Superior Toxicology & Wellness

Joe Nieusma, Ph.D.
Senior Toxicologist
[redacted]
Grand Haven, Mi 49417
[redacted]

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RE: [redacted] house post Marshall fire risk assessment.

Superior Toxicology is pleased to present our findings regarding the need for complete demolition and rebuild of [redacted]. This opinion was requested by [redacted], attorney for [redacted] to provide an independent assessment of the hazard from contamination and how to remove as much risk as possible for their family following the Marshall fire that damaged their Superior, Colorado home in late December of 2021.

The opinions and statements contained in this report are based on: 1) my personal knowledge and review of the scientific literature pertaining to the types of hazards associated with combustion, water and smoke damage in a residential setting; 2) facts or data reasonably relied upon by persons in toxicology; 3) my scientific expertise and experience relating to toxicity of both voluntary and involuntary exposure; and 4) specific materials provided by the client as referenced in this report. My complete Curriculum Vitae is attached in Appendix 1 to fully describe my qualifications. [redacted]

Background

On December 30, 2021, shortly before 10:30 a.m. MST, a grass fire broke out in Boulder County, Colorado, United States. The large fire was named the Marshall Fire by local fire authorities. In terms of structures lost, it was the most destructive fire in Colorado history. (Boulder County, Colorado). The home at [redacted] was spared from burning completely to the ground by heroic effects of first responders using tremendous amounts of water to flood, soak and permeate all remaining materials with that water. Additionally, the home immediately adjacent to [redacted] owned a Tesla electric vehicle that was completely consumed by the wildfire, contaminating the immediate vicinity with the toxic remains of large battery packs.

The [redacted] consists of [redacted], and [redacted] years old. There is history of allergies to animals, environmental agents, and mold in multiple family members both adults and children. At least one family member also suffers from asthma. Multiple family members suffer from various skin conditions on the feet, face, neck, mouth and chin. Since the fire, the family has experienced many medical issues including chronic bloody noses multiple times per day, breathing issues with asthma worsening, eyes nearly swollen shut at times, skin reactions including rash, hives, flushing, and regular skin reactions of the feet and face that have worsened since the contamination from the fire was in the home. The [redacted] after moving in and out of the contaminated home, the dog experienced respiratory issues and has now begun heart medicine for an enlarged heart. Several children have experience learning challenges and have had individual education plans

established for their progress in school. All family members have felt mental stress and psychological strain from the post-Marshall fire events they have endured while trying to maintain a family business, educational progress and everyone's personal health and wellbeing while living in a house contaminated with multiple toxic and carcinogenic agents.

It is a fact that members of the [redacted] have known medical conditions and are considered as part of a population most at risk to effects of toxic exposure. These chronic health conditions in the [redacted] can more likely than not set them up for additional adverse effects of exposure to the contaminants proven to be in the residence at this time if remediation is not conducted fully, safely and without additional contamination of the home. Remediation is of utmost importance for the sake of this family's future health.

Hazard Assessment

At this stage of post-fire cleanup, the potential health risk from the wildfire residuals is most likely from inhalation, skin contact, and ingestion of particulates—mainly char and ash deposited by the smoke, as well as the polycyclic aromatic hydrocarbons (PAHs) that have become adsorbed onto the fire particulates and onto surfaces in the home. Wildfire smoke is a veritable cocktail of products of incomplete combustion. Ash and char, the main components of wildfires, usually contain heavy metals, PAHs, and dioxins and furans and this has been shown to be true in this case (Medina, 2016, Humphrey, 2022a, Humphrey, 2022b).

The health effects of wood smoke inhalation range from acute irritation, inflammatory responses, asthma triggers, and immune system suppression to changes in lung function (measured as increased airway resistance); reduced lung function capacity; chronic illnesses, including bronchitis, obstructive pulmonary disease, and cardiac disease; and cancers of the lung, skin, and bladder (Medina, 2016).

