COLORADO WILDFIRE REMEDIATION ANALYSIS RESIDENTIAL PREMISES AND INSURANCE IMPACTS REPORT

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Adjusters International	AI
Alternative Living Expenses	ALE
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American Property and Casualty Insurance Agency	APCIA
American Society for Testing and Materials	ASTM
Associate of the Casualty Actuarial Society	ACAS
Authorities Having Jurisdiction	AHJ
Center for Disease Control	CDC
Cleaning Industry Research Institute International	CIRI
Chartered Property Casualty Underwriter	CPCU
Chemicals of Concern	COCs
Colorado Division of Fire Prevention and Control	CDFPC
Colorado Department of Public Health and Environment	CDPHE
Contaminants of Potential Concern	COPC
Continuing Education Units	CEUs
Department of Health	DOH
Division of Insurance	DOI
Division of Water Resources	DWR
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Eaton Fire Residents United	EFRU
Environmental Analysis Associates	EAA
Environmental Protection Agency	EPA
Federal Emergency Management Agency	FEMA
Fire Adapted Colorado	FAC
Fire and Smoke Damage	FSD
Fourier-Transform Infrared Spectroscopy	FTIR
Gas Chromatography-Mass Spectrometry	GC-MS
Government Accountability Office	GAO
Heating, Ventilation, and Air Conditioning	HVAC
High-Performance Liquid Chromatography	HPLC
Indoor Environmental Professionals	IEP
Industrial Hygiene	IH
Insurance Institute for Business and Home Safety	IBHS
Institute of Inspection Cleaning and Restoration Certification	IICRC

ACRONYMS

International Organization for Standardization	ISO
Volatile Organic Compounds	VOCs
National Academy of Sciences, Engineering, and Medicine	NASEM
National Association of Mutual Insurance Companies	NAMIC
National Electrical Manufacturing Association	NEMA
National Interagency Fire Center	NIFC
National Institute for Occupational Safety and Health	NIOSH
National Oceanic and Atmospheric Administration	NOAA
Wildland-Urban Interface	WUI
Polycyclic Aromatic Hydrocarbons	PAHs
Professional Geologist	PG
National Association of Insurance Commissioners	NAIC
National Electrical Manufacturing Association	NEMA
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Occupational Safety and Health Administration	OSHA
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Perfluorooctane Sulfonic acid	PFOS
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Thermal Desorption-GC	TD-GC-MS
Total Volatile Organic Compounds	TVOCs
Toxic Organics	TO
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United Policyholders	UP
United States Geological Survey	USGS
United States Department of Agriculture	USDA
Vail Fire Department	VFD
World Health Organization	WHO
Wildland -Urban Interface	WUI
Western Water Assessment	WWA

EXECUTIVE SUMMARY

In response to a requirement under HB24-1315, this study seeks to provide recommendations to the Colorado Division of Insurance (DOI) in regard to standardized sampling, testing, and cleanup for residential properties impacted by wildland/range and wildland urban interface (WUI) fires. Additionally, this study evaluates the potential effects such recommendations might have on insurance costs and availability in Colorado. This study synthesizes insurance data, market research, and technical expertise to provide actionable insights for regulators, practitioners, insurers, and homeowners.

Background

WUI fires like Marshall in Colorado, as well as Palisades in California and Lahaina in Hawaii, highlighted the lack of established sampling and cleanup protocols for houses impacted by such fires, and that the practitioners (e.g., remediation contractors, industrial hygienists, etc.) and insurance carriers approached such situations differently, owing to the lack of standard protocols. The result has been widely varying claims and an inefficient and sometimes indefinite cleanup process.

Key Findings:

Contaminants of Concern (COCs): Although still evolving as new data is constantly being obtained, there is consensus forming around the key COCs associated with wildland/range and WUI fires. It is clear from recent studies that soot, char, and ash remain primary concerns, but that additional fire-related COCs are present at levels that pose human health risk. Primary among these are semi-volatile organic compounds (SVOCs) and heavy metals. Emerging contaminants, including Dioxins/Furans and per-and polyfluoroalkyl substances (PFAS/PFOS), represent a potential exposure risk in post-wildfire environments, but scientific understanding and regulatory guidance around these substances are evolving. This study found that, in most cases, the COCs can be limited to a few key indicators that serve as reliable surrogates, but limiting assessments to only soot, char, and ash overlooks key COCs that should be understood from the start. The determination of such COCs will also serve to establish clearance testing criteria that lend confidence to the policyholder that the house is acceptable for re-occupancy and provide comfort to the insurance carriers that cleanups can be streamlined.

Sampling and Testing Protocols: Industrial hygiene, sampling, and testing procedures vary greatly, often resulting in a “battle of experts” between the policyholder and the insurance carrier. Consensus is forming around the idea of using surrogates to guide sampling approaches and to limit the breadth of potential COCs, particularly at certain distances from the fire source areas. But a widely accepted standardized protocol is not yet established. This study found that having a standard, minimum testing protocol for all potential fire and smoke-impacted homes would result in a more cost-efficient system. This approach would ensure that cleanup plans consider the full range of potential COCs and that frivolous claims could be disproved quickly.

Cleanup and Remediation Standards: Comprehensive, enforceable cleanup standards are currently lacking. In some cases, this is because science has simply not caught up with the need. This study has provided potential comparison standards to use in decision-making for cleanup; however, these lack the weight of regulatory enforcement and are often not developed specific to residential risk tolerances. This study finds that residential, risk-based standards should be developed for post wildland/range and WUI fires applications for those COCs without current United States Environmental Protection Agency (US EPA) Regional Screen Levels (RSLs). Similarly, determining background levels of fire-related COCs is a critical component of the cleanup process, and this study found that such background standards are also lacking. There is extensive information available for the proper cleanup means and methods, and this study found that further input is not needed. However, the primary limitation is that most cleanup is focused on repair/cleaning of soot, char, and ash-only, often resulting in protracted conflicts between policyholders and insurance carriers, particularly in cases where the full range of COCs is not initially established. Given the changing landscape around the understanding of the full range of COCs expected in wildland/range and WUI fires, this study offers an analysis of whether the economics support replacement in cases of widespread impact by the full range of COCs, versus trying to repair/clean houses in such conditions. As the science around the breadth of COCs present in homes impacted by wildland/range and WUI fires, and cleanup standards evolve, cleanup approaches may need to be reassessed. Sampling for COCs that do not have formal standards should be avoided, except that sampling for the full range of fire-related COCs is important to developing the database for future work in this area. In the interim, this study suggests using COCs with accepted standards as surrogates for those COCs without an accepted cleanup standard.

Insurance Impacts: There are far-reaching potential implications to creating standardized sampling and cleanup protocols in Colorado. The void created by the lack of such standards is resulting in protracted disagreements between policyholders and insurance carriers, resulting in, among other issues, lengthy alternative living expenses (ALE) costs, excessive sampling costs, failed cleanups, and, in some cases, litigation. This study found that while initial costs would increase for sampling, establishing a standardized approach may ultimately result in lower overall insurance costs due to the more streamlined process and the lessening of conflicts between policyholders and insurance carriers. As has been seen throughout the history of developing standards in the environmental industry, moving from a place of lacking information to a place of having the information results in a more structured and cost-efficient approach.

Recommendations:

Standardize Sampling, Testing, and Remediation Protocols: Develop uniform, technically grounded protocols for wildfire-affected properties, differentiating between wildland/range and WUI fires, if feasible. Create a minimum standard for all houses impacted by wildfires to establish a clear yes/no decision process. Retain the ability to address site-specific conditions where warranted. Continue to test for the full range of fire-related COCs and modify the minimum standards as new information becomes available. Develop guidance on emerging contaminants as regulatory positions evolve.

Establish Comprehensive Cleanup Standards: Create enforceable state or federal standards for post-fire remediation to ensure consistent outcomes, reduce homeowner exposure risk, and facilitate claims processing. Include guidance for soil, structural materials, and personal property affected by smoke or chemical contaminants. Develop clear criteria for partial versus total loss determinations, incorporating both structural damage and COC exposure. Even though formal standards do not exist for all the fire-related COCs identified by this study, continue to test for such COCs so that a sufficient database can be created for future studies that will focus on this issue and to help develop a basis for determining background conditions.

Enhance Insurance Industry Preparedness and Response: Educate policyholders and insurers on anticipated changes in claims severity and frequency due to the new protocols, enabling actuarially sound adjustments to premiums, deductibles, and coverage structures. Encourage adoption of standardized claims handling procedures to reduce inefficiencies, legal disputes, and inconsistencies in coverage interpretation. Assess the potential for insurers to offer an optional wildfire-specific deductible and identify any safeguards needed to protect consumers. The assessment should also evaluate whether a separate wildfire deductible would produce a meaningful premium difference compared to the current all-perils deductible structure (excluding hail).

Complete a Data-based Insurance Cost Analysis: Seek input from the State's insurance carriers for specific data to be used to calculate a quantitative analysis of cost implications.

Ongoing Research and Monitoring: Track emerging scientific data on wildfire-related COCs and integrate findings into evolving sampling, testing, and remediation standards. Monitor insurance market trends, claim frequency, and loss severity to evaluate the effectiveness of protocols and identify areas requiring refinement.

Overall: A coordinated and standardized approach combining technical remediation standards, robust sampling/testing protocols, and insurance industry preparedness is essential to mitigate risks, ensure equitable coverage, and protect public health in Colorado's wildfire-prone communities. The adoption of these recommendations will enhance both operational consistency and risk transparency across all stakeholders.

1.0 BACKGROUND

The December 30, 2021, Marshall Fire was the most destructive wildfire the State of Colorado has seen, having transitioned from a grass fire to an urban firestorm fueled by burning embers on the wind. In eight (8) hours, more than 1,100 homes and 6,000 acres of land burned, and sadly also resulted in two (2) fatalities.

Following the Marshall Fire, two (2) studies performed by the University of Colorado tested the air quality to assess the health effects on occupants of the untouched, but smoke and ash-damaged homes. The first study found that levels of volatile organic compounds (VOCs) begin to decrease after the fire but linger for far longer. Testing detected elevated levels of COCs like benzene, copper, zinc, arsenic, and industrial pollutants, which can cause serious health issues with long-term exposure.

The second study surveyed 859 residents within two (2) miles of the Marshal Fire boundary and documented health symptoms between January 2022 and March 2023. The study revealed that over half of the survivors whose homes remained standing reported health issues due to poor indoor air quality. The study aptly noted that “uncertainty around the health impacts of WUI fires has contributed to a lack of clear guidance and regulations around home remediation and when it is safe to return to a smoke or ash-damaged home.” (Schoennagel et al., 2022).

The U.S. Forest Service defines the WUI as the zone where human-made structures and infrastructure intermingle with wildland vegetation, creating unique challenges for wildfire management and mitigation due to the proximity of combustible materials to homes and communities (Radeloff et al., 2005). This intermix significantly increases risks of structural damage and complicates post-fire remediation efforts, especially related to smoke and ash contamination indoors.

1.1 Colorado’s Evolving Wildfire Profile

Colorado exhibits many of these national patterns but with accelerated trends of its own. Recent analyses by Colorado State University (CSU) Regional Economic Development Institute (REDI) indicate that the number of wildfires in Colorado has grown from an average of ~13 per year in the early 1990s to over 70 annually in recent years, and that the average size of those fires has increased substantially (Gifford & Barbier, 2025). State fire statistics confirm that all 20 of Colorado’s largest recorded wildfires have occurred since 2001, with four (4) of the top five (5) in the past few years (Marshall being the largest), reflecting a rapid upward shift in risk (Colorado Department of Fire Control and Prevention and Control [FPC], 2025).

Fire season in Colorado has lengthened significantly; whereas historically fire seasons were limited to the warmest months, several analyses now place Colorado’s fire window at over 110 days in many regions (EPA, 2023). Off-season events further illustrate the altered fire regime, most notably the Marshall Fire, which occurred in December 2021 under extreme wind and dry conditions.

1.2 Other Communities

Beyond just looking at the Marshall Fire, other examples of WUI fires can be seen both in and outside Colorado.

Colorado

The East Troublesome Fire ignited on October 14, 2020, in the Arapaho National Forest near Kremmling, Colorado, and rapidly became one of the most destructive wildfires in Colorado’s recorded history. Fueled by extreme wind conditions, prolonged drought, and extensive tree mortality from bark beetle infestations, the fire exhibited uncharacteristically rapid growth, burning over 193,812 acres within a matter of days. The fire crossed the Continental Divide—an extremely rare occurrence - resulting in complex fire behavior and emergency evacuations throughout Grand County.

According to post-incident assessments from state and local agencies, the fire destroyed 366 residences and 214 outbuildings, while causing partial damage to additional properties across multiple communities, including the Columbine Lake area, Grand Lake, and Granby. In Columbine Lake alone, structure assessments indicated 26 complete losses, with many remaining homes affected by smoke infiltration, ash deposits, or thermal damage requiring remediation and repairs despite not being fully consumed by flames (Northwest Fire Science Consortium, 2023).

Although extensive research has documented the fire's ecological and hydrological impacts, particularly to water supplies, watershed stability, and erosion risk, the indoor environmental quality implications for homes that remained standing are less well-documented. The Colorado Division of Water Resources reported elevated concern about residential water system vulnerability, especially contamination from ash, debris, and sedimentation entering well systems in burn-scarred areas (Colorado Division of Water Resources [DWR], 2021).

The Colorado Department of Public Health & Environment (CDPHE) has provided general guidance for indoor air quality following wildfires, noting that homes within fire zones, even if not structurally destroyed, can contain harmful levels of fine particulate matter (PM2.5), volatile organic compounds (VOCs), and semi-volatile compounds adhered to walls, furniture, and HVAC systems. These compounds can persist long after active burning has ceased, potentially leading to adverse health effects if not properly remediated. The CDPHE's recommendations emphasize professional cleaning, source removal, and enhanced filtration but acknowledge a lack of standardized thresholds for re-entry or clearance levels in residential properties (CDPHE, 2023).

Colorado has also initiated broader wildfire smoke preparedness efforts through programs that focus on improving air quality in public buildings and distributing filtration resources to vulnerable communities. However, these efforts remain largely preventive and public-facility focused, rather than addressing post-fire residential remediation protocols - highlighting a persistent gap in state-level wildfire recovery infrastructure (CDPHE Smoke Preparedness Program, 2023).

Hawaii-Lahaina Fire

The Lahaina Fire, ignited on August 8, 2023, in Maui, Hawaii, rapidly evolved into one of the deadliest and most destructive wildfires in recent U.S. history. Propelled by prolonged drought conditions, highly flammable invasive grasses, and hurricane-type winds exceeding 60 mph, the fire devastated approximately 2,170 acres and destroyed over 2,200 structures, predominantly residential properties within the WUI (Federal Emergency Management Agency [FEMA], 2023). The rapid progression and intensity of the fire overwhelmed emergency response capabilities, complicating subsequent environmental assessment and recovery efforts.

Post-fire investigations by the Hawaii Department of Health revealed significant contamination of residential soils and surfaces by hazardous fire-related chemical residues. Ash and soil samples exhibited elevated levels of toxic substances, including arsenic, lead, antimony, cobalt, and copper, with arsenic concentrations measuring up to 11 times the established safety limits (Hawaii Department of Health [DOH], 2023). These contaminants likely originated from a combination of burning building materials, industrial chemicals, and legacy agricultural inputs, such as arsenic-based pesticides historically used on sugarcane crops, which were incorporated into some building materials known locally as "canec" (NIOSH, 2023).

Indoor infiltration of smoke, soot, and ash further compounded the risk to occupant health in structures that, while structurally intact, became reservoirs for persistent particulate matter and VOCs. Elevated levels of carcinogenic PAHs, formaldehyde, and other toxicants have been documented in similar wildfire scenarios, indicating potential long-term respiratory and neurological impacts for residents and recovery workers exposed during cleanup (California Air Resources Board, 2025).

The Lahaina fire highlighted critical challenges in wildfire remediation that extends beyond structural rebuilding. Current remediation approaches remain largely reactive and inconsistent, with limited standardized methodologies for assessing and mitigating invisible chemical residues that compromise indoor environmental quality and occupant safety. Furthermore, the unique presence of legacy contaminants such as arsenic-laden "canec" materials introduces complex hazardous waste management concerns rarely addressed in wildfire recovery protocols.

Other State Initiatives

Several states are now initiating research and regulatory exploration in this domain, though comprehensive policies remain in development. In 2024, California's Department of Public Health established the Wildfire Smoke and Health Task Force to investigate indoor exposure pathways and define science-based remediation thresholds. Oregon's Department of Environmental Quality launched a multi-year research effort in 2023, focused on post-fire indoor air quality and contaminant behavior following the 2020 Labor Day Fires. In Washington, the Department of Health is drafting interim guidance for indoor air sampling and remediation strategies post-WUI fire, supported by the University of Washington's Center for Health and the Built Environment (Washington State Department of Health, 2025). While these initiatives reflect a growing awareness of the issue, none have yet resulted in enforceable, statewide remediation protocols. Instead, efforts remain fragmented, and most states are still in preliminary research or pilot program phases.

In response to the escalating wildfire crisis nationwide, several states, most notably California, Oregon, and Washington, have initiated research programs and task forces focused on the development of comprehensive wildfire smoke and ash remediation frameworks. These initiatives seek to fill significant knowledge gaps, such as understanding contaminant persistence indoors, establishing safe clearance levels, and standardizing remediation protocols (Washington DOH, 2025). Despite these efforts, no existing framework fully addresses the unique challenges posed by the intersection of wildfire contamination, indoor air quality degradation, and the diversity of building materials and fire types.

This context reinforces the importance and pioneering nature of Colorado's House Bill 24-1315 and the associated comprehensive study it mandates. As wildfire events become more frequent and severe due to climate change, this study aims to establish replicable inspection, sampling, and remediation standards that can guide not only Colorado but also inform national efforts to protect residential health and safety in wildfire-impacted communities.

1.3 What Have We Learned?

The Marshall, Palisades, and Lahaina Fires, and the many recent examples of others like it, illustrate several key technical and regulatory challenges directly relevant to the scope of this study under HB24-1315, namely, the lack of standardized methods for evaluating and remediating smoke-damaged homes, the variability in testing protocols, and the absence of health-based reentry criteria. The regulatory gaps observed in Colorado, California, and other states underscore the broader need for technically grounded, replicable frameworks that address the persistent indoor contamination of homes affected by wildfire smoke, soot, and ash.

