TECHNICAL MEMORANDUM No. 1

Post-Fire Water Quality Investigation: Analysis of Cause of Water Contamination

March 22, 2018

This Technical Memorandum is intended to inform stakeholders on the question of "Is the water contamination in Santa Rosa a direct result of the wildfires?"

EXECUTIVE SUMMARY

On October 8th and 9th, 2017, the Tubbs wildfire burned through large portions of the City of Santa Rosa destroying approximately 3,000 residential and commercial structures. The burned areas, including the Fountaingrove neighborhood, were mandatorily evacuated and residents were not allowed to return to their properties until the beginning of November.

On November 8th, Santa Rosa Water received a taste and odor complaint from one of the residents in the burned area of Fountaingrove. In response, Santa Rosa Water staff took water samples and found contaminants including benzene, a volatile organic compound (VOC) never before detected in Santa Rosa's water system. Benzene was detected at levels above the allowable regulatory limit (Maximum Contaminant Level, MCL). Working with our State regulator, the State Water Resources Control Board Division of Drinking Water (DDW), Santa Rosa Water immediately isolated the contaminated area and issued an advisory water quality notice in the contaminated area (the "advisory area").

Subsequent testing of water samples identified a suite of contaminants that include (but are not limited to) aromatic hydrocarbons (including benzene, toluene, ethylbenzene, and the xylenes), polynuclear aromatic hydrocarbons, chlorinated compounds (not related to water chlorination), ketones, furans, and thiophenes. Benzene has been used as the indicator chemical for the investigation and the basis for the water quality advisories, due to its relative pervasiveness and concentrations. Santa Rosa Water staff, in collaboration with the DDW, the United States Environmental Protection Agency (USEPA), Sonoma County Health Services, APEX Forensics, and UC Berkeley, have been methodically investigating this issue to determine how these contaminants entered the water system. This investigation has identified the source of the contaminants as the wildfires that burned through the affected area in October 2017. This includes contaminants from some combination of thermal degradation (i.e., melting, burning, and pyrolysis) of plastic pipes and/or entry of ash, soot, and other debris into the piping and ancillary equipment during the fire event. These contaminants were then back-siphoned into the distribution system where they adsorbed onto and/or absorbed into components of the water infrastructure, such as pipes and gaskets. Exhaustive attempts to flush these contaminants out have been unsuccessful.

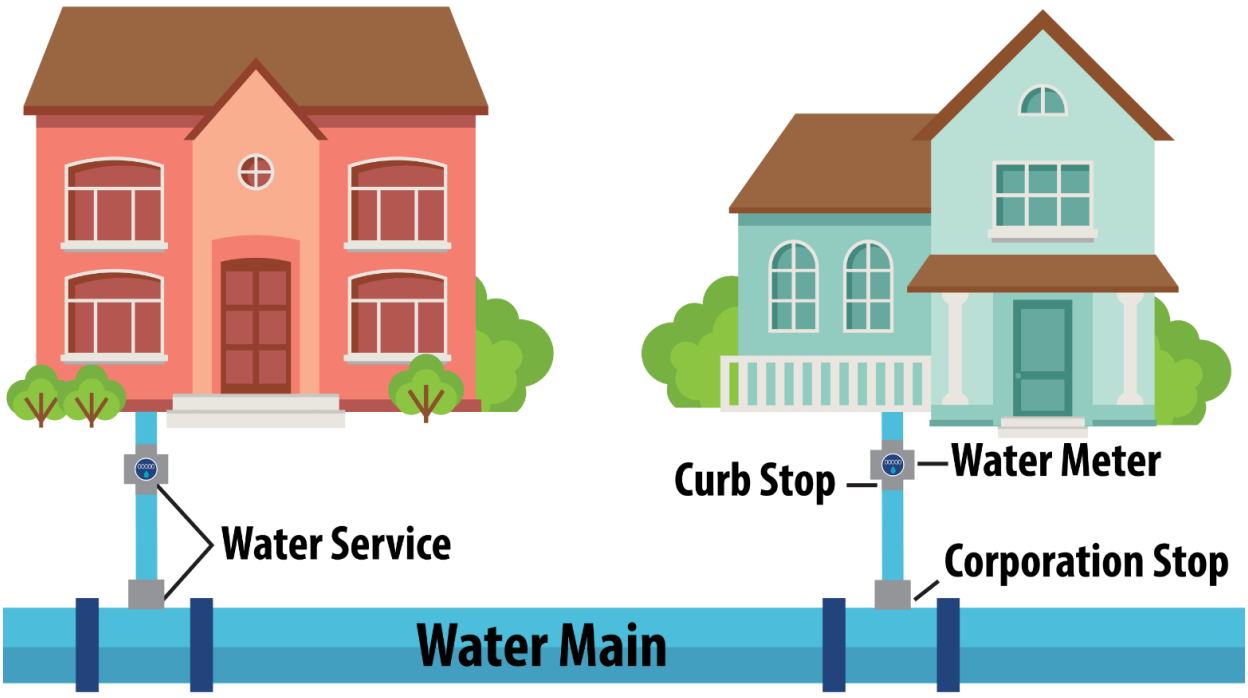
Note: This technical memorandum (TM) was prepared by City staff, in consultation with and review by representatives from: DDW (Janice Thomas, District Engineer; Marianne Watada, Associate Sanitary Engineer); USEPA (Bruce Macler, Region 9 Water Division Toxicologist); Sonoma County Health Services