Background sources of PAHs in urban outdoor air and in homes not affected by wildfire smoke include smoke from fireplaces and cigarettes, asphalt pavement sealers containing coal tar, and vehicle exhaust. Background PAH levels in indoor air range from 0.00027 $\mu g/m^3$ to 0.05 $\mu g/m^3$, approximately twice the background levels found in outdoor air (Medina, 2016). PAHs exist in equilibrium between a vapor and a solid phase and have a strong affinity for organic matter like charcoal. They attach to building materials and furnishings, such as carpet, gypsum wallboard, and even stainless steel, and slowly off-gas for time periods ranging from hours to weeks or months. As a result, PAHs are commonly found as a component of household dust. Typical background levels are in the range of 0.15 to 1.64 micrograms per gram ($\mu g/g$) of dust. Dust ingestion by children is the second most important route of exposure to carcinogenic PAHs, after inhalation exposure. Acute effects notwithstanding, household dust needs to contain more than 150 times the typical PAH background levels to pose a lifetime cancer risk above one-in-one-million (Medina, 2016).

IAQ Professionals issued a report for this property with findings including quantitative information on common contaminants from wildfires including dioxins, furans and heavy metals. The five forms of dioxin detected were at levels of 4.60, 5.59, 1.31, 5.24 and 46.9 pg/g for the house. The one form of furan detected was at 29.1 pg/g for the house (Humphrey, 2022a). These levels are shown in table 1 below. The dioxin that has been shown to be a known human

carcinogen is tetrachlorodibenzo-p-dioxin and this species is present in the home. The furan that has been shown to be a known human carcinogen is tetrachlorodibenzofuran and this species is present in the home (Humphrey, 2022a). There is no known safe level of exposure to known carcinogens and all exposure should be eliminated or minimized to remove or reduce potential risk, respectively. The detected levels of each of these species is high and will result in acute and chronic adverse effects for occupants of the dwelling.

Table 1: Dioxin & Furan species detected at [redacted]

Analyte Dioxin and Furan species	Pg/g
Total tetrachlorodibenzo-p-dioxins	4.60
Total pentachlorodibenzo-p-dioxins	5.59
Total hexachlorodibenzo-p-dioxins	1.31
Total heptachlorodibenzo-p-dioxins	5.24
Total octochlorodibenzo-p-dioxins	46.9
Total tetrachlorodibenzofurans	29.1

The data on the metal contamination levels in the [redacted] home is shown in table 2 (Humphrey, 2022a). The metals contamination needs remediation for the residence and any residual levels will contribute to exacerbation known medical conditions of family members. The well-known health effects of metals exposure are not detailed in this report at this time for simplicity's sake. All potential exposures including inhalation, ingestion, and skin contact, would be decreased by following the recommendations contained in the report below.

Table 2: Metal contamination levels detected at [redacted].

Metal	**Surface Result (mg/kg)**	**Walls Result (mg/kg)**	**Detection Limit (mg/kg)**	**Exposure Limit**	**Exposure characterization**
Cobalt	<0.2	0.769	0.2	0.1 mg/m^3 OSHA	High
Chromium	1.83	1.43	0.5	0.005 mg/m^3 OSHA	High
Cadmium	<0.2	<0.2	0.2	0.005 mg/m^3 OSHA	None
Silver	<0.5	<0.5	0.5	0.01 mg/m^3 OSHA	None
Lead	0.616	11.9	2.5	0.05 mg/m^3 OSHA	High
Vanadium	<0.5	0.653	0.5	0.05 mg/m^3 NIOSH	High
Zinc	49.5	51.1	0.5	5 mg/m^3 OSHA	Moderate
Arsenic	<1.0	<1.0	1.0	0.01 mg/m^3 OSHA	None

An important principal, that is universally ignored most of the time, is that this "safe limit of exposure" is for one chemical in the exposure situation. It does not consider mixtures of toxic exposure at all. It does not consider simultaneous exposures to additional toxins like furans species, heavy metals, particulate matter from char and soot, mold from water damage, volatile

organic compounds, dietary toxins, air borne toxins (burned Tesla batteries in close proximity), drinking water borne toxins or health-based exposure challenges (drugs). Considering the multiple toxins detected in this house, there is no safe scenario to base a sound remediation strategy from to ensure the future safety of the occupants.