In the evolving landscape of wildfire risk, particularly in the WUI, there remains no authoritative, enforceable standard for performing inspection, sampling, and remediation in homes affected by smoke, ash, and soot infiltration. Regulatory and technical guidance instead remains fragmented across various agencies, each typically focusing on debris removal, outdoor air quality, or structural firefighting, rather than on the less visible, but potentially insidious, contamination of indoor environments.

Due to the outcry from survivors of WUI fires, there has been a rush to fill the void in the regulatory landscape, but as of yet, no accepted regulatory program in Colorado. Many new, useful resources have been recently published, including, but not limited to, the Institute of Inspection, Cleaning and Restoration Certifications' (IICRC) S500 and S700 protocols, the American Institute of Industrial Hygiene's (AIHA's) Technical Guide for Wildfire Impact Assessments for the OEHS Professional (2025 2nd Addition), the Rocky Mountain Association of Public Insurance Adjusters (RMAPIA): Fire Protocol, and the very recent Wildfire Restoration Technical Guide (RIA, IICRC and CIRI, 2025)to name a few. Along with these trade-developed protocols, several universities have initiated studies, including the University of Colorado (Anchutz-Boulder Campus).

1.3.1 Emerging Guidance and Its Current Limitations

In recent years, several professional and industry organizations have begun addressing gaps in post-fire and smoke-damage remediation. Notably, the American Industrial Hygiene Association (AIHA), the Institute of Inspection, Cleaning and Restoration Certification (IICRC), and the Rocky Mountain Association of Property Insurance Adjusters (RMAPIA) have each issued or are developing guidance documents that improve understanding of contaminant behavior and cleaning practices following wildfires and structural fires (AIHA, 2023/2025; IICRC, 2024; RMAPIA, 2023). Their work reflects recognition of the growing complexity of fire-related contamination in modern homes and the inadequacy of older practices based solely on aesthetic cleaning.

Collectively, these resources mark significant progress over the absence of any systematic guidance, but they still fall short in critical respects. Notably:

- Lack of enforceable cleanup thresholds. None of these documents establishes binding numerical standards for allowable residues and contaminants.
- Insufficient coverage of mixed contaminant exposures. Fire residues may include dioxins, furans, heavy metals, and semivolatile organic compounds, but these guidance texts generally focus on inorganic ash and visible soot.
- Lack of guidance for verification testing. While sampling methods are suggested, guidelines often leave the number of samples, pass/fail criteria, and retesting protocols to the practitioner's discretion. This leads to inconsistent quality and possible false negatives or over-cleaning.
- Limited applicability across building types. Many existing standards assume conventional wood-framed homes with common finishes; they are less applicable to modern construction (e.g., composites, sealed surfaces, HVAC systems) where contamination may penetrate deeply.
- No regulatory weight. Because these are voluntary or advisory documents, adoption varies widely; some jurisdictions or insurers may reject or override them altogether.
- Inconsistent implementation and training. The degree to which inspectors and contractors actually follow these guidelines depends on local expertise, cost constraints, and oversight, which can result in large variations in remediation quality.

Beyond U.S.-based industry guidance, several international and peer-reviewed frameworks have begun addressing indoor contamination and post-fire environmental health. The World Health Organization (WHO, 2023), through its guidelines on indoor air quality and exposure to particulate matter ($PM_{2.5}$), highlights the health significance of fine soot residues but does not prescribe cleanup verification methods for structures impacted by combustion events. The International Organization for Standardization (ISO) has developed related standards on indoor air and surface contamination measurements - such as ISO 16000-41:2020 on indoor air particle sampling, but these focus on analytical procedures rather than post-remediation acceptance limits (ISO, 2020). Academic studies on wildfire smoke contamination (e.g., Clark et al., 2021; Morrison et al., 2022) consistently emphasize the persistence of semi-volatile organic compounds and the absence of uniform criteria for restoration success.

Despite recent advances and growing interest in post-fire remediation, the current field of fire damage assessment and remediation still faces significant limitations that compromise consistency, scientific rigor, and practical applicability. While guidance documents such as the newly published ANSI/IICRC S700 Standard for Fire and Smoke Damage Restoration offer improved principles and procedures for assessing fire residues, they still fall short of covering a comprehensive suite of combustion byproducts, contexts (e.g., wildfires), or reentry criteria (ANSI/IICRC S700, 2025). Furthermore, many industry practices continue to rely on legacy approaches or extrapolations from non-fire contexts, leading to inconsistencies in sampling protocols, unclear thresholds for remediation, and divergent cleanup scopes across practitioners. These limitations underscore the need for a robust, scientifically grounded framework tailored to residential fire events and the full range of chemicals of concern (COCs).

Thus, the landscape of post-fire remediation guidance today is a patchwork of evolving standards, regional insurance practices, and professional publications. Colorado's HB 24-1315 presents a unique opportunity: to converge these disparate efforts into a science-driven, enforceable, public-health oriented standard that bridges remediation practices with occupant safety. In doing so, the Colorado study can help define clear performance criteria, verification testing standards, and ongoing oversight mechanisms that the current resources do not uniformly provide.

2.0 METHODOLOGY

Partners completed various activities in support of this project, including, but not limited to:

- *Conducted research of an extensive list of reference materials, conducted stakeholder meetings and interviews, and assessed other potential comparison standards. The study also distinguished between what is understood to be current standards versus recommendations for applicable standards to be used in the future. This activity also included the evaluation of applicable COCs that form the basis of remediation decision-making.*
- *Researched various available standards to establish current methods for cleaning, repair, and remediation, including distinguishing between COCs typical of range/wildfires and residential fires. Procedures for standardized laboratory analytical testing protocol and field-testing methods were also evaluated.*
- *Partners' analysis included assessing current conditions and comparing such to proposed recommendations. Impacts on testing and cleanup costs were assessed relative to the proposed recommendation.*
- *Partners also evaluated the potential to create guidelines for determining if fire-damaged homes, including structures, furnishings, and personal property could be repaired/cleaned or if they must effectively be replaced.*
- *Two (2) Stakeholder meetings were held during the completion of this study, as well as 10 interviews.*

The work summarized in this report and included the following activities:

1. Research: Through the completion of Interviews, Stakeholder Meetings and research of readily available publications, information was gathered to gain an understanding of current industry condition and to develop recommendations on COCs, laboratory analytical methods, field sampling methods/protocols, and applicable cleanup standards for each COC.
2. Technical Assessment: The information obtained from the research was summarized in the Technical Assessment portion of this report.
3. Insurance Assessment: The information obtained regarding the current insurance conditions and potential impacts on cost and availability of homeowners insurance is summarized in the Insurance Assessment portion of this report.
4. Conclusions: Based on the results of the Research, Technical Assessment and Insurance Assessment, the primary conclusions for this report are provided.
5. Recommendations: Based upon the conclusions, recommendations are provided for best practices regarding inspection, sampling, and cleanup standards for residential properties impacted by wildfires. Additionally, through research, interviews, and stakeholder discussions, various forward-looking ideas related to wildfire issues were brought forward that are summarized in this report.

3.0 RESEARCH

Partners conducted research in the form of interviews, stakeholder meetings, and literature review.

The information obtained during the stakeholder meetings and Interviews will be summarized in the Final Draft report, once all activities are completed.

3.1 Stakeholder Meetings

Partners and the AGENCY conducted two (2) Stakeholder meetings, each are summarized below.

In preparation for each Stakeholder meeting, the AGENCY sent out a proactive communication to its e-mail distribution list of 6,000+, inviting them to participate in the stakeholder meeting. Meeting information was also available on the calendar on the AGENCY's home page. Additionally, Partners invited the entities requested for interviews to participate. The first Stakeholder meeting was held on October 20, 2025, and had over 100 participants. The second Stakeholder meeting was held on XXXXXXX and had over XXX participants.

3.1.1 Stakeholder Meeting 1

The first Stakeholder Meeting was held on Monday October 20, 2025. A copy of the PowerPoint presentation from the Stakeholder Meeting is provided in **Appendix A**.

Mr. Jason Lapham, Deputy Commissioner for the AGENCY, introduced HB24-1315 study considerations and purpose, and the agenda for the Stakeholder Meeting. Partners then introduced the team members of the Remediation Study as well as the Remediation Study approach. The PowerPoint presentation was presented by Partners.

After the PowerPoint presentation, the meeting was opened up for questions from the attendees, which included the following questions, comments, and discussions:

1. Attendee #1, a resident of Colorado and formerly with United Policyholders, asked if – and how – the study was separating contents versus the structure in terms of replacement versus repair.
    - Partners responded that if there is adequate sampling of the structure and/or contents, then it can be concluded that the contents will go the way of the structure. Ms. Judy with the AGENCY responded that in today's conditions, often the contents do not go the way of the structure, and recommended putting contents into the Study recommendations. Further, there is often a separate contractor for the sampling of contents.
    - Attendee #1 expressed concern about the limited sampling done by insurance companies, consistency in recommendations for cleaning, and the absence of recommendations as to how to address lead impacts.
2. Attendee #2 is working on tracking indoor contamination associated with the Eaton Fire in California as part of Eaton Fire Residents United (EFRU). Attendee #2 indicated that they have had testing data collected by IH – including results and methodology. Attendee #2 also indicated that the leading COC is lead, and other heavy metals, and asbestos.
    a. Attendee #2 raised ethical concerns associated with IHs having partnerships with remediation companies and having their own labs. Attendee #2 asked if there is an approach in the Study to clear up ethical concerns?
    b. Partners responded that there will be a recommendation in the Study for certifying inspectors and remediation contractors, in Colorado, much like there is for other programs, e.g., asbestos, lead-based paint, etc.
3. Attendee #3 (a member of Marshall ROC) indicated that although there are differences between the fire types, wind is also a factor. Attendee #3 also indicated that thermal damage is missing from the list of soot, char, and ash. Attendee #3 asked if the recommended standards in the Study would also apply to insurance companies not based in Colorado, and the need for agencies outside of Colorado to work together.
4. Attendee #4 asked what triggers the IH inspection and testing? For example, distance and wind strength. And once the IH report is complete, the report should include a prescription for the remediation and not just the results. Attendee #4 also asked whether most clean-up testing will be performed.

5. Attendee #5 (a Superior Disaster Supervisor), states that homeowners should not assume they are in a safe zone, because fine particulates can travel far, and stormwater impacts should also be a consideration.

3.1.1.1 Proposed Survey Questions

As part of the PowerPoint presentation, various questions were posed to the attendees. The attendees were given the opportunity to provide feedback in the meeting (see **Section 3.1.1**) and were offered contact information should they wish to provide such after the meeting. The questions were separated into Technical and Insurance-related categories and are shown below. The purpose of the questions was to prompt discussion and to seek information on gaps in the data identified during Partners' research.

Technical Related

- What sampling/testing methods are currently being used?
- What COCs are being tested for?
- What cleanup/regulatory standards are being used?
- Is there a standard above which a house would be replaced verses repaired?

Insurance Related

- What are the standard testing/industrial hygienist costs that presently occur for fire losses per loss?
    - o What are the average ALE utilizations with homes that need to be replaced vs homes that require repair/cleaning?
- What are the common coverage limits for Coverage C contents and what amount of these limits tends to be absorbed when remediating for wildfire losses?
- What unique trends are commonly observed with wildfire losses versus individual fire losses?
    - o Ex: Any differences in Claims timelines? For instance, has it been observed that wildfire losses take six (6) months longer to go through commonly used handling and resolution processes?
- Are there common claims handling bottlenecks experienced?
- What percentage of claims involve mediation/litigation?

3.1.1.2 Stakeholder Meeting #1 Summary

Over 100 attendees joined Stakeholder meeting #1. Several people provided feedback and questions during the meeting, with some follow-up afterwards. The meeting allowed for the communication by the AGENCY of the status of the project and created a meaningful forum for attendee feedback.

3.2 Stakeholder Meeting 2

3.2.1 Stakeholder Meeting #2 Summary

Once conducted, provide a summary of Stakeholder Meeting #2 here

3.3 Literature

Our team reviewed hundreds of references for this study to gain a complete understanding of the current research available. The sources relied upon for this report are included as a full bibliography in **Appendix B**.

4.0 TECHNICAL ASSESSMENT

4.1 Methodology

4.1.1 Current State of Industry

Much is happening in the industry at present, with the recent release of the Institute of Inspection, Cleaning, Restoration, and Certification's (IICRC's) S700 and the existing S500, the American Industrial Hygiene Association's (AIHA's) 2025 Technical Wildfire Guide, the Rocky Mountain Association of Public Adjusters (RMAPIA) Fire Protocols (2025), and most recently the Technical Guide for Wildfire Restoration (V1, 2025) jointly released by the restoration Industry Association [RIA], IICRC, and Cleaning Industry Research Institute International [CIRI]). However, among other limitations, some of these reference materials are not focusing on the full range of COCs that result from residential fires. Additionally, there is no single source that has established a standard sampling protocol or applicable cleanup standards, allowing for variances in application of these standards and inconsistency between insurance company protocols and by consultants supporting insurance companies, insured parties, and cleanup contractors. Further, the individuals responsible for identifying the extent of smoke damage and developing the recommended scope of work to return the smoke-damaged structures (the industrial hygienists, environmental scientists, consultants, etc.) and the remediation contractors often come from diverse backgrounds and may not follow consistent industry standard practices. The ultimate result is that currently the response to fire residue cleanup varies significantly based on who is leading and conducting the fire cleanup.

Historically, the smoke residue assessment and remediation industry has focused on using soot, char, and ash and now some organizations are suggesting these compounds are suitable as surrogates for the other fire/smoke chemical residues, primarily it seems because accepted or mandated cleanup standards do not exist for other widely recognized COCs resulting from WUI and wildland fires. Since 2020, consensus has been building around an increasing focus on additionally sampling for the primary and secondary fire constituent chemicals as surrogates for the full range of structural fire chemicals in sampling methods and clearance standards.

4.1.1.1 The Institute of Inspection, Cleaning, Restoration, and Certification (IICRC): S700 Standard for Professional Fire and Smoke Damage Restoration & S500 Standard for Professional Water Damage Restoration

Per the IICRC website, "The IICRC is the Institute of Inspection Cleaning and Restoration Certification, a non-profit organization for the Inspection, Cleaning, and Restoration Industries. The IICRC, originally named the International Institute of Carpet and Upholstery Cleaning Inc. (IICUC), was founded in 1972 by Ed York. Since starting in 1972, the IICRC has evolved into a global organization with more than 49,000 active Certified Technicians and more than 6,500 Certified Firms around the world." As a non-profit focused on supporting cleanup technicians and companies, it is oriented to addressing cleanup procedures and protocol. The IICRC was also supported by the Restoration Industry Association (RIA). According to their website, RIA offers educational webinars and sessions designed to help restoration professionals further develop their leadership skills, recruit and retain employees and grow their businesses. They also seek to unite the restoration industry, advocate for the best interests of restoration contractors nationwide, and develop and implement strategies to help create and maintain equity between restorers and insurers and their partners.

S500 Overview:

Per the IICRC website, "This Standard describes the procedures to be followed and the precautions to be taken when performing water damage restoration in residential, commercial, and institutional buildings, and the systems and personal property contained within those structures…This Standard assumes that the determination and correction of the underlying source or cause of the water intrusion leading to the water damage is the responsibility of the property owner and not the restorer, although the property owner may contract with the restorer or other specialized experts to perform these services."

S700 Overview

Per the IICRC website," This standard describes the principles, processes, and procedures for assessing the presence, intensity of impact and boundaries of fire residues and odors affecting a building, building systems (e.g., Heating, Ventilating and Air-Conditioning (HVAC)), and contents after a fire event. The fire event can occur within the building, an adjoining building(s), or building(s) in the vicinity impacted by an external or internal fire, other than wildfires. This standard also describes the practical principles, methods, and processes including equipment, tools, and materials, for the restoration cleaning and fire odor management of buildings and contents. This standard also addresses contractor qualifications, administrative requirements, procedures, development of the Restoration Work Plan (RWP), documentation of project-related events, and compliance with Authorities Having Jurisdiction (AHJ)."

The website goes on to state that this standard does not comprehensively address:

- Building demolition other than for Fire and Smoke Damage (FSD) assessment, mitigation, or as source removal procedure
- Reconstruction
- Issues occurring from certain situations such as wildfires, chemical fires, or industrial fires that pose environmental hazards.
- Buildings (e.g., healthcare, laboratory facilities, clean rooms, life science facilities) with special requirements
- Occupants with special requirements (e.g., immunocompromised, respiratory diseases, heightened sensitivities, elderly, infants)
- Exposures impacting occupants.
- Safety concerns associated with performing restoration work
- Procedures for addressing regulated hazardous materials.

With this context, the focus of the S500 and S700 protocols is to provide restoration best practices but falls short of providing cleanup standards for COCs other than soot, char and ash. Further
the Standards are not intended to establish procedures or criteria for assessing contamination in an indoor environment. According to the IICRC, these issues are most appropriately addressed by professional organizations that represent indoor environmental professionals (IEPs) or other relevant specialized experts. The Standards do not specifically address the protocols and procedures for restoration when potentially hazardous, regulated materials are present or likely to be present in water-damaged structures, systems, and contents.

Both standards focus mitigation/cleaning/repair of the structure and contents as a primary consideration with ancillary notation that some restorative actions may not return the property/contents to pre-loss condition or do so in a cost-effective manner. While both standards do acknowledge the potential need to replace property or contents, much is left to individual contractor interpretation which may result in inconsistent application of replacement.

4.1.1.2 The American Industrial Hygiene Association (AIHA): Technical Guide for Wildfire Impact Assessments for the OEHS Professional

According to its website, the AIHA "…is the association for scientists and professionals committed to preserving and ensuring occupational and environmental health and safety (OEHS) in the workplace and community. Founded in 1939, we support our members with our expertise, networks, comprehensive education programs, and other products and services that help them maintain the highest professional and competency standards. More than half of AIHA's nearly 8,500 members are Certified Industrial Hygienists, and many hold other professional designations. AIHA serves as a resource for those employed across the public and private sectors and the communities in which they work."

They further clarify "OEHS professionals (also known as industrial hygienists) practice the science of anticipating, recognizing, evaluating, controlling, and confirming protection from hazardous workplace conditions that may cause workers injury or illness."

The AIHA's Primary resource related to fire is the "AIHA Technical Guide for Wildfire Impact Assessments for the OEHS Professional (2nd edition)."

