUSION

There is no evidence that the heating or burning of HDPE or PEX plastic pipe is responsible for the contamination of the water system within Paradise, California.

Plastic piping materials such as HDPE and PEX, when produced, sold, and certified for their purpose according to standards by the American Water Works Association (AWWA) and other standards development organizations or agencies, are proven to provide safe and reliable delivery of clean drinking water.

Based on the experience of PID and the evidence to date, PPI recommends, regardless of piping materials, that in the event of catastrophic fire with evidence of a negative pressure event and subsequent contamination of the drinking water piping, that water mains be flushed until water tests confirm that contaminant levels are in conformance with all federal and state drinking water requirements.

Utilities and customers should consider replacing contaminated water service lines with new pipes (e.g., HDPE conforming to AWWA C901, PEX conforming to AWWA C904) when flushing does not eliminate contamination.