This limit, while reportedly safe for most individuals, would not be safe for [redacted]. The presence of these dioxin chemical species will require the extensive remediation including the removal of drywall, laminate counter tops, porous cabinets, vinyl flooring and water supply lines in the home (Hubbs & Murphy, 2019; Medina, 2016). The furans species are found in food and dietary exposure in the USA is up to 8.54 pg/day of the dibenzofurans species (Gonzalez & Domingo, 2021). Again, with the family's medical conditions, any furan levels in the residence are problematic and need to be carefully remediated by removing the contaminated materials listed above. Furan species are not completely removed by laundering (Fent et al., 2020). All soft textiles including but not limited to clothes, drapes, curtains, mattresses, furniture, coats and footwear, will need to be disposed of and replaced. The residence has been lived in and visited for only a few minutes and the family has tried to save items from the house and they still had reactions to the skin quickly. This process will be essential for all items and goods that are contaminated. The list of detected dioxins and furans does contain the dioxin and furan species that are known human carcinogens (Fent et al., 2020). There is no safe level of remediation or exposure for known human carcinogens. Additionally, the rest of the chemical species present also have acute and chronic exposure hazards. These potentially toxic species associated with the particulate matter observed in the home is the prime target for causing any adverse health effects. All potential exposures including inhalation, ingestion, and skin contact, could also be involved in the resultant adverse effects.

Typical exposure risk in the wake of a fire is present for this home, however, there is additional risk at this home due to the close proximity of a Tesla auto consumed by fire and the extensive volume of water spent on this home to save it from complete loss by fire. These two issues present significant additional risk to this home and when taken in consideration with the dioxins, furans and heavy metals also present, make this home uninhabitable unless demolished and rebuilt with uncontaminated materials. The Tesla fire is significant due to the hazardous gases, extreme heat and particulate after the fact that can result in future exposure, adverse effects and harm to inhabitants of the home.

When burned, the lithium-ion batteries in electric cars produce hydrogen fluoride gas and phosphoryl fluoride as well as carbon monoxide, carbon dioxide, lithium cobalt oxide, nickel oxide, manganese oxide and lithium hexafluorophosphate (Sironval et al 2018, Sironval et al., 2020, Larsson et al., 2017). The use of water on the fire causes hydrogen fluoride gas to be released more quickly. The hydrogen fluoride binds to water droplets and increases the amount of very toxic hydrofluoric acid on all surfaces touched by that water. The collective presence of these toxins may result in severe allergic reactions on unprotected skin. Additionally, these metal oxide particles will result in lung inflammation and lung fibrosis. The particles result in oxidative stress and hydroxyl radical generation leading to genotoxic potential including DNA lesions, DNA strand breaks, chromosomal breaks and micronuclei formation (Sironval et al 2018, Sironval et al., 2020, Larsson et al., 2017). The presence of the Tesla in close proximity of this

home has potentially coated all surviving surfaces with potentially carcinogenic particles that will persist over time in addition to the chemical risk for short term exposure issues.

Mold has been detected in the house in the IAQ Professionals environmental report dated July 11, 2022, and has yet to be remediated to my knowledge (Humphrey, 2022b). Species that are toxic varieties include Aspergillus, Eurotium, Hyphae and Penicillium/Aspergillus and would therefore contribute to the toxic potential of living is this home (Humphrey, 2022b). Mold permeates all areas, construction materials, confined spaces, HVAC spaces, and surfaces with active growth and spores for future growth. The mechanism of mold toxicity involves assault on the inhabitant's respiratory system with progressively worsening symptoms as exposure continues. Symptoms begin with shortness of breath, coughing, sneezing and progress to respiratory infections, and inflammation. Chronic exposure can lead to cognitive difficulties like brain fog, poor memory, and anxiety. Exposure to mold can cause pain in the abdomen and muscles, weight changes, numbness and tingling in extremities, metallic taste in the mouth, dizziness, digestive issues, fatigue, mood changes, excessive thirst, dehydration, and hormone imbalances manifested by rash and hair loss (Lidicker, 2021).