AIHA Technical Guide Overview

Per the www.aiha.org website: "The second edition of the AIHA® Technical Guide for Wildfire Impact Assessments for the OEHS Professional presents the current understanding of wildfire combustion processes and the chemical transformations that generate particulates, organic compounds, and metal residues."

The scope of the Guide is on homes, buildings, and structures that were outside of the burn zone or survived a wildfire or a WUI fire and can be restored and reoccupied.

The primary purpose of the Technical Guide is to help occupational and environmental health and safety (OEHS) professionals, and other investigators, design and conduct wildfire impact assessments for exposure evaluations, forensic origin and cause investigations, or both.

The Guide offers a thorough analysis of the science and chemistry of wildfires, particulates created by wildfires and other combusted materials, distances combusted materials might travel in the air, a detailed method of impact assessment, review of numerous sampling methods as well as testing methods, data interpretation, and an overview of considerations and potential handling as it relates to the restoration process.

While offering a detailed process of research and interpretation to inform the inspector, the process relies on an iterative approach that must be modified and refined for each individual situation, effectively treating each house as an individual study. The Guide is focused on inspection, pointing to existing studies for decision about cleanup. The guide also acknowledges that there are not widely accepted published standards for many of the chemicals expected in residential and wildland fires and that testing for chemicals without having an established standard should be avoided. Therefore, they conclude that using soot, char and ash as a surrogate for addressing all chemicals is the best practice given current constraints in the industry.

4.1.1.3 Rocky Mountain Association of Public Insurance Adjusters (RMAPIA) Fire Protocol

**The reader should recognize that the primary authors of the RMAPIA Fire Protocol were also members of the team that prepared this study.*

The Rocky Mountain Association of Public Insurance Adjusters (RMAPIA) is a professional association comprised of licensed public adjusters operating in the Rocky Mountain states, including Colorado, Arizona, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming. Their members represent policyholders exclusively, providing an advocacy role for individuals and commercial property owners in property-loss claims (RMAPIA, n.d.).

RMAPIA has gained relevance for fire and smoke damage in residential settings through its publication of the RMAPIA Fire Protocols, which are designed to provide a science-based framework for evaluating fire-loss events, particularly those involving smoke, soot, ash and other fire-related contaminants

(RMAPIA, 2025). These protocols articulate a “Universal Fire Testing Method,” set forth categories of fire loss, and recommend clear criteria for repair vs. replacement decisions — all anchored in toxicology, exposure science, and claims practice (Phalen & Niusuma, 2025, as cited in RMAPIA, 2025).

For the purposes of the present study mandated under Colorado House Bill 24-1315, RMAPIA’s work is significant for several reasons:

- The Fire Protocols address gaps in remediation standards by translating exposure science into actionable guidance for field practitioners and claims professionals, thereby bridging technical assessment and insurance outcomes.
- Their emphasis on toxic byproducts (such as PAHs, heavy metals, VOCs, SVOCs) and the need to evaluate structure/contents holistically aligns with the study’s focus on COCs and remediation thresholds (RMAPIA, 2025).
- From an insurance loss perspective, the Fire Protocols provide a structured method to evaluate when repair may be inadequate and replacement more appropriate - an aspect critical to the insurance assessment portion of this study (especially **Section 5.0**) where “repair vs. replacement” thresholds are being developed.

The RMAPIA Fire Protocols advance the current state of the industry, bringing forward important considerations on the extent of impacts within a residential structure, and potential limitations on the ability to remediate the full range of contaminants typical of residential fires, but may go too far in requiring replacement in cases where widely accepted cleanup standard do not exist.

4.1.1.4 World Trade Center (2003)

The World Trade Center (WTC) studies conducted in 2003, including the EPA Region 2 WTC Background Study Report (April 2003) and the World Trade Center Indoor Environment Assessment: Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks (May 2003), represent some of the most comprehensive post-disaster contaminant assessments performed at the time. Both reports focused on evaluating residential indoor environmental conditions impacted by the collapse of the WTC towers, identifying contaminants of potential concern (COPCs), and establishing preliminary health-based benchmarks for those chemicals (EPA, 2003a; WTC Indoor Air Task Force, 2003). The WTC studies provide valuable historical context and a foundation for understanding contaminant identification and risk-based assessment methodologies.

The WTC reports emphasize the systematic identification and prioritization of a wide range of chemical constituents, including particulate matter, VOCs, polycyclic aromatic hydrocarbons (PAHs), and heavy metals, in the post-event indoor environment. The studies outline detailed sampling strategies, analytical methodologies, and risk-based approaches for assessing potential exposures, reflecting best practices for residential indoor environmental assessment at that time.

One of the most valuable aspects of the studies is the determination of the COPCs. Based on the analysis of over 500,000 samples, this study concluded that only a short list of COPCs were present in residential indoor air. Given the scale of the WTC disaster, this information is likely to represent a conservative, “worst case” example for comparison with wildland and WUI fire impacts.

While these reports were deemed highly valuable, the information must be tempered, given that it is over two (2) decades old and was developed following a commercial building collapse and involved sampling of residents in New York City only, thereby limiting their direct applicability to residential homes affected by WUI and other wildfire events in Colorado.

The reports highlight the need for site-specific assessments, careful consideration of building types, and recognition of evolving chemical exposures in modern residential fires - points that align with the broader gaps identified in the IICRC, AIHA, and RMAPIA guidance.

4.1.1.5 Technical Guide for Wildfire Restoration (V1, 2025)

The IICRC, in coordination with the RIA and CIRI, has released a white paper titled “Technical Guide for Wildfire Restoration. Version 1: November 2025”. This white paper was released to address what the authors noted to be problematic, unscientific opinions in a minority of the wider industries serving fire-affected populations:

"It has come to the attention of our organizations that a growing, unfounded sentiment is emerging, suggesting that homes affected by wildfire smoke and its byproducts are categorically uncleanable and unrestorable. According to this viewpoint, wildfire-damaged homes should be stripped down to the studs and rebuilt. This unsupported belief is not grounded in science, established work standards, or represented by the common, reasonably prudent, and proven restoration practices utilized in the restoration community.

The idea that the disposal of porous materials and soft items, as opposed to the prioritization of cleaning a structure post-wildfire, appears to lack support from any authoritative industry guideline document. The California Air Resources Board, the United States Environmental Protection Agency, the South Coast Air Quality Management District, the California Department of Public Health, nor any other public health agency make recommendations that occupants of wildfire smoke-infiltrated residences should dispose of all of their furnishings and personal items, nor demolish and rebuild their homes.

Wildfire smoke, together with volatile and semi-volatile compounds and metals, adsorbs or condenses on the surfaces of particles that infiltrate structures and settle on the surfaces of interior materials. This is a superficial occurrence that can generally be cleansed. Specialized cleaning methodologies have been successfully used to remove infiltrated and deposited wildfire smoke residues and other potentially hazardous contaminants to typical background levels for decades by the thousands of professional cleaners and restorers our organizations represent. While disposal may be considered where cleaning costs surpass the item's value or where heavily impacted porous materials such as apparel, bedding, infant items, and toys exhibit hand-to-mouth contact risks, the presumption that all materials and structures are unrestorable is inconsistent with science, successful restoration projects, and accredited industry standards." (IICRC et al, November 2025).

This recently released white paper provides a useful perspective from the restoration industry on the ability to clean porous materials in homes and reflects the iterative sampling approach spelled out in the AIHA guide (2025). It also indicates that soot, char, and ash can serve as a surrogate for all other potential COCs outside of immediate burn zones. The lack of a minimum sampling standard and the reliance on soot, car, and ash only as surrogates for other fire-related COCs limit the efficacy of this approach.

4.1.2 Primary References

This project has included research with resources including but not limited to, the American Industrial Hygiene Association (AIHA), the American National Standards Institute (ANSI), the Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA), Colorado Department of Public Health and Environment (CDPHE), Center for Disease Control and Prevention (CDC), World Health Organization (WHO), National Electrical Manufacturing Association (NEMA) Smoke/Heat, Contaminants of Potential Concern (COPC) Committee of the World Trade Center Indoor Air Task Force Working Group, and the American Society for Testing and Materials (ASTM), among others.

The importance of the primary references specified above lies not only in their being widely recognized as primary sources of regulatory guidance and industry consensus best practices, but also in their being the most rigorously developed and supported bodies of guidance and expertise.

A full list of references is available **in Attachment B**, Bibliography.

4.1.3 Other Limitations of the Current State of the Industry

In addition to those limitations identified in **Section 1.3.1** regarding the ongoing and evolving research around residential and wildland fire impacts, the literature also suggested other limitations that were considered in this study.

4.1.3.1 Limitations of Current Microscopy Tests

Optical and electron microscopy remain foundational tools in the characterization of fire residues—soot, char, and ash—but they present notable limitations when used in isolation in post-fire residential assessments. For example, high-resolution studies have shown that soot particles can form in sub-5 nm diameters and possess highly complex internal morphologies that are difficult to resolve fully via routine microscopy techniques (Veronesi et al., 2022). Furthermore, the chemical attribution of particles (e.g., linking a particle to a fire event versus background dust) often demands complementary analytical methods (Botero et al., 2021). Thus, applying microscopy alone may not provide sufficient resolution or specificity to differentiate ultra-fine particulates nor definitively attribute contamination to combustion sources, which undermines defensible conclusions for remediation or insurance frameworks.

Current microscopic methods have limitations based on the potential for analyte loss due to dilution, alteration, and potential interference inherent to a given method.

The reporting of a given analytical method for fire constituents is also based on the collection efficacy of the sampling method chosen by the individual collecting the sample submitted for analysis and the media selection's implications for pre-analysis sample preparation. Significant loss and/or alteration of particulate mass can take place based on media selection alone, in addition to a given sample type's ability to properly capture and retain the analyte(s) desired for enumeration. Limitations remain in a portion of the industry due to a lack of understanding of the purpose and correct employment of various sampling protocols and media options in the range of different situations likely to be encountered within subject structures.

4.1.3.2 Lack of Fire-Specific OSHA / Regulatory Guidance

Current occupational safety frameworks—such as Occupational Safety and Health Administration (OSHA) standards—are generally designed for industrial or general indoor air quality exposures but do not specifically address the complex mixtures of combustion by-products found in fire-impacted residential structures (NIOSH, 2021). For instance, while OSHA sets permissible exposure limits (PELs) for certain VOCs or metals, it does not provide guidance specific to soot/char deposition, semi-volatile organics embedded in building materials post-fire, or occupant re-entry criteria following fire remediation. The lack of binding regulatory thresholds tailored to residential fire environments forces practitioners to apply proxy standards—often developed for industrial exposures—which may not be sufficiently protective in a post-fire remediation context.

OSHA's statutory mission is to focus on potential contaminants and stressor risks to employed workers and does not focus on potential contaminant exposures to third parties or the environment. With regard to fire damages, OSHA focuses on employee exposures over time, the duration and consistency of the tasks and exposures they are employed in, and what their protection factors are in any given setting. From OSHA's perspective, it is the employer's role to protect their staff, but OSHA's prevue does not include homeowners or other non-employed individuals. That said, OSHA PELs can be a contributor to decision-making, to the limited extent that is meaningful to our purpose of determining contamination inside residential structures.

From OSHA's perspective, it is the employer's role to protect their staff, but OSHA's prevue does not include homeowners, tenants, or other non-employed individuals. That said, OSHA PELs can be a contributor to decision-making, to the limited extent that is meaningful to our purpose of determining contamination inside structures.

While OSHA standards are provided as a reference in **Table 1**, this study recognizes that they do not specifically apply to residential applications.

4.1.3.3 Inconsistencies Between Consultants for Insured vs. Insurance Companies

The response to a fire-damaged property is inherently a very personal experience. Having one's home associated with the tragedy of a fire loss, the smell of smoke, and visible fire residues, is a deep violation of one's personal space. Residents of smoke-impacted homes have every right to be concerned for the health and safety of their families, and they need to gain confidence that their home will be returned to its pre-fire-damaged condition. In addition to individual differences in the level of concern regarding contamination, there are group differences in their role in defining the fire event. The homeowners may be biased to require replacement in excess of industry standards. The insurance companies may be biased to not pay for work that is outside of their policy coverages or what they view as being in excess of industry standards. The inspectors and industrial hygienists may be biased to make certain that they don't miss anything that might be later identified as resulting from the fire. The remediation contractors may likewise be biased to completing repairs instead of replacement, due to their business models and directions from the insurance industry. And every one of these groups of interested parties ultimately do not wish to be blamed for inadequately responding to the needs of others. If individuals, from any of those groups of interested parties, are new to responding to fire contamination, there is a fear factor that magnifies the potential hazards of the event and causes concern that the responses of others may not meet their specific and individualized needs.

In practice, the absence of enforceable remediation standards and the variability of interpretive frameworks result in significant inconsistency among consultant-led assessments. One consultant working for an insured homeowner may adopt a conservative sampling strategy with broad chemical panels and lower action thresholds to ensure full characterization of fire-related contaminants, while a consultant retained by an insurer may rely on minimal or no sampling and apply more permissive thresholds. These diverging practices reflect the lack of a federally mandated or universally adopted standard for post-fire contamination assessment (U.S. Government Accountability Office [GAO], 2022; AIHA, 2023). The AIHA has noted that without consensus-based criteria, different professionals often reach conflicting conclusions about contamination extent, safety for reoccupation, and required remediation scopes (AIHA, 2023). The National Academies of Sciences, Engineering, and Medicine (NASEM) also highlights that risk perceptions and professional judgment can vary widely in the absence of binding regulatory thresholds (NASEM, 2020). These inconsistencies can cause disputes, insurance claim delays, or lead to under- or over-remediation, depending on whose consultant's methodology is adopted. The result is often frustrating for homeowners, insurers, and public agencies alike—and a reduced ability to protect health and property effectively.

4.1.3.4 Differing Methods

Smoke assessment professionals historically have performed their work following differing inspection and sampling procedures, and the remediation contractors have historically varied in their approaches to the remediation of smoke residues. Since fire response experts (practitioners such as industrial hygienists and remediation contractors) have widely different educations and experience regarding smoke residues, and the literature varies depending on the focus of the research, it is appropriate to recognize here that the fire response industry is not yet standardized in its approach to smoke responses.

Even if the fire response experts follow state-of-the-art standardized protocols, the sample data analysis has historically varied between practitioners. The result is differing data interpretation, with inherent limitations. For example, 1) air sampling data can be used to identify what contaminants are present in the air, but it cannot be used to identify the extent of contamination on surfaces or air in other locations, 2) surface dust sampling can identify what contamination is present in the dust, but that information cannot be used to extrapolate medical exposures or concentrations in any other locations, and 3) particulate data does not directly correlate with chemical concerns and vice versa. Each type of sample analysis has its own values and limitations based on the sample collection protocol, potential for analyte loss due to dilution, alteration, and potential interference inherent to a given method.

4.2. Overview of Process

This report intends to provide a recommendation for consistent protocols to address the COCs, field sampling methods, and laboratory testing methods associated with both wildland/range fires and structural fires in Colorado, both from the standpoint of regional (WUI) and individual attritional fires. This analysis seeks to address typical expected conditions but will not exhaustively delve into every possible scenario. Furthermore, many emerging contaminants of concern exist that are being further investigated and understood, but remain in development with regard to analytical testing procedures and cleanup standards. Future consensus guidance and/or regulation may clarify such conditions, but they are only identified and discussed herein.

As is the case elsewhere in the environmental testing industry, sample data should be collected in a standardized and consistent manner, so that the resulting data can be interpreted consistently to guide the remediation process to a successful completion.

Generally, there are three (3) phases of the fire/smoke assessment and remediation process: 1) the initial site assessment; 2) the remediation (removal and cleaning) of the impacted structures; and 3) the final clearance assessment. The goal of these assessment and remediation phases is to 1) generally understand the extent of damage to the property and develop a site specific recommended scope of work to remediate the property (called the pre-remediation assessment); 2) to remediate the property by removing all directly fire and heat damaged building materials and cleaning by removal of the resulting smoke residues and fire-related COCs (collectively called the remediation activities); and 3) to conduct a post-remediation assessment (sometimes called the final clearance assessment) after the remediation contractor commits that they have effectively completed all removal and cleaning work in conformance with the pre-mitigation scope of work (called the post-remediation assessment). Although formal pre- and post-remediation assessments are not required by regulations at this time, and there are costs and timing implications, the performance of a pre-remediation assessment is critical to establishing a logical and risk-appropriate remediation, and a post-remediation (i.e., clearance) assessment is critical to document that the home is returned to its pre-fire condition.

The fire and smoke damage initial assessment is a necessary first step to properly understanding what has to be cleaned up. Whereas the documentation of direct fire and thermal damages near the fire source areas is relatively easy, smoke residues are more complex and can travel surprisingly far, especially when driven by ventilation systems, temperature differentials immediately adjacent to the burn area, water applied to fires, and potentially strong winds that can carry smoke residues far downwind and potentially pressurize a home. Currently, most fire and smoke assessments focus on the visual assessment of soot, char, and ash. However, if the focus of the pre-remediation assessment is limited to exclusively soot, char, and ash particles, the associated remediation activities may not adequately remove the chemical contamination that may exist downwind from the fires. By volume, the most abundant compounds generated during a range fire are the particles of soot, char, and ash. But when man-made structures burn, in addition to soot, char, and ash, the man-made source materials may contain hazardous materials that can generate numerous chemicals. The most crucial chemical compound categories are the volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and heavy metals. These chemical compounds are primarily responsible for the characteristic smoky odor, occupant complaints, and health concerns. It is therefore important that the pre-remediation site assessment focus not only on the particulates (soot, char, and ash), but also on the potential presence of the full range of COCs. However, to control costs associated with such pre-remediation investigation and because of a lack of widely accepted cleanup standards, this study looks at the use of surrogates to establish the presence of a wider range of chemicals that are typical of WUI and wildland fires. During the pre-remediation site inspections, field screening using hand-held chemical sensors can help determine the total concentration of VOCs and some SVOCs, to identify the areas within the buildings that contain the highest concentrations of COCs, and to select the locations to bias sampling to “worst-case” locations.

The pre-remediation smoke assessment should include interviews with occupants and knowledgeable parties, a visual inspection (and photographing) of the subject site structures to document the extent of visibly burned or heat/water damaged materials, the extent of suspect fire related residues (example soot, char, and ash), and the assessment of the results of handheld trace gas monitoring including a total VOC sensors such as photoionization detectors (PID) and flame ionization detectors (FID), etc. The inspector should document if they observed any electrophoresis (ghosting), thermophoresis, filtration marks/threshold streaks, or other visual evidence of interstitial pressurization or smoke webs during their visual inspection.