– Environmental Health & Safety Section (Christine Sosko, Director of Environmental Health); APEX Forensics (Kurt Johnson, Director of Forensic Services and Senior Chemist); and UC Berkeley (Dr. David Jenkins, Professor Emeritus of Civil and Environmental Engineering). Among this broad technical group, there is consensus in the core conclusion that the water contamination issue discussed in this TM was solely caused by the damage of the City's infrastructure by the fires.

WILDFIRE DAMAGE TO WATER INFRASTRUCTURE

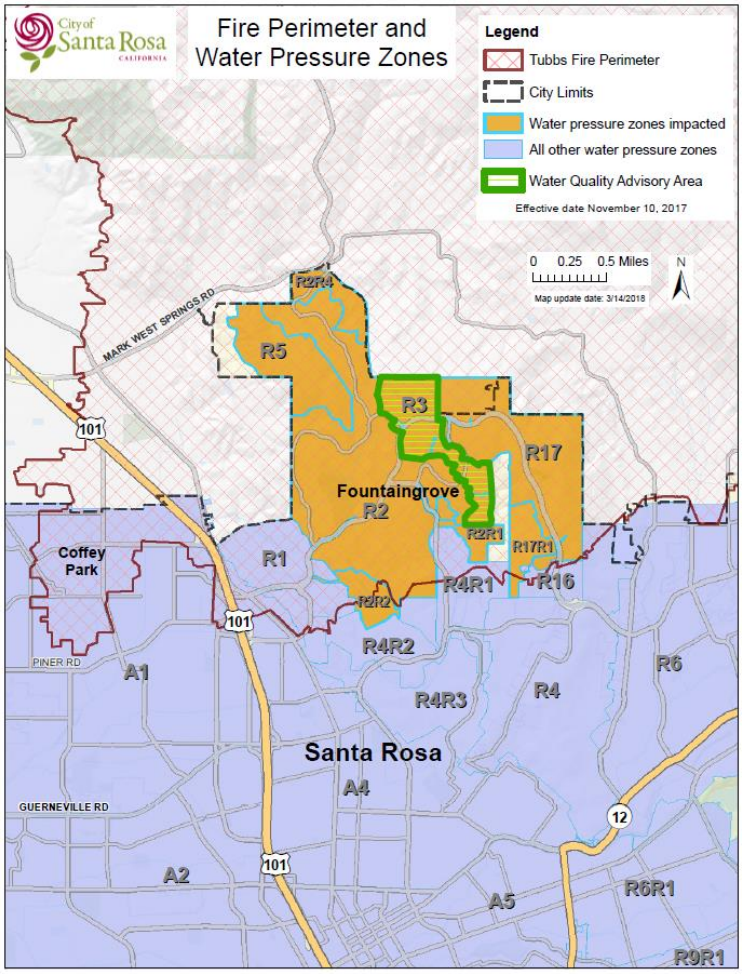
The City's distribution system includes 20 pump stations, 24 treated-water storage tanks (reservoirs), wells, pipelines, and meters. See Appendix A for a map of water distribution system components. The existing water distribution system is divided into 18 major pressure zones, and several smaller sub-zones, that are served by pipelines ranging in diameter from 4- to 24-inches (Appendix A). "Water Main" lines distribute water to "Water Service" lines, which are connected to meters at private properties (Figure 1). Pipe materials include asbestos cement, polyvinyl chloride (PVC), high-density polyethylene (HDPE), ductile iron, and cement mortar lined and coated steel.