This analysis is based on the known mixture of toxins present in the home including dioxins, furans, lead, cobalt, chromium, vanadium, ash, soot and mold from water exposure combined with the potential for Tesla battery fire residue as well. The particulate matter as ash, soot, and char is what contains the heavy metals. This particulate matter more likely than not enters the home through the HVAC system and any compromised windows in the home.

Usual protocols for less toxic situations would allow for remediation through cleaning and sealant usage to stop future exposure, but in this case, with the presence of multiple toxins with significant acute and chronic exposure issues, the home has to be treated as a complete loss with scrap and rebuilt as the plan to restore to pre-loss condition. The complete removal of all construction materials of the previous dwelling will remove the presence of dioxins, furans, cobalt, chromium, lead, vanadium, zinc, lithium cobalt oxide, nickel oxide, manganese oxide and lithium hexafluorophosphate, hydrofluoric acid, soot, char, ash and all the various types of mold present in this house.

Many of these compounds have also been identified inside homes, which complicates the evaluation of health hazards from wildfire smoke residues. Background sources of PAHs in urban outdoor air and in homes not affected by wildfire smoke include smoke from fireplaces and cigarettes, asphalt pavement sealers containing coal tar, and vehicle exhaust. Background PAH levels in indoor air range from 0.00027 $\mu g/m^3$ to 0.05 $\mu g/m^3$, approximately twice the background levels found in outdoor air (Medina, 2016).

PAHs exist in equilibrium between a vapor and a solid phase and have a strong affinity for organic matter like charcoal. They attach to building materials and furnishings, such as carpet, gypsum wallboard, and even stainless steel, and slowly off-gas for time periods ranging from hours to weeks or months. As a result, PAHs are commonly found as a component of household dust. Typical background levels are in the range of 0.15 to 1.64 micrograms per gram ($\mu g/g$) of dust. Dust ingestion by children is the second most important route of exposure to carcinogenic PAHs, after inhalation exposure. However, household dust needs to contain more

than 150 times the typical PAH background levels to pose a lifetime cancer risk above one-in-one-million (Medina, 2016). Dust accumulation in the [redacted] house has to be controlled and eliminated as to prevent exacerbation of the family's medical conditions including asthma, environmental allergies and multiple chemical sensitivity conditions.

Where lead dust and the other seven heavy metals may have contaminated textiles or soft goods, drives the removal and replacement of these goods. The use of ozone, hydroxyls, cleansers, or deodorizers are not effective to remove lead dust or other heavy metals and should not be used for this purpose. Walls, floors, doors, cabinets, water pipes, railings and dishes and other hard goods would more likely than not be contaminated above levels that will cause adverse effects for Mrs. Pace and should be replaced. Clothes, bedding, soft goods, or children's toys should not be cleaned as the laundering process does not remove all of the contaminates (Fent et al., 2020). These items should be treated as contaminated and properly disposed of to prevent chronic exposure situations or exacerbation of [redacted] known medical conditions. Children often chew on their toys, clothes, blankets, and put things in their mouths. This is how lead can be ingested and is the main cause of lead poisoning amongst children (Scott & Scott, 2019). These same pathways of exposure discussed by Scott & Scott (2019) are relevant to the rest of the metals listed by Humphrey (2022a) as having high levels in this property.

Remediation Strategy

Traditional remediation strategies described by Battelle (1998) are not going to be effective for [redacted]. The use of more chemicals to sequester toxic chemicals is not an option with her medical conditions. The only way to solve the problem for [redacted] is the removal of all construction materials and building fresh from dirt for a positive outcome of restoring to pre-loss conditions (Hubbs & Murphy, 2019; Medina, 2016).

Summary

It is more likely than not that remediation would not restore this home to pre-loss condition and with the extensive and wide variety of known toxins and carcinogens, this home is best suited for complete removal and rebuild from dirt.

I have based my opinion on the information described herein as well as my experience and training as an industrial toxicologist and pharmaceutical scientist. I reserve the right to modify or supplement my opinion if additional information becomes available.

Sincerely,

Joe Nieusma, Ph.D.
[redacted]

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