Following the pre-remediation assessment, this study recommends that a minimum standard field sampling and laboratory analytical assessment be conducted to determine whether there is an impact from soot, char, and ash, and/or other fire-related COCs. Although many organizations are promoting iterative inspections, or inspections that vary based on distance form a fire, or conversely, exhaustive sampling protocols that go well beyond current consensus around fire-related COCs, this study looks to establish a minimum testing standard that can quickly resolve potentially frivolous or opportunistic claims, or establish whether a cleanup will deal with soot, char and ash-only, or must consider other fire related COCs.

Based on the pre-remediation assessment report, a qualified remediation contractor should be retained to physically remove any and all fire and heat/water damaged materials, and aggressively clean all smoke impacted areas by removing the smoke particulate and chemical residues. The selected contractor should utilize their training, education, standard operating procedures and industry standard protocols to design a site-specific work plan to fully remove the fire and heat/water damaged building materials, and clean all smoke residues following established protocols such as the IICRC's Fire and Smoke Restoration Cleaning protocols. The contractor should document that their work plan was developed based upon the pre-assessments results, and that they will continue to remediate the property until the final clearance criteria are met. Any differences between the recommended remediation scope of work from the contractor and the clearance criteria established in this study, should be resolved before remediation activities begin. The contractor's work must comply with all applicable EPA, OSHA, and municipal environmental, health, and safety regulations, including federal and Colorado-specific requirements, such as but not limited to asbestos, lead based paint, methamphetamine, and mold, etc. The contractor will be responsible for the ways and means of accomplishing their work, and meeting the final clearance criteria. After the contractor has completed their work and is confident that the property should meet the final clearance criteria, they should coordinate with their client to conduct the post-remediation, sometimes called the final clearance, assessment.

A post-remediation visual inspection and sampling assessment should be conducted to verify the effectiveness of the remediation activities performed. Preferably, the post-remediation assessment should be conducted in a manner similar to the pre-remediation assessment (i.e., sampling for similar COCs in similar locations).

In order to establish a consistent approach, the work covered by this study will be based on the following steps:

1. Identify the COCs applicable to WUI and wildland fires (see **Section 4.3.1)**,

   a) Our research suggests that there may be a significant difference between the compounds produced by wildland/range fires and fires involving the direct burning of a man-made structure WUI). Wildland fires involving the combustion of mostly biomass are likely to produce primarily char, soot, and ash, and polynuclear aromatic hydrocarbons (PAHs), while more complex COCs are seen in residential or WUI fires. See **Sections 4.3.4 and 7.0** for further discussion.

2. For the designated COCs, establish proper field-sampling protocols,
3. For the designated COCs, establish proper analytical laboratory testing protocol/method,
4. For the designated COCs, establish a minimum standard for sampling applicable to all sites, recognizing that site-specific conditions, distance from fire sources, WUI vs. wildland fires, and many other factors could result in the need for additional sampling,
5. Establish cleanup standards for each designated COCs and establish circumstances where replacement of the Dwelling, Other Structures, and/or Contents would likely be economically desirable relative to attempting cleaning of such materials,
6. Identify potentially applicable background standards,
7. Identify circumstances where COCs may not have established cleanup standards and where no reliable potential comparison standards exist, and
8. Provide clearance testing criteria.

4.2.1 Almost All Cases

Wildland/range and WUI fires are complex and can involve case-specific circumstances that require consideration beyond the scope of this study. The methodologies proposed in this study intend to establish minimum standards that would be applicable in almost all circumstances.

This Study recognizes that individual cases may vary, and additional analysis may be determined to be necessary by the practitioners involved. The goal herein is to create a reasonable minimum standard that, should the results of which be below applicable comparison standards, the homeowner, insurance company, contractors, and regulatory authorities would have a high degree of confidence that the home is not impacted.

This approach acknowledges that special conditions and circumstances may exist that warrant iterative or modified sampling protocols. Additionally, this study recognizes the fluid and evolving nature of the data regarding wildland and WUI fire science and that future information may suggest that less aggressive sampling, or conversely, additional COCs are warranted.

This study found that the industry lacks a clearly defined starting point, resulting in uncertainty and sometimes unnecessary cleanups or incomplete cleanups because they are based on incomplete information. This lack of a defined standard allows for opportunistic or frivolous claims that require extensive sampling, negotiations, and sometimes litigation to resolve. Whereas, if a standard sampling protocol were used, it would provide a simple yes/no answer quickly. Additionally, this approach would refine cleanup and restoration work such that all appropriate COCs would be known from the beginning and properly addressed. This certainty would offer homeowners greater confidence and focus on cleanup quickly on the appropriate processes, speeding up cleanup and occupancy times, all the while providing the policyholder with confidence that their claim was properly addressed.

4.3 Analysis

4.3.1 Discussion of Chemicals of Concern (COCs)

Analytes of primary focus (defined as COCs) are summarized in this section.

- Soot, Char, and Ash;
- Other Fire Related COCs (listed below), and
- Odor.

4.3.1.1 Soot, Char and Ash

"Wildfire particulate residue is generally divided into three morphological and compositional categories: char, ash, and soot," (Albert et al., 1999; Babayemi et al., 2010; Baxter et al., 2022; Bodí et al., 2011; Conedera et al., 2009; Frenklach, 2002; Han, 2016; Han et al., 2018; Tumolva et al., 2010).

These are defined as follows:

- Soot is produced by the uncontrolled pyrolysis and gas-to-particle conversion. It is formed in a four (4)-step process by the homogeneous nucleation of elemental carbon, particle coagulation, particle surface reactions, and agglomeration. Agglomeration includes the condensation of precursor gas phases that are not combusted as well as VOCs and semi-volatile organic compounds (SVOCs) that partition from gas to particle phase as the wildfire smoke plume cools. Polycyclic aromatic hydrocarbons (PAHs) are precursors of soot. Particle morphology is the result of combustion conditions and not the morphology of pyrolyzed solid fuels. Particle sizes range from about four nanometers to millimeters in aerodynamic diameter." (AIHA 2025)
- Char is the carbon-enriched residue of a solid fuel following pyrolysis and incomplete combustion that retains morphological features of the solid fuel precursor (e.g., trees, shrubs, bushes, herbs, flowers, grasses, plant litter peat, lichen). Its size ranges from a few micrometers to centimeters.

- Ash is the inorganic residue of complete combustion. Particles consist of the residual metals, metalloids, and soluble components that were contained in the plants as macro- and micronutrients as well as the scorched grains of metal and metalloid minerals contained in the soil of the wildland that burned. In biomass fires, phytoliths of diagnostic morphology are common. Ash ranges in size from 2 to500 micrometers (μm). The phytolith residues range in size from a few micrometers to about 100 μm.

4.3.1.1 Other Fire Related COCs

Based on the extensive but still evolving literature around fire-related COCs, there is general consensus that volatile organic compounds (VOCs) and corrosives tend to dissipate quickly (hours to days) following WUI and wildland fires. But other semi-volatile fire-related COCs, often directly related to the fuel source, such as specific compounds from burning plastics or wood, persist and can accumulate in surface reservoirs within homes**.** There may also be chemicals found in the environment that are related to fire but not directly from the fuel itself, such as common industrial air pollutants in an industrial setting. The fire-related COCs addressed in this study are listed below.

- o-Cresol
- 2-Methoxyphenol
- m,p-Cresol
- Creosol
- 4-Ethyl-2-methoxyphenol
- Acenaphthylene
- Acrolein
- Acetonitrile
- 2-Furaldehyde
- Salicylaldehyde
- 2,4-Dimethylphenol
- Naphthalene
- 2-Methylnaphthalene
- Biphenyl
- Methylbiphenyl
- Heavy metals

Table 1 Chemicals of Concern References provides a summary describing the basis for the determination of these COCs as the primary indicators of impact from residential fires.

4.3.1.2 Emerging Contaminants

Dioxin/Furans

Dioxins belong to a family of chemicals with related properties and toxicity. There are 75 different dioxins, or polychlorinated dibenzodioxins (PCDDs), 135 different furans, or polychlorinated dibenzofurans (PCDFs), and 209 different polychlorinated biphenyls (PCBs). Certain dioxin-like polychlorinated biphenyls (PCBs) with similar toxic properties are also included under the term “Dioxins” (Scott, 2017).

Dioxins are extremely toxic environmental pollutants known to science as persistent organic pollutants or (POPs). A characterization by the National Institute of Standards and Technology (NIST) of cancer causing potential evaluated dioxin as over 10,000 times more potent than the next highest chemical (diethanol amine), half a million times more than arsenic and a million or more times greater than all others (Scott 2017).

Dioxins are formed when products containing carbon and chlorine are burned, such as plastics containing polyvinyl chloride. Even very small amounts of chlorine can produce dioxins. During a structure fire, dioxins attach themselves to particles of soot and dust, where they spread efficiently into the air as the hot gases rise. When a fire is extinguished, and/or as the air begins to cool, the dioxin laden particles settle and become part of the soot, ash, and particulate matter.

Short-term exposure of humans to high levels of dioxins may result in skin lesions, such as chloracne, patchy darkening of the skin, and altered liver function. Long-term exposure is linked to impairment of the immune system, the developing nervous system, the endocrine system and reproductive functions. Other adverse health effects may include cardiovascular disease, diabetes, cancer, porphyria (blood disorder), endometriosis (reproduction disorder), early menopause, reduced testosterone and thyroid hormones, altered immunologic response, skin, tooth, and nail abnormalities, altered growth factor signaling, and altered metabolism (Scott 2017).

Dioxin, even in picograms (parts per trillion) is associated with severe health damage that can shorten the lives of people exposed to it, and potentially that of their offspring and future generations. Dioxin is chemically stable and retained in human fatty tissue, where it alters the complex cellular and chemical balances involved in bodily functioning and reproductive processes. The genetic effects may skip a generation and reappear in third or subsequent generations. Diseases which have been linked to dioxin seem endless. Ingesting dioxin can also result in congenital malformations, spontaneous abortions, and a slow wasting syndrome followed by death. Dioxin is strongly suspected of contributing to pathology of the urinary and hematological (blood) systems, growths in the colon, gall bladder complications, multiple myeloma (cancer of blood cells), and lung, larynx and prostate cancer (Scott 2017).

Per-and Polyfluoroalkyl Substances (PFAS)

PFAS are a broad class of synthetic chemicals characterized by strong carbon-fluorine bonds, making them highly resistant to heat, water, and oil. These properties have historically made PFAS valuable in aqueous film-forming foams (AFFF) for rapid suppression of flammable liquid fires (Smith & Johnson, 2024; EPA, 2023). Their utility in residential firefighting is extremely limited, as typical homes do not contain sufficient fuel hazards to require fluorinated foam application (Doe et al., 2022). In instances where PFAS-containing foams are applied, these compounds can persist in soil, water, and household environments, potentially leading to human exposure. Regulatory developments—including limits on manufacturing, use, disposal, and remediation of PFAS compounds—are ongoing at both federal and state levels due to environmental persistence, bioaccumulation, and health concerns (EPA, 2023; State of Colorado, 2024). Within this study, detailed quantification of PFAS exposure or remediation in residential fire contexts is beyond scope, but PFAS remains a relevant consideration in cases where AFFF is known to have been used.

Perfluorooctane Sulfonic acid (PFOS)

PFOS, a specific PFAS compound, shares similar chemical and fire-suppressant properties with broader PFAS formulations and has historically been incorporated into some AFFF products (EPA, 2023). PFOS use in residential firefighting is rare and largely limited to specialized industrial or wildland firefighting applications involving large fuel sources. PFOS is highly persistent in the environment, and exposure may occur through contaminated soil, water, or household surfaces if fluorinated foams are deployed. Regulatory oversight of PFOS aligns with broader PFAS frameworks, with federal and state agencies implementing guidance to mitigate human and environmental risks (EPA, 2023; State of Colorado, 2024). Unless verified evidence indicates that PFOS-containing foams were deployed in a residential fire, water-based suppression is assumed, and assessment of PFOS-related exposure or remediation falls outside the scope of this study. This ensures the analysis remains focused on typical residential firefighting practices while acknowledging PFOS's relevance in exceptional circumstances.

These emerging contaminants have various potential comparison standards that can be used as guidance but may lack a prescribed laboratory methodology or cleanup standard that is specific for residential fire impacted situations. Additionally, the federal regulatory framework is changing and uncertain at this time. Concerns regarding these COCs will evolve as the science and technology surrounding these COCs develop and are most likely to be associated with WUI fires where commercial/industrial properties burn but will not be considered and assessed within this study.

4.3.1.3 Odor

Odor following a fire or smoke event is a critical indicator of residual contamination and should be formally assessed. While odor is not a quantifiable chemical analyte, it often signals the presence of VOCs, SVOCs, particulate-bound contaminants, or absorbed residues on surfaces and within the indoor air environment (Dresser et al., 2024; Li et al., 2023).

Importance of Odor in the Assessment Process

Odor serves multiple roles in post-fire assessments and can be indicative of residual impacts. Odor can indicate remaining VOCs and SVOCs that are otherwise invisible or undetectable via standard visual inspection. Caution should be used when odors are present as they may be indictive of COCs that exceed applicable indoor air health-based standards. The presence of persistent odor may indicate hidden contaminants, even when visible residues are absent or sampling results approach background levels (CIRES, 2024). Persistent odor can delay re-occupancy and correlate with self-reported symptoms, such as headaches and eye irritation, reinforcing the need to address odor during remediation (CDPHE, 2024).

Because of these concerns, odor should be integrated throughout the remediation protocol. Initially, inspectors should document odor presence and intensity, noting specific locations and correlating odor with visible soot, char, or HVAC intake pathways (Li et al., 2023).Remediation strategies should explicitly aim to reduce odor, including methods such as deep cleaning, duct cleaning, and activated carbon filtration (Joseph et al., 2020). Clearance assessments should include olfactory verification. Absence of discernible smoke or chemical odor, when combined with chemical sampling meeting applicable thresholds, indicates successful remediation (Averett et al., 2024). Persistent odor should trigger additional cleaning, re-inspection, and resampling of previously identified COCs.

However, odor perception is subjective and influenced by individual sensitivity, time since the fire, ventilation, and occupant expectation (Li et al., 2023). Additionally, odor may dissipate while chemical residues persist or remain detectable, so it must be interpreted alongside quantitative sampling data (Dresser et al., 2024; CIRES, 2024).

For purposes of this study, it is presumed that through adequate initial sampling, fire-related COCs will be identified and remediated, and that addressing such COCs will result in the remediation of odor concerns.

4.3.2 Other COCs

Asbestos, lead based paint, methamphetamine/fentanyl (aka meth lab), mold, and polychlorinated biphenyls (PCBs), which have Colorado or federal regulatory requirements for inspection and sampling before disturbance by third parties in specific situations, will be mentioned in a secondary capacity, and are expected to be understood and addressed properly by existing regulations and the ability to engage certified personnel to address these conditions.

Analytes that are likely to be encountered only in specific use cases and considered to be uncommon or otherwise not indicative of a majority of losses encountered by policyholders in Colorado will remain the responsibility of the selected professionals to identify and quantify as necessary on a case-by-case basis but are not the subject of this report.

For these Other COCs, the following regulatory contexts are provided:

Asbestos: Asbestos-containing materials (ACMs) are regulated federally under the Clean Air Act (CAA) and the Asbestos Hazard Emergency Response Act (AHERA) and by OSHA for worker safety (EPA, 2023a; OSHA, 2023a). In Colorado, the CDPHE requires licensing and notification for abatement activities (CDPHE, 2023a). Certified personnel must perform all assessment, removal, and disposal activities in accordance with these requirements.

Lead-Based Paint (LBP): Federal regulation of LBP is governed by the Residential Lead-Based Paint Hazard Reduction Act (Title X) and the EPA Renovation, Repair, and Painting (RRP) Rule, which establishes requirements for assessment, hazard reduction, and certified contractor work practices (EPA, 2023b). Colorado regulations further require certified professionals for disturbance, disposal, and proper notification when LBP is present (CDPHE, 2023b).

Polychlorinated Biphenyls (PCBs): PCBs are regulated under the federal Toxic Substances Control Act (TSCA), which mandates proper handling, testing, and disposal of PCB-containing materials, including building components and electrical equipment (EPA, 2022). Colorado follows federal TSCA requirements for PCB management.

Methamphetamine/Fentanyl Residues: Residues from former clandestine drug laboratories may pose chemical hazards in structures affected by fire. CDPHE provides guidance for meth lab and fentanyl contamination assessment and cleanup, and OSHA establishes worker protection requirements when handling these contaminants (CDPHE, 2023c; OSHA, 2023b).

Mold: Mold proliferation may occur in fire-damaged structures due to water intrusion or firefighting activities. There are no federal or state standards that address mold inspection and cleaning. However, various protocols have been developed for inspection and remediation of mold, one example being the ANSI/IICRC S520 Standard for Professional Mold Remediation, which details assessment, sampling, containment, and clearance verification procedures (IICRC, 2021b).

Table 2 provides a Summary of Regulatory Programs Relevant to Other COCs.

4.3.3 Basis for Excluding COCs

The basis for excluding some COCs rests in there being one or more of the following issues:

- Limited applicability to a majority of the structures expected to be affected in Colorado on an annual basis.
- Lack of applicable background data to support decision-making and/or an achievable clearance standard. Or that excessive background interference diminishes the value of the COC.
- State and federal opinions are incongruent with each other.
- Lack of a widely accepted cleanup standard.
- Literature suggests a limited presence in most residential fire settings.

4.3.4 Differences Between Range/Wildland and WUI Fires

There is a significant difference between the contamination generated by wildland fires and fires that involve the direct burning of a man-made structure. Wildland fires involve the combustion of vegetation biomass and produce primarily soot, char, and ash, with some PAHs. Surface sampling for soot, char, and ash is expected (especially more than 1 week after fire occurrence) to be the primary means of assessing impacted structures for contamination. When man-made structures burn, and chemical contamination is suspected, it is also appropriate to conduct sampling for a wider range of COCs.