FIGURE 1. DIAGRAM OF WATER DISTRIBUTION INFRASTRUCTURE



The Fountaingrove neighborhood is a primarily residential neighborhood in the northern part of the City, in a hilly area of varied topography with numerous peaks and valleys. Santa Rosa Water services Fountaingrove via eleven pressure zones. Seven pump stations pump water up to ten aboveground water storage tanks, which then gravity feed to homes and businesses. **Figure 2** shows the location of Fountaingrove, and the eleven pressure zones that serve the area.

FIGURE 2. TUBBS FIRE PERIMETER, FOUNTAINGROVE ADVISORY AREA LOCATION, AND PRESSURE ZONES



As the Tubbs wildfire spread eastward into the City of Santa Rosa late in the evening of October 8th, 2017, Fountaingrove was one of the first neighborhoods to ignite. The wildfire continued to actively burn through October 9th. During this time, private water infrastructure at homes and businesses and public water infrastructure sustained substantial damage that included pipes burning and melting, breaks in the water lines, burned meters and gaskets, etc. **Figure 2** shows the perimeter of the fire and its relation to Fountaingrove.

CONTAMINATION DETECTION

Historical Test Results

Santa Rosa Water routinely samples water per the requirements of the DDW and the USEPA. Benzene is one of 73 VOCs currently tested quarterly at the following four locations in the City's water supply and distribution system: Water Sampling Station (WSS) 114 at 3834 Skyfarm Drive (in Fountaingrove), WSS 009 at 301 Todd Road, and Farmers Lane Wells 1 and 2 on Farmers Lane. In the past, Santa Rosa Water has also tested for benzene at other water sampling stations and water storage tanks throughout the City (see Appendix B). Benzene is a regulated chemical with an established California State Maximum Contaminant Level (MCL) in drinking water of 1.0 microgram per liter (µg/L) or 1.0 part per billion (ppb).

Prior to the October 2017 wildfire, no traces of benzene have ever been detected anywhere in Santa Rosa Water's system. Appendix B provides all historical collection dates and test results for samples taken city-wide, including several locations in Fountaingrove, since 2001.[1]

The Sonoma County Water Agency (SCWA), the wholesaler that provides water to the City of Santa Rosa, also reports no benzene detection in sampling history. SCWA's sample results (1996 through the present) are provided in Appendix C.

Post-Fire Test Results

Since the fire, Santa Rosa Water has increased water sampling beyond regulatory requirements to more closely and widely monitor our entire water system. The testing to date has identified a suite of contaminants including, but not limited, to aromatic hydrocarbons (such as benzene, toluene, ethylbenzene, and the xylenes), polynuclear aromatic hydrocarbons, chlorinated compounds (not related to water chlorination), ketones, furans, and thiophenes.

The results of the investigative samples show MCL exceedances for benzene in select locations, including at water services to destroyed properties, some service lines to existing homes within the advisory area, and in components of the water system including the water mains, valves, hydrants, and water sample stations (where water is collected to obtain a representative sample of the drinking water provided to properties). Appendix D provides a map of all locations tested and sample results as of March 7, 2018.