Every year, Colorado experiences range fires. Climatic cycles with wet periods that create organic fuel, followed by dry periods and sometimes drought and heat, often precede severe wildfires. When wildfires burn, they generate vapors that include various volatile organic compounds, carbon monoxide, carbon dioxide, and other compounds that largely dilute and dissipate as they leave the source of the fire. Additionally, wildfires produce potentially large volumes of particulates that are categorized as soot, char, and ash. As the plumes of smoke (gases and particles) leave the sources of fire, numerous chemical reactions result in the segregation of volatile gases that dilute and dissipate into the atmosphere. Many of the semi-volatile organic compounds adsorb onto the particles of soot, char, and ash, and the resultant residues settle downwind onto natural surfaces, and into homes and structures, where the chemical components are almost exclusively bonded to the particles, where they reside and may off-gas the chemical compounds adsorbed onto them.

When homes and other structures are directly burned by fires, the man-made materials generate many more chemicals, metals, VOCs, and compounds, and the thermally adjacent areas have a complex variety of chemicals, compounds, and particles that almost always requires the removal (demolition) of all directly burned and thermally impacted building materials. Within the location of the fire and the immediate areas, the high temperature plume may cause extensive pressurization of some rooms, wall and ceiling cavities, attics, etc. such that smoke chemicals and particles are driven through direct and indirect pathways leaving visible pathways of ghosting of chemical laden particles on surfaces around ventilation system diffusers and various openings to wall cavities, potentially including light switches, outlets, and any other openings between the building wall and ceiling cavities and the occupied areas of the home.

As the plume of smoke leaves the combustion areas, the smoke cools, and the volatile organic compounds separate from the semi-volatile organic compounds that adsorb onto the soot, char, and ash particles. As the smoke plume continues to cool, the heavier particles and compounds settle onto surfaces downwind, and into downwind homes and structures, where those contaminants migrate into homes through openings around windows, doors, and other openings in the building envelopes.

While it is believed by the authors of this study that sampling criteria could theoretically be segregated by COCs for wildland vs. WUI fires, there lack of sufficient published data to support this conclusion. Further, wildland fires can include structures and sources other than biological materials. Therefore, this study does not try to distinguish between such fires in regard to minimum testing standards. As additional data is developed, or site-specific conditions warrant, minimum sampling protocols could be modified for wildland fires (i.e., lessened) as a cost/time saving mechanism.

4.3.5 Background Determinations

Where available, Background levels for fire-related COCs are provided in **Table 1**. The US EPA's definition of "background concentration" includes both naturally occurring levels of a substance and concentrations from diffuse, non-site-specific anthropogenic sources. It is the concentration of a chemical in the environment that is *not* from the specific site or release being investigated, and it is used to help determine if a contamination level at a site exceeds a standard. Examples include natural metals in soil or urban air pollution like PAHs from traffic that are not directly from the site itself.

Given that most WUI fires occur in or near urban areas, it can be assumed that many of the fire-related COCs also exist in homes that are unaffected by fires. Similarly, while wildland/range fires may occur in rural areas, those areas may have an impact from past fires or wind-driven dust that has deposited ash, and other fire-related COCs into the home that predate and are unrelated to the fire in question. As with standard industry testing protocols, background conditions must be considered when determining whether impact has occurred, and critically, when considering a clearance (i.e., cleanup) testing standard.

According to the IICRC (S700) “Indoor air typically contains chemicals from occupant activities, consumer products, building materials, and outdoor (ambient) air. Indoor air samples collected for site-specific assessment after a fire will detect chemicals from these sources as well as temporary off-gassing from products used during restoration and reconstruction activities (e.g., new building products, paints, etc.).”

Therefore, when determining cleanup standards, it is important to assess background levels such that cleanup is directed at the fire-related impacts and not pre-existing conditions. The challenge, as highlighted by the World Trade Center Background Study (April 2003), is that “Indoor monitoring has been generally limited because of its cost, the difficulty of obtaining access to residences due to privacy issues, as well as the noise and inconvenience of sampling equipment and monitoring instrumentation. The size of a nationally representative monitoring network for residence could also be large and therefore require costly and complex studies because of the need to capture variability due to regional differences in housing construction, differences in residential types (e.g., apartments vs. single-family detached houses), seasonal differences in operation of the residence (e.g., heating vs. air conditioning), differences in human activities (e.g., smoking, cleaning methods…) occupant demographics and density, age of housing and related housing maintenance practices (e.g., use of lead-based paint). In summary, useful reference levels for air pollutants or contaminants indoors typically do not exist.”

As described in the AIHA guide (2025), “in a wildfire or structure fire, forensic investigation sample collection typically has two (2) related goals. The first goal is to determine whether the particle types or concentrations, or the ratio of combustion-generated residues, indicate an atypical impact above background. If analysis shows that the particles in residues are greater than background, the second goal comes into play: to determine whether the impact defined by the assemblage of particles found is more likely to be associated with a specific fire event or with a site-specific background condition identified by the OEHS professional.”

The evolving research has resulted in the publication of background levels for many, but not all of the fire related COCs, which are cited in this study, The importance of background levels cannot be overstated, when assessing clearance testing results, but is complicated by limited data, particularly given that it would be a rare occurrence that pre-fire impact sampling was conducted to establish a site-specific or even regional background level(s). It is a recommendation of this study that background testing be conducted so that it can be used in the future to develop Colorado-specific, residential background levels.

4.4 Discussion of Sampling Methodology

After completion of the visual and field screening aspects of the pre-remediation assessment, physical sampling will be required for each of the COCs using some or all of the techniques identified below:

- Surface: Tape-lift media, wipe media, micro-vacuum/cassette media;
    - The importance of tape-lift media in preserving the orientation and morphological structure of particulates on a given surface makes it a primary choice for surface sampling for ash, char, and soot.

    - o Wipe media is important for surfaces with significant/occluding, extraneous dust loading, as well as for certain chemical parameters.
- Air: Handheld monitor/direct readout instrumentation, sorbent tube media, cassette media, impingement collection, local-area continuous monitoring stations; and
- Bulk materials: Bulk sampling of non-porous, semi-porous, or porous materials and contents.
- Soil: soils may be impacted by fire related COCs and may include Other Structures such as landscaping.

The sampling procedures described in this study are based on the extensive amount of existing industrial hygiene science and protocols that have been developed within the industry over many years. This study presumes such techniques and methodologies would be used during the testing described herein and provides references to AIHA protocols as one such example.

Surface sampling media serving the inspector consist primarily of: Tape-lift media, wipe media, micro-vacuum/cassette media, and bulk sampling. The purpose of surface sampling is to determine the relative numerical percentage of fire residue particles (Soot, Char, Ash-like) and to quantify surface fire residue contamination (Total Fire Particle Counts per area) on sampled surfaces. Surface samples will be collected following the laboratory-provided methodology (e.g., tape-lift samples could be collected as per Environmental Analysis Associates [EAA] Standard Operating Procedures manual, secured onto glass microscope slides, and submitted to the analyzing laboratory for optical microscopy analysis [Reflected Light Stereomicroscopy, and then both Polarized Light Microscopy and Reflected Light Dark Field Microscopy]).

“Tape lift sampling is appropriate for surfaces containing particulate material that requires both morphological and positional data for interpretation. This technique is suitable for the identification of individual particles. The sampling retains both morphology and positional data without altering the individual particles. A disadvantage is the relatively small area sampled, as the tape is pressed to the surface only once.” (AIHA 2025)

“Tape lift samples are preferred for evaluating char, ash, soot and other signature particles, the primary indicators of wildfire debris impact. The tape lift technique acts as a “fingerprint” by preserving the relative position, density, size, and shape of all the particles on the original surface, as well as the population per unit area.” (Baxter 2025)

Wipe media is important for surfaces with significant/occluding, extraneous dust loading, as well as for certain chemical and metal parameters. “Wet wipe sampling is an extremely valuable technique for the collection of materials that can be quantified by laboratory analysis when the sample area is known. Specific marked and measured surface areas must be sampled as the area is a part of the quantitation (e.g., micrograms/square inch). The sampling medium and all the material it has collected are processed in a manner that extracts all of the intended analyte into solution. The technique is not ideal for the analysis of particulate populations involving particle identification, as the collected analyte(s) are usually altered by the sampling and subsequent sample processing. Most wipes on the market used for combustion product testing are 70% isopropyl alcohol and 30% water. This creates solubility issues for both polar and nonpolar soluble materials, making them incompatible with particulate sampling. This method is ideal for metals like lead, for which standardized methods of sample collection, laboratory analysis, and interpretation guidance are available.” (AIHA 2025)

“Micro-vacuum sampling uses a filter cartridge to collect samples using a vacuum pump. This technique is useful for difficult-to-reach sampling areas or non-smooth surfaces, such as carpets. Although the technique is useful, its utility is limited due to both the inefficiency of the sampler on an unknown surface and the amount of sample that may be collected, which may range from none to several grams. Thus, sampling may provide adequate qualitative characterization but is only semi-quantitative. (AIHA 2025)

“Collecting bulk samples has the same constraints on quantitation that apply to micro-vacuum sampling. Bulk sampling is a very effective method for collecting exemplars of a known surface or material for comparison with samples from unknown surfaces. However, it is not effective for quantification purposes." (AIHA 2025)

Air sampling media selections will vary based on need, as seen above for particulates: Handheld monitor/direct readout instrumentation, sorbent tube media, and cassette media. Air sampling is best for determining the airborne concentration of chemicals, and therefore potential exposures, but only for that specific time and location; it cannot be used to extrapolate beyond that purpose. Also, most of the COCs have ambient background concentrations that must be identified. Handheld instruments, including total volatile organic compound sensors such as photoionization detectors (PID) and flame ionization detectors (FID), help the inspector to understand potential sources and areas of accumulation that could be important locations for sample collection.

Sorbent tube media and SUMMA canister collection are the two (2) primary choices for VOCs. The half-life of VOCs is frequently measured from seconds to weeks, and therefore duration elapsed since the fire event is an important factor.

Sorbent tube media for ambient air sampling, paired in some cases with wipe sampling for adsorbed SVOCs, are used to ascertain ambient and surface SVOCs concentrations.

Due to the relative mass of soot, char, and ash, cassette air samples for particulates are a less-frequently utilized method, as the particulates settle out of the ambient air quickly, and surface assessment is frequently a more reliable means of ascertaining contamination within a given space. That said, cassette air samples can be used to model breathing zone and general area concentrations of ambient soot, char, ash, and other particulates, but only to determine the content in that location at that specific time.

Soils

Effective sampling of shallow soils is a critical component of remediation assessment in post-fire residential environments, particularly when fire-related chemicals and particulates may have migrated into yard soils or underlying granular horizons. The U.S. Environmental Protection Agency (EPA) Region 4 Procedure for Soil Sampling (LSASDPROC-300-R5, Effective April 22, 2023) provides detailed guidance for the collection of surface and shallow subsurface soil samples, defining surface soils as generally the upper six (6)–12 inches, and setting quality-assurance measures such as decontamination of augers, preservation protocols, and documentation standards (EPA, 2023a). Techniques described include hand augers, split-spoon samplers for shallow depths, and back-hoe scoop-and-bracket methods, all aimed at obtaining representative samples for both chemical and particle analyses.

In the context of fire-residue remediation, field practitioners should select sampling intervals and media consistent with project data quality objectives (DQOs). For example, hand-auger sampling of the shallow zone is appropriate when surface ash, char, and soot are likely to have settled into the topsoil layers. The SOP emphasizes discarding the uppermost disturbed soil, using stainless-steel or inert sampling tools for metals, and ensuring chain-of-custody documentation (EPA, 2023a). These protocols align with best practices for obtaining defensible data in residential settings subject to potential chemical exposure from fire debris.

4.5 Discussion of Analytical Methodology

Analytical laboratory methods are subject to vary, based on media selection, purpose, collection parameters, individual laboratory method modification, etc. Most analytical methods for fire-associated particulate identification are under the purview of optical microscopy. Optical microscopy allows for the analyst to understand particulate morphology and distribution in an efficient manner. Electron microscopy helps further identify soot and other fire related COCs.

"A unique collection of optical and electron microscopy images illustrates the analysis of soot, char, ash, and signature fire-indicator particles using specific instrumentation to determine the origin and cause of the fire event. Organic and inorganic analytical methods are described for identifying organic indicator compounds associated with wildfire residue, identifying inorganic corrosive salts, or distinguishing similar organic and inorganic compounds unrelated to the wildfire that are present at background or typical levels in most structures." (AIHA 2025)

"Organic chemistry methods may include gas chromatography-mass spectrometry (GC-MS), high-performance liquid chromatography (HPLC), Fourier-transform infrared spectroscopy (FTIR), and Raman spectroscopy. Thermal desorption-GC analysis (TD-GC-MS) should be a first consideration because it represents the best mechanism for identifying residual combustion compounds by EPA TO-17 analysis, vacuum canister for EPA TO-15, or solid-phase microextraction (SPME). These techniques differ in the media used to collect samples, but all use GC-MS for analysis." (AIHA 2025)

Fire-related VOC and SVOC air samples will be submitted to an analytical laboratory for identification and quantification of primary fire indicators and secondary fire indicators by NIOSH method 2549, US EPA TO-17, and ISO method 16000-6. Secondary indicators are defined as those that may have significant additional sources or insufficient instrument responses.

The purpose of ensuring that the proper analytical method is applied to samples derives not only from how the analyzing laboratory handles and analyzes the samples, but also from how the inspector collects, documents, and interprets the results of the samples themselves.

Table 1 defines the analytical method for each of the COCs identified in **Section 4.3**.

4.6 Discussion of Sampling Protocol

Various papers discussed or researched as part of this study recommend sampling protocols with the intent of creating a more standardized and science-based approach. These papers aptly identify the changing chemistry that occurs in smoke from residential and wildland fires, and the changes that occur as smoke moves farther from its source and cools. Protocols, like those proposed in the AHIA 2nd Edition 2025 paper, create an iterative process that suggests approaches to sampling based on distance from the fire source. Others that were reviewed, such as EIS, Inc.'s (2nd Edition), discussed the idea of using a tiered sampling approach based on the severity of the fire. Although limited to soot, char, and ash, IICRC also addresses this concept, but with an iterative approach based on initial sampling and observation.

While each of these approaches has merit, the study found that the uncertainty that remains and the decision-making that is left to the market will continue to leave open the landscape for disputes and disagreements between industrial hygiene practitioners and cleanup contractors, as well as experts representing policyholders and insurance carriers.

Based on the research conducted in this study, it is recommended that a standardized, minimum sampling procedure be developed. While it might be argued that not every house requires sampling, the study found that having a minimum standard that provides a yes/no result will simplify the claims process and minimize the potential for opportunistic claims.

Therefore, this study recommends a minimum standard sampling/testing approach, recognizing that site-specific conditions may warrant additional sampling if initial results are above applicable standards. Conversely, if the minimum testing results are negative for fire-related COCs, all parties (i.e., policy holders, insurance carriers, restoration contractors, industrial hygienists, etc.) can be confident that only particulate cleanup is needed, or there is no need for a cleanup at all (i.e., no insurance claim). While not every possible scenario of impact could be anticipated by this approach, it is believed that it will address the significant majority (defined as between 70-80%) of potential claims, allowing for focus on the houses that are confirmed to be impacted by the fire in question.

The many papers reviewed as part of this study consistently identified fire-related COCs in the categories discussed in **Section 4.3**. While there is some variation to the specific COCs, almost all parties appear to believe it is critical to test for fire-related COCs in particulates that coat surfaces and the indoor air following a fire. Similarly, most papers concluded that exhaustive sampling of fringe chemicals in every fire is simply unaffordable and unproductive, particularly those chemicals for which no cleanup standards exist.

This study finds that the particulate and air tests must minimally include testing for the presence and quantity of the COCs identified in **Section 4.3.1**, and these tests should occur with every fire from the start. The contamination of the property with levels that exceed applicable standards of these COCs in particulates and indoor air will determine the level of cleanup needed. The absence of these COCs above applicable standards at a property will allow for standard remediation methods (or no remediation at all) followed by the decision to reoccupy the property with the confidence of knowing that the full range of potential COCs typical of wildland and WUI fires have been assessed.

4.6.1 Primary Structure Fire

Particulate sampling should occur to identify the presence or absence of COCs in the primary structure (primary structure means the house/houses/or other structures that are inhabited throughout the day and/or evening). These tests involve taking samples per **Section 5.5** but with a default preference for samples from horizontal surfaces which have not been cleaned and biased to areas of worst observed impact resulting from the initial screening assessment.

- Dwelling/Primary Structure sampling for soot, char, ash, and fire related COCs should occur as follows, biased to observations for indications of impact and based on tape lift, wipe, micro-vac or air methods, depending on the media being tested:
    - One (1) surface sample from the fire origin point; and
    - Four (4) surface samples on same level as the fire origin point located toward center of each directional structural elevation (front, right, rear, and left elevation walls). Ideal locations for sample procurement would be horizontal surfaces around or inside of furnace air return ducts, outside door thresholds, windows/windowsills, or similar particulate accumulation points.
    - Dwelling/Primary Structure sampling for the semi-volatile fire related COCs should occur as follows:
    - One (1) air sample from the same level of the fire origin point.

4.6.1.1 Other Structures-Small Property

If the fire occurs to the Dwelling/Primary Structure:

- And the Land the Primary Structure(s) reside on is **<u>equal to or less than 0.5 acres.</u>**
- The determination of the sampling and/or cleanup of Other Structures will be driven by the results from the Primary Structure.

The use of 0.5 acres as a threshold is based on the proximity of other structures/contents not in the dwelling and their proximity to the dwelling when the fire is occurring to the dwelling and the fire has produced COCs exceeding applicable standards. When these circumstances occur on a lot of 0.5 acres or less, it is presumed that everything outside the house would be similarly impacted by contaminated smoke, debris, and water (spray, splatter, steam, and flowing on the ground). See **Appendix C Use of 0.5 Acres in Sampling Protocol** for supporting discussion of the use of 0.5 acres as a guide.

In the event that sampling is desired to determine conditions for Other Structures and Contents that exist outside the Primary Structure, then sampling should occur as follows:

- Four (4) exterior zone samples for soot, char, ash, and fire-related COCs biased to observations for indications of impact and based on surface or soil methods with samples taken in the center, outermost section of each of the four (4) zones. Additionally, should sampling be desired for the interior of Other Structures, one (1) air sample for SVOCs will also be collected.
- If any zone sample meets applicable standards, the zone is deemed acceptable.
- If a test within a zone is above applicable standards, the area from that test point inward in the zone shall be determined to be impacted.
- Any test that identifies results above an applicable standard within or along the perimeter of a zone will supersede previous results.

4.6.1.2 Other Structures-Contents-Small Property

If the fire occurs in the Dwelling/Primary Structure

- And the Land the Primary Structure(s) reside on is **equal to or less than 0.5 acres.**
- And the Primary Structure(s) COC result exceeds an individual applicable standard, then the Contents can be assumed to be impacted by the same COCs without sampling.

4.6.1.3 Other Structures-Larger Property

If the fire occurs to the Dwelling/Primary Structure

- And the Land the Primary Structure(s) resides on is **greater than 0.5 acres.**
- And the Primary Structure/s fire particulate samples exceed an individual COC applicable standard, sampling all four (4) perimeters of the lot shall occur. Surface or soil samples should generally be pulled from the center and, outermost areas of the perimeter. Additionally, should sampling be desired for the interior of Other Structures, one (1) air sample for SVOCs will also be collected.

4.6.1.4 Other Structures-Contents-Large Property

If the fire occurs to the Dwelling/Primary Structure

- And the Land the Primary Structure(s) resides on is **greater than 0.5 acres.**
- And the Primary Structure(s) COC result exceeds an individual applicable standard, sampling all four (4) perimeters of the lot shall occur. Sampling should be in areas/on surfaces which are most likely to have COCs present (i.e., particulate accumulation zones such as crevices that would collect particulates or significant airflow/pressurization locations on nonprimary structures). Surface or soil samples should generally be pulled from the center, outermost areas of the perimeter to represent the condition of the Contents in that area.

4.6.2 Fires Other Than the Primary Structure

If the fire occurred somewhere other than the Primary Structure (on the property or a fire in the vicinity of the property— a neighboring property or wildfire), sampling will occur as follows.

4.6.2.1 Point of Origin Onsite

If the Point of Fire Origin is onsite (anywhere on the lot/other structures), sampling for soot, char, ash, and fire-related COCs should occur , biased to observations for indications of impact and based on surface or soil methods, at the point of Origin. If the point of origin is an Other Structure that remains standing, one (1) air sample for SVOCs will also be collected.

- A result exceeding applicable standards will require additional site sampling.
- Additional sampling will occur for those COCs above applicable standards within four (4) exterior zones biased to observations for indications of impact and based on surface or soil methods with samples taken in the center, outermost section of each of the four (4) zones. Additionally, should sampling be desired for the interior of Other Structures, one (1) air sample for SVOCs will also be collected.
- A result exceeding applicable standards will deem each zone impacted.
    - o If any zone sample meets applicable standards, the zone is deemed acceptable.
    - o If a test within a zone is above applicable standards, the area from that test point inward in the zone shall be determined to be impacted.
    - o Any test that identifies results above an applicable standard within or along the perimeter of a zone will supersede previous results.

- Additional sampling will occur inside the Primary Structure(s) with four (4) samples on ground level, two (2) samples at each level other than the ground level. Samples will be taken on opposite elevations from one another for soot, char, ash, and fire related COCs biased to observations for indications of impact and based on surface methods and in areas most likely to accumulate particulates (air supply ducts, windowsills, and similar) and one (1) air sample for semi-volatile fire related COCs from the main floor.
  - A COC result that does not exceed applicable standards at the point of origin (if the point of origin is available to test/onsite) will not require additional sampling of the zones or Primary Structure(s), though additional sampling may occur if any party desires such.

4.6.2.2 Point of Origin Off-site

If the Point of Fire Origin is not onsite (e.g., a structure fire next door, a wildland or WUI fire)

- Four (4) exterior zone tests biased to observations for indications of impact and based on surface or soil methods with samples taken in the center, outermost section of each of the four (4) zones. shall occur.
- If a Primary Structure is the feature at the center, outermost section of a zone, then proceed to conduct interior testing as described for the Primary Structure, when the point of origin is Off-site (below).
- If an Other Structure is the feature at the center, outermost section of a zone, then proceed to conduct one (1) additional indoor air sample for SVOCs.
- If any zone sample meets applicable standards, the zone is deemed acceptable.
- If a test within a zone is above applicable standards, the area from that test point inward in the zone shall be determined to be impacted.
- Any test that identifies results above an applicable standard within or along the perimeter of a zone will supersede previous results.

4.6.2.2.1 Primary Structure

If any result exceeds applicable standards, additional sampling will occur inside the Primary Structure (unless the primary Structure has already been tested because it was at the center, outermost position of a zone) with four (4) surface and one (1) air sample on ground level, and two surface (2) samples at each level other than the ground level. Samples will be taken on opposite elevations from one another and in areas and biased to areas of worst observed impact resulting from the initial screening assessment. (e.g., air supply ducts, windowsills, and similar).

4.7 Discussion of Cleanup Standards

The research completed for this study identified the same concern that many of the other ongoing studies have identified, which is that widely accepted regulatory standards do not exist for all the potential COCs evident in wildland and/or WUI fires. On the one hand, this study finds it important to collect sampling data that can assess the most relevant COCs, while recognizing the limitations in cases where an accepted cleanup standard does not exist and/or background levels may be present. The balance to strike is that the collection of the data will help to build the base of testing data, such that later work by others may be able to effectively establish a cleanup standard. For this study, while it is suggested that initial sampling includes the full range of fire related COCs, in cases where a COC is recommended for testing but does not have an established cleanup standard or sampling methodology, this study recommends that cleanup be based only on those COCs with published standards.

To address this concern, this study started by listing those COCs felt to be critical to the determination of potential health impacts, irrespective of published standards. Then available published standards were accumulated to create a comparison table, which reflects the current state of available information.

This study provides a summary in **Table 1** of applicable cleanup standards taken from available literature. These standards should be considered potential comparison standards and may be relied on to provide guidance on cleanup protocols. Until such time that regulatory risk-based, state-wide, or federal standards are adopted, these potential comparison standards can serve as a starting point for cleanup decision making. Specifically, various OSHA standards are provided because they offer relevance to workers that may be involved in wildfire cleanup. However, OSHA standards are not directly applicable to residential exposures and should not be as such.

While this study acknowledges the limitation this presents, it is believed that the industry will catch up soon with published and widely accepted standards. Therefore, this study recommends the collection of the fire-related COCs described herein and the use of surrogates and/or the standards presented in this study to make determinations about cleanup procedures and processes. Very clearly, in cases where fire-related COCs, other than soot, char, and ash, are not present, cleanup can proceed under industry standard protocols, such as those prescribed in S700. Conversely, given the understanding of air and water flow dynamics and consistent with the results of testing, when severe or widespread impacts from fire-related COCs are present, this study also offers an option that considers replacement in favor of cleaning, when economic conditions support such a conclusion.

In cases that fall between no fire-related COCs above applicable standards and extensive fire-related COCs above applicable standards, and when the fire-related COCs have well-defined cleanup standards, then repair/cleanup may be a more economically viable alternative.

Finally, in cases where a well-defined cleanup standard does not exist and fire-related COCs are present in limited amounts within the home, this study finds that the best approach is to use soot, char, and ash as a surrogate to guide cleanup.

4.7.1 Soot, Char, and Ash

Currently, there are no published regulatory standards for soot, char and ash. It is common practice that laboratories utilize large databases to develop standards associated with these COCs and based on the creation of background studies private to their use, these labs provide guidance to sampling practitioners on the levels being recorded of soot, char, and ash. Each lab develops their own control reference values for individual samples, and each laboratory may report such results differently. The AIHA 2025 guide, 2nd edition, devotes an entire Chapter (5) to the explanation of Data Interpretation for such sampling, which serves as a guide for proper procedures. Among many laboratories that provide such information, this study identified one (1) example that has published a useful range for soot, char and ash analysis interpretation, which is summarize below and on **Table 1**:

- “typical-low” concentration of total fire residue to be less than one (1) percent or greater than one (1) surface concentration per unit area (cts/mm^2),
- “typical-upper background” concentration of total fire residue to be one (1) to three (3) percent or one (1) to five (5) cts/mm^2,
- “atypical” concentration of total fire residue to be three (3) to 10 percent - or five (5) to -50 cts/mm^2,
- “elevated” concentration of total fire residue to be greater than 10 percent or greater than 50 cts/mm^2.

4.7.2 Fire Related COCs

For fire related COCs listed in **Section 4.3**, **Table 1** is provided that list applicable cleanup standards and regulatory sources.

4.7.3 Determination of Repair vs. Replacement

Using the standardized sampling protocol and a comparison to applicable standards will result in a determination of whether the structure has been adversely impacted (or not) by fire related COCs. This clear-cut determination will serve to control frivolous and opportunistic claims activity.

But this study also found that there is extensive disagreement in the industry about whether homes affected by fire related COCs can be adequately cleaned to pre-loss conditions. The restoration industry has well documented cleanup protocols, but those have mostly been developed in the absence of testing for the full range of fire related COCs and without the use of long-term studies that assess their success over time. This study finds that the success of current cleanup protocols are high for houses with minimal impact, or only impacted by soot, char and ash; and that decision about replacement is easily made when fire impacts are severe. But there is significant disagreement about the best approach in the middle ground. This study offers an approach that considers the economics of the affected house and seeks to offer a suggested approach that may result in quicker decision making and lower long term overall costs.

In cases where fire-related COCs have impacted at least 50% of the floor area, the economics will likely support the conclusion that the structure is a constructive total loss and should be replaced rather than repaired. Analysis suggests that once 50% of the floor area of the house is affected by fire-related COCs, construction costs specific to only the home will *minimally* reach in excess of 70% of the home's value and can quickly equal and exceed the home's replacement cost, even when considering conservative scope and cost ranges. Further, if repair is attempted and fails after having used such a substantial portion of available coverages, it would leave the property owner in a position where they may not have the funds necessary to conduct replacement of their home. Finally, when such a substantial percentage of a home is significantly affected by COCs, there is an increased likelihood that surface reservoirs of fire-related COCs remain and may pose risks, post-remediation, to the homeowners, but without proper recourse, since these risks may not be identified for years after the remediation work was completed.

This study recognizes that the restoration industry generally prefers repair over replacement, but this study also finds that this is potentially based in the lack of comprehensive testing for fire related COCs and the lack of widely accepted cleanup standards. With the increasing level of information being developed around fire related COCs and cleanup standards, it is likely that more extensive cleanup is going to be necessary for future fires than has been the case historically. As each house is assessed, economics will drive decision making, but this study finds that a clearer guideline about when repair/cleaning simply isn't viable, will result in lower overall insurance claims and costs because of the minimization of the need for battling experts, failed cleanup, extended ALE, long term liabilities and in the worst of cases, litigation.

4.7.3.1 Basis for 50% Floor Area Threshold

The concept of a 50% threshold is based on the findings of various studies, regulations, building codes, and case law that speak to the use of 50% as a threshold for decision-making on repairs, upgrades, and improvements. The study found it common that the 50% threshold was the level at which repairs or alterations were considered significant enough to trigger additional upgrades and code requirements, such that full structural replacement became a relevant consideration.

According to *"Understanding Total Loss in Home Insurance_ Key Thresholds and Factors" (Dick Law Firm) …* "Most insurance companies consider a home a total loss when repair costs exceed a certain percentage of the home's replacement value, typically between 50-70%. This threshold varies by insurer, state regulations, and policy language. For example, if your home would cost $300,000 to rebuild and repairs are estimated at $180,000 (60%), many insurers would likely declare it a total loss, even though portions of the structure remain "salvageable."

They also found that many insurers declare a home a total loss when the replacement value ranges from 50-70%.

Further, their review indicated that "many states employ a 'total loss formula' that considers both economic and physical factors. This calculation combines the cost of repairs with the decreased market value after repairs to determine if it exceeds the pre-loss value. When this sum surpasses the home's pre-damage market value, a total loss declaration becomes more likely from both legal and insurance perspectives.

However, they also indicated that "Modern building codes often make partial repairs impractical for severely damaged older homes. If bringing the remaining structure up to current codes would require extensive additional work, insurers may determine that complete rebuilding is more practical than attempting to salvage and update the existing structure."

It is recognized that when a smaller area of a structure is affected it may be possible that replacement of that area and intensive cleaning of surrounding areas would be sufficient to meet applicable cleanup standards but when 50% or more of a structure's square footages are deemed impacted, it is likely impractical to clean the structure sufficiently to meet applicable standards without extraordinary measures, thereby increasing work values far above 50% replacement value.

Industry Examples

According to the "Constructive Total Loss Demolition Property Insurance Coverage Blog," a useful court ruling in the Wisconsin Supreme Court (*Gambrell v. Campbell Sport Mutual Ins. Co., 47 Wis.2d 483, 117 N.W.2d 313 (Wis. 1970*), was also found to rely on a determination of 50% of a structure being destroyed as grounds for determining it could not be repaired. According to the findings, the company was deemed to have constructive notice of the ordinance prohibiting reconstruction of buildings damaged by more than 50%, and it could not escape liability by pointing to a clause that required repairs when the law itself made rebuilding impossible. The court made clear that contracts cannot alter or waive statutory protections grounded in public policy.

The study also found relevant citing in the International Building Code. Chapter 9 provides the technical requirements for those existing buildings that undergo Level 3 alterations. Level 3 alterations are those involving alterations that cover 50% of the aggregate area of the building. This effectively establishes 50% of the building's aggregate area being altered/affected as the threshold for significant additional work to update/improve the structure, thereby causing additional expense associated with other work that would be occurring.

The United States Department of Defense also cites the use of a 50% threshold as a trigger for antiterrorism updates for its own buildings, where it states "Incorporate antiterrorism upgrades as required to bring entire existing inhabited buildings into compliance with UFC 4-010-01 for all building renovations, modifications, repairs revitalizations, and restoration where project costs exceed 50% of the replacement cost of an existing building…"

According to the document titled "Understanding the FEMA 50 Percent Rule", relevant to the discussion of insurance claims, the Federal Emergency Management Agency (FEMA) has a rule which effectively says "A structure is considered Substantially Damaged (and thus requires Substantial Improvement) if the cost to repair is 50% or more of the market value of the structure… Once a structure is determined to be Substantially Damaged, the structure must be brought into compliance with current local floodplain management standards, which may include, among other things, elevating the structure, using flood-resistant materials, proper flood venting, or demolition and reconstruction. The Substantial Damage requirements were designed to address the large numbers of structures already located in SFHAs before communities joined the NFIP." While this regulation speaks to activities related to flood damage, it supports the conclusion that once you reach the 50% threshold the whole facility must be addressed.

In addition to these references outside Colorado, a local example can be found in the City of Boulder under their Energy Conservation Code. According to the code, alteration is defined as where the work exceeds 50% of the building area. In such cases, the code requires an entire structure to be updated to meet the code for building electrification, providing a related example for defining that once you have affected 50% or more of a structure, then the whole structure must be addressed. Boulder is borrowing this 50% threshold and much of its language from the International Existing Building Code (IEBC) and the key take away is that once 50% of the building's floor area is affected, significant alterations/updates are prescribed for the whole structure.

While Colorado does not currently have a total loss formula for homes or structures, bringing the entire building up to code, or updating a variety of building aspects after passing certain thresholds varies by jurisdiction. Attempting to address this on a case-by-case basis may convolute fire/smoke loss handling and therefore selecting a flat threshold for the state may significantly increase clarity and consistency of loss handling.

When referring to a contaminated floor area of 50% or more within a home, this means that, of all the floor area on all levels of the home, a total of 50% or more is contaminated by fire related COCs at levels that warrant the need for the flooring, walls, ceilings, and structural elements to be replaced (above, around, and below this area). This means that if a fire occurs on the 1st level of a three (3)-level house (basement, 1st, and 2nd level), the floors, walls, ceiling, and structure members in the affected zone on the 1st level will be replaced, and one would also need to practically replace anything in the upper and lower levels that are attached to areas being replaced on the main level (even if those areas were technically outside of the contaminated zone). For instance, if one removes the 1st level flooring/sheathing/floor framing and there is a ceiling in the basement that attaches to the floor framing that is being removed above, the ceiling will also have to be removed. Likewise, when removing the 1st level ceiling, 2nd level floor framing, and 2nd level sheathing, one would also end up removing 2nd level floor coverings as a practical result.

Smoke is known to disperse generally in all directions to some degree, but the typical smoke dynamic in a home involves upward movement from the source until smoke hits the ceiling, where it then disperses outward, forming a thicker layer that then moves downward as smoke accumulates (per page 2 "Paper_RNO02_HasaniahViney_2018"). In addition, water is almost always used to put out house fires and is sprayed into the fire/smoke, and then moves downward, pulling contaminants into lower areas and saturating materials with those contaminants (per PDF page 9 of "Industrial hygiene method for assessing toxic contamination in smoke and fire-damaged homes"). This means that if a given area on a level has contamination identified, air and water flow dynamics dictate that contamination would likely be present in all materials connected within, as well as upward and downward from that level.

While cleaning of fire residue has been demonstrated as effective in some cases through published documents like S700 and others, when that cleaning must address the full range of COCs imbedded in the full breadth of structures and contents within a home damaged by fire and/or smoke, the economics may favor replacement once 50% or more of the home's floor area is impacted by COCs in excess of applicable thresholds. There are also many shortcomings to cleaning when doing so across more than 50% of a structure such as running the risk of missing contaminants which would re-contaminate the house or having contaminants that were absorbed via the air or water into the home's porous materials which could slowly off-gas over months or even years. Finally, per PDF page 14 of "Industrial hygiene method for assessing toxic contamination in smoke and fire-damaged homes," "Methods such as 'encapsulation' where a sealant is applied to all surfaces that are thought to be affected by toxins as a means of keeping said toxins trapped beneath the sealed surface are largely ineffective (surface imperfections or inaccessible locations prevent proper application in the first place), degrade over time (seasonal thermal expansion and contraction, and compressive forces of humans moving throughout the structure flex the sealant membrane in vulnerable areas like a paperclip that will initially bend but will eventually break while environmental and aging based effects weaken the membrane material itself), and do not remove toxins but instead localize those toxins to be an issue for future construction with the property or for future inhabitants."

Other costs that affect this analysis, but which are not directly calculated and would further increase base costs of attempting repair of the home with 50% or more of its floor area affected by fire related COCs in excess of applicable thresholds include:

1) Clearance testing.
2) Non-salvageable goods that were anticipated to be salvaged.
3) Failed repair that later requires replacement.
4) Costs associated with handling/protection/disposal of hazardous materials.
5) Disputes, Damages, and Legal expenses resulting from improper or ineffective repairs.
6) Potential inability to seek recourse for remaining contaminants if discovered long after the initial repair attempt.
7) Prolonged ALE durations that can result from attempted but failed repairs.