No benzene has been detected in any of the source waters going to Fountaingrove, including wholesale water purchased from SCWA or groundwater pumped from Santa Rosa's wells.

CONTAMINATION PROCESS

Santa Rosa Water has been working closely with experts from the DDW and USEPA, an Emeritus Professor of Environmental Engineering from the University of California at Berkeley, and forensic chemists to determine the source of contamination, and why contaminants remain in the water infrastructure system.

The widespread and sporadic pattern of contamination does not support the theory that a single incidence or source of contamination is the cause; rather, multiple point sources are likely. Early in the investigation, staff considered the possibility that underground fuel tanks could have leaked contaminants. However, prior to build-out the area was largely open space/agricultural land, not a historical industrial area where legacy contamination would be expected. An in-depth underground fuel tank investigation did not find any evidence of underground tanks (Appendix E), and soil samples show no evidence of contamination (Appendix F). A chemical analysis shows that the specific contaminants detected in Fountaingrove, and the levels of contamination, are not consistent with an underground leak, and forensic chemists found no evidence to date that pipes were permeated from the outside (i.e., from soil). An above-ground spill during the fire would likely have burned, and would not present as a widespread and sporadic contamination. In sum, the distribution of the contamination and suite of contaminants evaluated show no evidence that would support a subsurface petroleum fuel release or similar source for the contaminants found.

[1] Santa Rosa Water is required by law to keep records going back 5 years. 2001 is the oldest data in Santa Rosa Water's records.

The pattern of contamination and the specific contaminants detected in affected areas support the conclusion that the source of contamination is from the by-products (i.e., gases, liquids, and char) produced by thermal degradation of plastic pipes and appurtenances from exposure to the high temperatures generated by the fire, and/or entry of ash, soot, and other debris into the piping and ancillary equipment during the fire event. Specifically, evidence indicates that benzene and other contaminants entered the water system by the following circumstances:

1. **Water infrastructure within or adjacent to parcels burned by fire was exposed to extremely high temperatures.** Research shows that exposing plastic to fire and high temperatures can cause pyrolysis, i.e., decomposition brought about by high temperatures. High-Density Polyethylene (HDPE) and Polyvinyl Chloride (PVC) pipes are common throughout the affected area. Studies show that pyrolysis of HDPE can produce benzene and other contaminants, and that temperature and residence time have a large influence on the pyrolysis product and distribution.[2] Temperatures during the peak of the Tubbs fire reached levels sufficient to cause pyrolysis.

2. **A loss of water pressure created a vacuum that pulled contaminants into the service lines and main lines.** During the fire, the water system serving the advisory area had a uniquely dramatic drop in pressure due to the excessive demand on the system relative to the available water supply. Contaminants from pyrolyzed pipes and appurtenances, in conjunction with contaminated hot air, ash, char, and other debris, were back-siphoned into service lines and distribution main lines when the water system lost pressure. Contaminants then adsorbed onto and/or absorbed into components of the water infrastructure, such as pipes and gaskets.

3. **Drinking water is picking up contaminants from water distribution infrastructure**. Clean water stored in or traveling through contaminated portions of the water system can absorb benzene and other contaminants. The amount of time the water is in contact with a contaminant influences the final concentration of at least some contaminants: the longer that water is in contact with contaminated infrastructure, the more of some contaminants are found in the water.

CONCLUSION

The results to this investigation have identified the source of the contamination present in the water distribution system as the wildfires that burned through the affected area in October 2017. Damage from the fires includes a combination of thermal degradation (i.e., melting, burning, and pyrolysis) of plastic pipes and/or entry of ash, soot, and other debris into the piping and ancillary equipment during the fire event. During a loss of water pressure, contamination was back-siphoned into water service lines, where the contamination entered into the components of the water infrastructure and exhaustive attempts to flush these contaminants out have been unsuccessful.

[2] Pyrolysis of high-density polyethylene in a fluidized bed reactor. Influence of the temperature and residence time. Journal of Analytical and Applied Pyrolysis, Volume 63, Issue 1, March 2002, Pages 1-15. Maestral et al.