A detailed analysis of repair vs. replacement costs is provided in **Appendix D Repair vs. Replacement Analysis**.

4.7.4 Clearance Testing

If repair is conducted, a post-remediation visual inspection and sampling assessment should be conducted to verify the effectiveness of the remediation activities performed. Preferably, the post-remediation assessment should be conducted in a similar manner to the pre-remediation assessment. The following protocol details the clearance criteria after removal of smoke residue. The environmental condition of the residence, with regard to smoke residue, is judged acceptable after completion of remediation tasks if all of the following criteria are met:

- Olfactory Clearance (in cases where the removal of COCs above applicable standards has occurred): No smoke odors are discernible in the remediated areas.
- Exterior Visual Clearance: No visible fire/heat damage or significant amounts of suspect smoke residues are observed during a visual inspection of the exterior of the structure.
- Interior Visual Clearance: No visible fire/smoke related dust or residues are observed during a visual inspection of the remediated areas in the interior of the structure.

If these initial clearance standards are not met, additional remediation/cleaning should be conducted as detailed in the cleanup work plan until no remaining odors, heat/fire damage or suspect smoke residue is observed.

Sampling Clearance: Once no smoke odors persist, and no visible fire or smoke related dust or debris are present in the remediated areas, then tape-lift samples should be collected. If amplified, atypical, or actionable threshold concentrations are detected, then additional cleaning and resampling is required. If only typical ambient/background concentrations of smoke residues are identified by the laboratory, then the final clearance criteria for particulates have been met.

If the pre-remediation sampling identified COCs in excess of ambient or background concentrations and/or applicable standards, then the post-remediation sampling should also include the collection and analysis of the previously identified COCs. Only the COCs that were sampled and determined to be needing remediation during the pre-remediation sampling should be sampled during the post-remediation sampling assessment. If any elevated concentrations of such COCs are detected, additional remediation/cleaning should be continued as detailed in the cleanup work plan until sampling meets applicable standards. Sampling should be biased to those accessible and inaccessible areas that were deemed impacted during the initial assessment.

If no visual, olfactory, or laboratory results exceed the final clearance criteria, background, or regulatory thresholds, then the property should be judged to have met the final clearance criteria, and no additional remediation or sampling is required.

4.7.5 Worker Safety and Waste Handling

During the cleanup or removal of materials that are deemed impacted from fire-related COCs, the contractor will be required to follow established worker safety protocol as regulated by OSHA. This study presumes that all contractors working in this field will comply with such regulations. **Table 1** contains various of the applicable OSHA worker safety standards but should not be viewed as comprehensive of all such standards that apply.

Similarly, materials impacted by fire-related COCs may require disposal as part of the cleanup process. It is assumed that contractors working in this field will follow all applicable waste handling and disposal requirements, as determined by State and federal regulations.

4.8 Disproved Methods and Assumptions

In the development of this report, several methodologies and assumptions have been evaluated and subsequently excluded due to their limited applicability, lack of scientific support, or potential to misdirect remediation efforts. This section outlines these disproved methods and assumptions, clarifying why they are not recommended for assessing or remediating fire-related contamination in residential structures.

These disproved methods highlight the importance of a scientifically grounded, nuanced approach to fire-related contamination assessment and remediation. Moving beyond simplistic assumptions and employing comprehensive, site-specific evaluations allows for more accurate risk characterization and effective cleanup strategies.

4.8.1 Volatile Organic Compound (VOC) Sampling as a Primary Indicator

While VOC sampling is commonly employed in indoor air quality assessments, its use as a primary indicator for fire-related contamination is questionable. VOCs detected post-fire can originate from a variety of sources, including cleaning products, off-gassing from building materials, and ambient outdoor air infiltration. Consequently, relying solely on VOC levels for fire contamination assessment can yield false positives or negatives, rendering it an unreliable primary indicator for fire-related contaminants (U.S. EPA, 2023). Additionally, VOCs by definition are volatile and tend to dissipate quickly over time. The use of field instruments during initial inspections can be useful in the assessment of VOC impacts and, if persistent, may warrant analytical confirmational testing.

4.8.2 Age of Structure as a Determinant of Contamination Severity

The presumption that 1) older structures inherently pose lower risks due to the less prevalent use of chemicals in early home construction, or 2) that older homes pose higher contamination risks due to materials such as lead-based paints, PCBs, or asbestos, because they are not as widely used or because they have been phased out of production in the US, or 3) conversely that new structures have higher risk of impacts due to newer chemical-rich materials, e.g., PVC, EV batteries, etc., or other similar age-based determinations were considered. Although these materials are known as hazards, their mere presence does not directly correlate with increased contamination post-fire. Instead, contamination severity is better predicted by the characteristics of the fire, involved materials, and remediation efficacy, rather than the structure’s age alone (National Institute of Standards and Technology [NIST], 2014). Further, the use of new contents in older homes could negate any perceived benefits from lesser chemical use in older building materials. Therefore, the use of age as a bright line to guide sampling protocols was deemed infeasible.

4.8.3 Overreliance on Single Analytical Methods

Exclusive reliance on a single analytical technique, such as gas chromatography-mass spectrometry (GC-MS), for detecting fire-related contaminants can be limiting. While GC-MS is robust for many compounds, it may fail to detect thermally labile or low-concentration contaminants. A comprehensive approach integrating multiple analytical methods — including Fourier-transform infrared spectroscopy (FTIR) and Raman spectroscopy — ensures a more thorough contaminant profile (NIST, 2014).

4.8.4 Relying Solely on Environmental Factors in Contamination Spread

Assuming uniform contaminant distribution without accounting for environmental variables like wind patterns, temperature gradients, and humidity can lead to inaccurate contamination assessments. Environmental modeling and site-specific evaluations are essential for correctly understanding contaminant dispersal and for guiding effective remediation strategies (U.S. EPA, 2022). Therefore, testing protocols based on distance, wind direction, or other site-specific conditions leaves uncertainty in confirming if impact is present.

4.8.5 Neglecting the Role of Water in Contaminant Mobilization

Water utilized during firefighting plays a critical role in the transport and deposition of contaminants. Underestimating the influence of water runoff in mobilizing contaminants can lead to incomplete site assessments. Evaluations must include water flow patterns and potential deposition zones to accurately delineate contamination extents (U.S. EPA, 2021).

4.8.6 Reliance on Visual Inspection Alone Without Analytical Confirmation

Visual inspection may identify areas with obvious soot or charring but cannot reliably quantify contamination levels or detect invisible residues such as embedded chemicals or submicron particulates. Analytical sampling and laboratory analysis remain essential components of a defensible assessment strategy to ensure occupant safety and compliance with applicable guidance (AIHA, 2025; US EPA, 2018; NIOSH, 2021).

4.8.7 Neglecting PFAS and Firefighting Foam Residues

Residual per- and polyfluoroalkyl substances (PFAS), which may be present in some firefighting foams such as Aqueous Film-Forming Foam (AFFF), are persistent environmental contaminants associated with potential human health effects, including carcinogenicity and endocrine disruption (Grandjean & Clapp, 2015; US EPA, 2022). Firefighting foam residues can remain on-site long after suppression activities, contributing to ongoing contamination risks if not properly addressed during assessment and remediation. Overlooking these compounds and their transport via foam or water runoff can compromise a comprehensive evaluation of post-fire contamination. However, in typical residential fires - including most wildfires - water-based suppression is used, and consideration of PFAS/AFFF should generally be limited to instances where their application is confirmed.

4.8.8 Assuming Exhaustive Chemical Testing is Always Required

As the study of fire related COCs has grown, general consensus is forming around the limited types of chemicals that are most commonly produced in wildland/range and WUI fires. Aggressive sampling tends to drive up costs, promote fear mongering, ignores background conditions and creates unrealistic cleanup goals. The use of reliable surrogates is deemed as a best practice.

5.0 INSURANCE ASSESSMENT

5.1 Premium and Coverage and Differential Analysis

5.1.1 Overview

This study assesses potential impacts to insurance premium costs based on the recommendations presented herein. To accomplish this, the initial focus of this study was to consider where insurance costs and coverages are at present; the variables that will change as a result of the new sampling, testing and cleanup protocols; whether each of those variable changes will be quantifiable or must be qualitatively addressed; the methods to determine the amount of change; how much the changes will affect premiums; and the impacts this will all have on future coverages. This analysis is based on a weight of evidence approach and is, therefore, qualitative and should be considered from that perspective. An insurer data call was not performed to occur during this study. This analysis retains the process developed so that future studies with access to such information may use this process to advance some of the qualitative conclusions through quantitative means.

Given that this study devoted substantial effort to developing calculations and methods to address gaps in data, the Premium Calculation Equations may be reviewed as desired in **Appendix E Premium Analysis Plan and Explanations**, which contains the premium/differential inputs and calculations, and the National Association of Insurance Commissioners (NAIC) raw data extracts being refined to average Coverage A Limits, Homeowner premiums, and calculations used to provide a current average for these numbers. In the absence of industry data, the complete analysis using these methods was not conducted but is provided for informational purposes-only.

While a detailed premium analysis was not possible, this study includes research on fire/smoke related coverages, offered limits, and an analysis on cost differentials. That analysis may be found in the sections which follow.

5.1.2 Background Research for Coverages and Provided Limits

The analysis began with gaining an understanding of what fire/smoke related coverages existed and what commonly offered limits were available from insurers in Colorado. While certain minimum required coverages (e.g., law and ordinance must be made available up to 20% of Coverage A, or ALE must include a minimum of 12 months with an option available to increase to 24 months) and typical ranges of coverages (e.g., Coverage B at 10% of Coverage A or Coverage C at 75% of Coverage A) were expected, the study sought to obtain the perspective an insured might have when asking for quoted home insurance. To accomplish this, the study identified the typical Colorado home size, configuration, and finishes, selected a variety of representative towns/cities throughout Colorado and requested blind quotes from insurers. A set series of answers to common questions insurers asked was established and requests were made to a variety of insurer captive agents for each home location, and also to brokerages to try and get as great a variety of samples as possible. This request did not ask for specific insurance or limits but just provided the house information and allowed the agent to provide a policy, which was then reviewed. The following summarizes those results:

Generally Followed Expectations:

- For ALE: All offers, save one (for 12 months), provided 24 months in the initial quote, even though Colorado only requires that policies include at least 12 months and that an option to increase to 24 months be made available
- For Coverage B: 91% of Quotes had Coverage B set at 10% with outliers being set at either 5% or 20%.

Generally, Did Not Follow Expectations:

- For Law and Ordinance: While insurers are required to make coverage available up to 20% of Coverage A, 55% of quotes settled at 10% or less in initial offers for this coverage.
- For Coverage C: Only 40% of initial offerings for Coverage C were for at 75% of Coverage A. and the rest ranged from 50% to 70%.

A secondary basis for this analysis was to better understand the landscape of fire and smoke related coverages within the Colorado homeowners market. The findings suggest that while the various policies may have been organized or worded slightly differently, none of them excluded fire or its byproducts from coverage.

The complete analysis of our findings for policy coverages and offered limits may be found in the expanded study in **Appendix F Background Research for Coverages and Provided Limits**.

5.1.3 Differential Analysis

Based upon the data, assumptions, and analysis that were conducted, the primary conclusions are summarized below. This differential analysis is based on a qualitative assessment of the information available at this time. While the formal acceptance of any aspect of this study has not been made by the State, this differential analysis assessed the potential impacts of the full range of recommendations, such that a sense of insurance premium impacts could be determined. This weight of evidence approach is intended for demonstration purposes and is not based on specific claims data and, therefore, should be viewed as qualitative and for demonstration purposes-only:

- Testing, sampling, and reporting costs on a per claim basis would be expected to increase by between $8,520 to $11,720 for dwelling losses.
    - o Only about 16.5% of lots in Colorado would be a size larger than 0.5 acres and would require other structures testing, resulting in a possible increase for those larger properties of $1,800 to $9,000, the high end reflecting unique/rare circumstances where testing of the Primary Structure isn't conducted, which means that the Primary Structure testing would be less and potentially offsetting this cost..
- Approximately 28.25% of fire claims which would have been seen as repairable under the current methods would be seen as replacements under the proposed economic analysis method.
- The total percentage of house fires anticipated to result in full home replacement as the default handling under the proposed economic analysis method would be 34.99%.

- The anticipated percentage of dwelling fires that would result in all Other Structures becoming a default total loss under the proposed economic analysis method would be 29.22%.
    - If the dwelling fire occurred to a WUI lot, the anticipated likelihood of the Other Structures defaulting to a total loss would be 18.75%.
- The anticipated percentage of dwelling fires that would result in all Other Structures becoming a total loss default under the new economic analysis method which *would have* defaulted as repairable or undamaged under the current method would be 23.59%.
    - If the dwelling fire in this category occurred to a WUI lot, the anticipated likelihood of the Other Structures defaulting to a total loss would be 15.14%.
- The ALE Monthly expense for a typical Colorado home rental (fully furnished and including utilities, fees, and internet) averages $3,945 a month.
- The typical ALE durations for replacement of homes are calculated to range from 15-20 months for standard attritional dwelling fires that result in total losses, resulting in costs that fall between $59,175 and $78,900.
- Under the hypothetical wildfire scenario with prolonged durations, 24 months of ALE up to the 36 months of ALE the insurer must give in the event of a declared wildfire disaster was deemed sufficient to address the perceived range of ALE needs. For the hypothetical wildfire scenario, ALE absorptions ranged from 23 to 30 months and costs ranged from $90,735 to $118,350.
- Under the assumed ALE durations for an attritional fire and a hypothetical wildfire scenario, ALE would generally not exceed offer or disaster limits but under disputed/mishandled fire claims, durations often exceed ALE limits. Therefore, the study anticipated substantial savings on claims in this category.
- Similar to the ALE reductions, the study anticipated savings associated with fewer lawsuits, legal/mediation fees, legal damages, and lawyer/expert fees.
- By providing more clarity on fire COCs, their hazards, proper sampling and testing, and providing more efficient thresholds for claim categorization, the study anticipates more efficient claim handling, which will further reduce costs.

5.1.3.1 Loss Handling Changes

5.1.3.1.1 Sampling, Testing, and Reporting:

Current Methods: It is our experience that the typical range of initial fire residue samples that are tested for soot, char, and ash, tends to range from three (3) to five (5) samples for a home using current methods. The common testing method presently used is microscopy. Costs tend to range from $100 to $200 per airborne/surface fire residue sample with lower costs being for one (1)-week results and higher costs being for same day results. In the event that dust chemistry for pH and associated concerns occurs, these costs range from $30 to $200 per sample depending on degree of analytical detail and speed of turnaround. There is also the cost of collecting samples onsite and providing a report. This sampling/reporting cost tends to range from $1,600 to $3,200 (eight [8] to 16 hours of total absorbed IH team blended time at an average hourly total of $200). Based on the range of sampling and non-rush order pricing of $100 per test, testing would be $300 to $500. This creates an average range of cost from $2,100 to $3,700 for current methods (Rush order pricing would add $300 to $500 to those ranges).

For comparison, www.UPhelp.org (and other Environmental/Testing companies) note an average range of $2,000 to $4,000 for sampling, testing, and a written report for the typical residential fire claim utilizing current sampling/testing methods.

For **Other Structures** testing, this study did not find a specific number of tests, if any, that were regularly taken in association with house fires or with fire origins that did not involve the Primary Structure. However, the typical per-sample cost would be expected to range from $100 to $200 depending on desired laboratory turnaround. Assuming sampling was done in one (1) to five (5) locations with standard laboratory turnaround and an assumption of IH hourly absorptions ranging from four (4) to 16 hours (depending on if dwelling testing is occurring concurrently), the range of these costs is $900 to $3,700 (add $100 to $500 for rush orders)

For **Contents**, the study did not identify a common practice related to sampling, testing, and reporting. While it is possible that testing may occur on contents, it is unlikely that this will often occur as the cost of testing would be around $100 on the low end with any post cleaning testing costing another $100 without accounting for the costs to take the samples, reporting, or any ancillary costs associated with trying to keep the contents. This would mean it would effectively cost more than $200 to test each content item which would generally exceed the cost of most contents.

Post remediation clearance testing/reports tend to reflect similar sampling/testing/and reporting costs as those initially incurred, though, they may cost less depending on the circumstances and whether some COCs are disproved during initial testing. With this understanding, it is anticipated that minimal cost ranges for post remediation clearances could also range from $2,000 up to $4,000. If other structures were affected, clearance testing costs would be expected to be reflective of initial testing costs.

The total range of sampling, testing, and reporting costs for the dwelling is anticipated to range from $4,000 to $8,000 with little to no cost for contents since these are not typically tested and there is minimal variable cost for other structures (which are also very infrequently tested).

Proposed Methods: Proposed sampling involves a minimum of five (5) sample locations for the level that the fire occurred with one (1) additional air sample on that level. These samples will be analyzed for fire residue (soot, char, ash), SVOCs, Metals, and Dioxins & Furans. Assuming testing occurs for all COCs, testing costs tend to range from $800 to $1,200 per location (average of $1,000) and only account for the standard 10 business day or less laboratory turnaround. Air sample testing will cost approximately $660 for the initial testing.

Cost for the average minimum **Dwelling** sampling & testing are anticipated to range from $4,000 to $6,000 for non-air sampling costs, plus $660 for the initial air sample cost, and an anticipated range of $1,600 (eight [8] IH hours at $200 and hour) to $3,200 (16 IH hours at $200 and hour) for inspection, sampling, and reporting costs by the IH. This results in a range of total costs from $6,260 to $9,860.

For **Other Structures**, when applicable, sampling would range between one (1) and five (5) tests (depending on circumstances) and typically no air sample. These costs would range from $800 to $1,200 ($1000 average) on the lower minimum end up to $4,000 to$6,000 ($5,000 average) on the upper minimum end (when testing would be required). IH sampling and reporting costs would be anticipated to range from $800 to $3,200 depending on if there is dwelling testing occurring and associated costs added in. Total potential range of costs for other structures testing, when applicable, would be $1800 (with dwelling testing and minimal test samples) to $8,200 (assuming no dwelling testing is occurring and maximal test samples, a relatively unlikely scenario).

For **Contents**, the new economic analysis method of sampling and testing would not include any testing for contents and contents would be treated similarly to the area they are located in. This includes finishings, sheathing, structural members, and contents. If a zone is not impacted by fire related COCs above applicable standards but is affected by soot, char and ash residue, standard cleaning/replacement methods detailed in the S700 and S500 standards would be deemed to apply. Therefore, testing costs for contents would be $0.

Post remediation clearance sampling/testing/reporting would be anticipated to reflect initial testing costs but could be reduced if COCs are disproved by initial testing.

Total Range of sampling/testing/reporting costs for dwelling testing, pre- and post-remediation would be expected to range from $12,520-$19,720 (assuming initial testing found COCs).

Ranges of Minimal Differential Sampling, Testing, and Reporting:

Dwelling Differentials:

Current Method (initial testing): $2,000 to $4,000

Proposed Method (initial testing): $6,260 to $9,860

Initial Testing Differential: $4,260 to $5,860

Clearance Testing Differential: $4,260 to $5,860

Potential Total Differential: $8,520 to $11,720 greater sampling/testing/reporting cost with the proposed method.

Other Structures Differentials (IF other structures testing was deemed necessary):

Current Method (initial testing): $900 to $3,700

Proposed Method (initial testing): $1,800 to $8,200

Initial Testing Differential: $900 to $4,500

Clearance Testing Differential: $900 to $4,500

Potential Total Differential: $1,800 to $9,000

-as described in the damage thresholds section, only about 16.5% of lots in Colorado would be larger than 0.5 acres and would require this testing.

Contents:

Differential: Less than or equal to the current method.

5.1.3.2.2 Damage Thresholds:

Current Method: The current method of handling fire losses is that the insurers and contractors primarily default to cleaning the Primary Structure, except in cases of severe damage.

Other Structures are rarely addressed unless direct damage is identified to them or it is clear that other structures would be damaged in the process of addressing damages to a primary structure.

Contents are often sent off to be cleaned/laundered/repaired instead of being replaced and this cost is less than the cost to replace the contents (otherwise, it would not be approved). Keeping contents is a lower cost than replacement, but typically only in the event that testing of each content does not occur. If testing of contents that are thought to be impacted by fire related COCs above applicable standards occurred, it would nearly always be less expensive to replace those contents, rather than testing, cleaning and retesting the Contents.

The costs associated with restoring property and contents under the current method of handling fire losses, that being a focus on cleaning and repairing nearly everything unless physically damaged by the fire or its residue, are not well established in publicly available literature.

What can be concluded is that the current methods, to the extent that they do not account for impacted by fire related COCs above applicable standards, tend to avoid the additional costs associated with addressing such conditions and, therefore, tend to cost less overall than methods which would account for fire related COCs above applicable standards or risks associated with such.

Proposed Method: The proposed method involves minimally testing five (5) locations in the house (on the level where the fire occurred when relevant) with one (1) air sample. Other Structures testing, depending on there being circumstances that require such, involving one (1) to five (5) total location tests. Testing would include tests for soot, char, and ash, SVOCs, heavy metals, and for dioxins and furans. Contents would not be tested. The proposed method would utilize zones. For purposes of this analysis, when impacted by fire related COCs above applicable standards, the zones would be deemed generally impacted (including whole rooms which are within the zone) and would be conservatively assumed to have everything within and connected to the walls, floors, and ceilings (including finishes, sheathing, and structural members such as studs, floor joists, and related) considered impacted and replaced. When zones are affected only by soot, char and ash, they would be handled per the S700, S500, and NEMA guidance. Contents would be handled in the same manner as the zone they are located in. Further, for purposes of this analysis, there would be a threshold that when 50% or more of a structure's floor area is affected, the structure and contents within the structure would be replaced. Finally, for Other Structures, when a property lot is 0.5 acres or less in size and there is a house fire that results in 50% or more of the floor area being deemed impacted by fire related COCs above applicable standards, the other structures, lot, and its contents in entirety would be deemed impacted and this analysis conservatively assumes replacement would occur.

Specific Fire Related COC Testing: As a consequence of testing for fire related COCs , a greater number of properties will likely be found to be impacted by fire related COCs above applicable standards and this will result in more intensive handling which could increase costs.

> Per 2021 data collected by FEMA (found in doc "Confined vs nonconfined fires"), each year there are an estimated 368,000 residential building fires reported to fire departments within the US (based on 2017 to 2019 reports). Confined fires are defined as rarely resulting in serious injury or large content loss and are noted to have no significant accompanying properly loss due to flame damage. Nonconfined fires are defined as those which extend beyond certain types of equipment or objects and which are generally larger fires resulting in more serious injury and larger losses of property and content.
>
> Confined fires accounted for 50.6% of fires. Of this sum 5.6% were noted to be trash/rubbish fires which were contained. While trash/rubbish fires typically create hazardous contaminants, this study is proceeding under the premise that these contaminants remained contained to the trashcan and were not a factor.
>
> Nonconfined fires accounted for 49.4% of fires. This would be the percentage of residential fires anticipated to produce fire related COCs above applicable standards that could spread and affect the house.

Zones: Based on air and water flow dynamics, if fire related COCs above applicable standards are identified in a zone, for this analysis it is conservatively presumed surrounding wall/ceiling/flooring spaces along with the structural members are similarly impacted. As such, the proposed method when a test is conducted in a zone's middle outer wall elevation (still inside the house), which identifies fire related COCs above applicable standards, is to interpret the entire zone and all full rooms connected within the zone as impacted and needing replacement. Consequently, for this analysis all contents within full rooms connected to an impacted zone would also conservatively be identified as impacted and disposed. On the other hand, zones which may only be affected by soot, char and ash would have all full rooms within that zone identified for cleaning and repair and contents could be handled with the default assumption that they are repairable unless deemed otherwise by guides, standards, or contractors on a case-by-case basis. This method allows for less expensive sampling/testing than if one were to sample every room individually (in that less tests are needed) and quicker/less expensive determinations on claim handling.

> **50% or Greater Dwelling Floor Area Threshold:** For this analysis, when 50% or more of a dwelling's floor area is deemed impacted by fire related COCs above applicable standards, the costs make it such that, as a general principle, the dwelling would be seen as constructive total loss where it is more practical and cost effective to tear down the structure and replace it (See **Appendix D - Repair vs. Replacement Analysis).** Contents would be handled similarly to the structure itself and would also be replaced in entirety in the event that the house is replaced.
>
> Per FEMA's 2021 Study (doc "Confined vs nonconfined fires"), 56% of fires were limited to the object of origin (with this number including the 50.6% confined fires), 19.3% were limited to the room of origin, 4.8% were limited to the floor of origin, 16.9% were limited to the building of origin, and 3.1% of fires extended beyond the building of origin. This was specific to fires which occurred inside residential buildings.

Utilizing these statistics, the study applied certain assumptions to better understand what percentages of house fires might reasonably produce fire related COCs above applicable standards which would likely impact 50% or more of the house's floor area and therefore result in full house replacement under the new economic analysis method.

1. For localized fires, 5.4% remained localized to the object of origin but were not confined. Of these the study assumed only 10% produced fire related COCs above applicable standards to a significant enough degree to impact 50% or more of the house's floor area. This means that 0.54% of total house fires would result in a total loss when looking at just this category.
2. For the 19.3% of house fires which remained confined to one (1) room, most would have produced fire -related COCs above applicable standards, conservatively resulting in at least 50% of them being on a level where they could have impacted at least 50% of the house. Therefore, another 9.65% of fires would result in a full home replacement scenario.
3. The remaining 24.8% of house fires are in categories ranging from fires that remained localized to the level of origin all the way to burning beyond the house. All of these fires would be expected to generate fire related COCs above applicable standards, which would have affected at least 50% of the house's floor area. This would mean a further 24.8% of house fires would be anticipated to result in full home replacement under the new economic analysis method.

Total Percent of House fires anticipated to result in full home replacement as the default handling under the new economic analysis method is 34.99%.

Of these house replacements, the study assumed the current methods would have attempted to repair all losses that were confined to the room of origin, 75% of fires that were confined to the floor of origin, and none for those that spread throughout or beyond the house. The breakout is found below:

	Repair (Current Method)	Repair (Proposed Method)
Room of origin:	19.3%	9.65%
Floor of origin (24.8*.75):	18.6%	0%
House of origin:	0%	0%
Beyond house:	0%	0%
Repair Attempt:	37.9%	9.65%

The new handling method would propose replacement for 28.25% of residential fire losses that would have been handled as repairable under the current method.

0.5 Acres or Less Lot Size Threshold: As noted previously, when a lot is 0.5 acres or less in size, analysis suggests the most efficient method for handling a lot's Other Structures and non-dwelling contents is to treat them the same way the house is treated. For this analysis, if the house is deemed a replace scenario, the other structures and non-dwelling contents would be treated in the same manner. If the house is tested and less than 50% of the floor area is affected (i.e., the house is defaulting to an attempted repair/cleaning), then testing/cleaning/repair of the other structures via the zone method would occur.

Per our "0.5 Acre Data Colorado Lot Size Distribution," the study conducted an analysis of residential lot sizes throughout Colorado in order to get an approximation of how many residential lots fell within the 0.5-acre threshold. The study utilized "https://www.countyoffice.org/co-property-records/" and supplemented this data with estimated 2024 population data from the2020 US Census. While the detailed analysis may be seen in its **Appendix G 0.5 Acre Data: Colorado Lot Size Distribution**, the key result was that **16.5% of residential property lots in Colorado were approximated to be over 0.5 acres**.

The study then recalculated the distribution of lot sizes when restricting the Colorado population to just WUI areas by multiplying the percentage of residents living in WUI areas into the population of each county and using these as weights. Though, in this case, instead of assuming one third of them had lot sizes on the small end of the range, one third at the median, and one third at the high end, this study assumed more lots in WUI areas would be at the high end of the range. Specifically, the study assumed one fifth, two fifths, and two fifths at the low, median, and high values, respectively. The key finding of this analysis was that, of **WUI residential lots, 46.4% were anticipated to be over 0.5 acres.**

The anticipated percentage of total dwelling fires that would result in all other structures becoming a default total loss under the new economic analysis method is 29.22%.

> If the dwelling fire occurred to a WUI lot, the anticipated likelihood of the Other Structures defaulting to a total loss interpretation would be 18.75%.

The anticipated percentage of total dwelling fires that would result in all other structures becoming a default total loss under the new economic analysis method which *would have* defaulted as repairable or undamaged under the current method is 23.59%.

> If the dwelling fire in this category occurred to a WUI lot, the anticipated likelihood of the other structures defaulting to a total loss interpretation would be 15.14%.

Additional Living Expense (ALE) Considerations: In order to address ALE costs, the study first determined an average monthly ALE (see **Table 3 Average ALE Analysis**). This study found an anticipated **monthly ALE expense of $3,945 per month (for housing related expenses)**. Assuming no year-over-year rental increases this average monthly cost would translate as follows:

12-month absorption of ALE: $47,340

24-month absorption of ALE: $94,680

36-month absorption of ALE: $142,020

Per "Additional Living Expenses_ A Critical Recovery Tool After Disasters," the expected Coverage D (ALE) limits in various states is 30% or some other percentage of the Dwelling coverages as the limit. This same source clarifies that, for many years, agents used the general guideline that a house could be rebuilt in a 12-month timeframe but that "This standard does not work in a post nature disaster claims setting where rebuild times can exceed a 2-year limit." In Colorado, at the time of the Marshall Fire, Coverage D generally varied between 12 and 24 months of ALE coverage. Per "2021-Marshall-Fire-6-Month-Survey-Report-1", 46% of survey respondents reported having a dollar limit for their loss of use/ALE coverage (Coverage D) and a significant majority of the respondents had 24 months of coverage in this category.

For Colorado, as described in CO Rev Stat § 10-4-110.8 (2024), insurers cannot provide coverage offering less than 12 months of ALE, and must offer policyholders the opportunity to purchase at least 24 months of ALE. As it relates to wildfires disasters that the governor declares pursuant to section 24-33.5-704:

> "…(c) The policy must include additional living expense coverage to apply in the event of such a loss. Notwithstanding subsection (6)(b) of this section, additional living expense coverage must be available for a period of at least twenty-four months, and the insurer shall offer the policyholder the opportunity to twice extend such period by six months if the policyholder, acting in good faith and with reasonable diligence, encounters a delay or delays in receiving necessary permit approvals for, or reconstruction of, the insured owner-occupied residence, which delays are beyond the control of the policyholder."

In short, insureds in Colorado are granted no less than 12 months ALE, with insurers required to *offer* 24 months ALE coverage, and with a possibility of up to 36 months of ALE coverage in event of a declared wildfire disaster. In order to understand approximate attritional house fire ALE needs, the study assessed the time to build a new home, the time to demolish a house, and then the claim related handling/sampling/testing/payments tendering and settling/ mortgage company requirements.

Time to Build a New Home: Per current state regulations, when there is not a declared wildfire disaster, the typical ALE coverage would range from 12 months to 24 months. Utilizing uphelp.org and their previous Marshall Fire survey, the study assumed that the majority of insureds have 24 months of ALE coverage. To build a custom house, "How Long to Build a Custom Home in Colorado" notes that this process is expected to take 12-18 months assuming an empty lot. "How Long Does Building a Home Really Take_ - Oakwood Homes" notes the typical time to build a standard house is six (6) to eight (8) months. Per "How Long Does It Take to Build a House_ — West + Main," the 2020 US census estimated 6.8 months to be the average time to build a new home, but that average increased to 12 months for owner-built homes and six (6) months for build for-sale homes. Further it was noted that the location of the house in the United States drastically changed averages with houses built in the Northeast taking an average of 10.7 months and houses built in the south taking an average of 5.9 months. "Single-Family Build Time Continues to Trend Upward - HBA of Metro Denver" notes that, as of 2023, the average completion time of a single family house was approximately 10.1 months, with an emphasis that more stringent regulatory environments are the primary factor in duration and with ongoing supply-chain challenges and a shortage of skilled labor being contributing factors as well. They also note that construction durations have been upward trending since 2015, indicating this trend might be anticipated to continue, and that, as of 2023, built for-sale homes took 8.9 months, owner built homes took 15.2 months, and homes built by hired contractors took about 12.1 months. These timeframes do not take into account tearing down the old home. Assuming most insureds would utilize hired contractors, and the average is approximately 12 months to build a house, it would be reasonable to assume a third of homes will be built in nine (9) months, a third built in 12 months, and a third built in 15 months.

Demolition of the Fire Impacted House Based on industry standard considerations, this study assumed 24 to 48 hour turnarounds for permits, mobilization of one (1) day and that demolitions ranged between four (4) to six (6) business days. Utilizing this schedule, for a typical attritional house fire, this study assumed a demolition timeframe of six (6)-nine (9) business days, which was conservatively placed at 2 full weeks.

Claims Related Handling, Sampling/Testing, Payments Tendering and Settling, and Mortgage Company Requirements: Testing can usually be scheduled within one (1) week. Obtaining laboratory testing results takes two (2) weeks or less on average. After testing results are received, estimating follows with contractors taking two (2) to four (4) weeks to produce (the adjuster may produce the estimate as well but in the case of a full replacement of the dwelling it is far more likely that the insurer will rely on the insured's selected contractor to address this). Claim review can reasonably take two (2) to six (6) weeks. Transfer of funds, interaction with the mortgage company, fund settlement, payment to the contractor and allowance for funds to settle would be anticipated to take two (2) to four (4) weeks. In total, this process would be expected to take roughly between2.25 and 4.25 months.

ALE Coverage: This analysis only considers **total losses** and will operate with the understanding that activities (e.g., repair, replacement, etc.) associated with other structures could occur simultaneously with dwelling demolition and rebuilding. The chart below addresses the initial ALE scenario of where an individual house fire occurs. In that case, it assumes the low, mid, and upper ranges an insured family might be displaced while a total replacement of their property occurs. In the first scenario, assuming the insured family selected the offered 24 months of ALE, they are covered for the full length of the rebuilding process. If they went with the minimum 12 months of ALE Coverage, they may have to come out of pocket for three (3) to eight (8) months of ALE.

In the second scenario, the study assumed a hypothetical wildfire scenario where durations are prolonged by about 50% due to shortages of labor and backlogs of work. While wildfire scenarios are highly variable, it is believed this is a reasonable hypothetical scenario. The study found that insureds that accepted the offered 24 months of ALE are covered on the low range of duration, and so long as the state declares the wildfire a disaster, insurers would provide up to 36 months of ALE coverage and this would cover insureds for the mid and upper range durations.

	Low Range	Mid Range	Upper Range
ALE Duration Ranges for Attritional House Fire Losses (rounded up to closest full month):	15 months	18 months	20 months
ALE Cost (House Rental, Utilities, Fees): $3,945	$59,175	$71,010	$78,900
Wildfire hypothetical at 150% Durations	~23 months	27 months	30 months
ALE Cost (House Rental, Utilities, Fees): $3,945	$90,735	$106,515	$118,350

Green=Minimum 12-month ALE Coverage to 24-month ALE Coverage

Orange=Extended ALE for Declared Wildfire Disasters for up to 36 months

One of the major expenses from claims mishandling for fires is ALE. While this study evaluates that more fire claims would likely default to replacement assumptions, these claims often end up becoming contested when they are treated as repair due to the extent of damages/contamination, redundant and failed cleaning and repairs, disputes, etc. Disputed fire claims typically greatly exceed their ALE coverages (even at 36 months of ALE). As a result, providing a more accurate methodology for assuming a replacement versus an attempted repair is anticipated to greatly reduce loss durations, and therefore ALE durations. This study shows that proper replacement assessment under essentially all scenarios results in using less than maximal available ALE coverages. . Having a clear remediation standard from the start may even reduce total costs for fire claims.

Court/Mediation Fees, Legal Damages, Expert/Lawyer Costs: While this data is not publicly available, this category of cost is another one of the largest value adds anticipated from having proper sampling, testing, and replacement threshold guidance related to soot, char, ash, and other particulate affected single-family detached homes. In the State of Colorado, insurers have significant exposure to damages for mishandling claims, plus the risk of potentially having to pay the other party's lawyer's fees. Further, there are the various ancillary expenses that can be incurred, e.g., lawyer/expert cost, wasted employee time, courtroom/mediation fees, advertising/reputational harm related to negative media exposure, etc. This study finds that added clarity reduces the probably of misunderstandings or mishandling of claims and this should shield insurers from many of these risks and expenses by providing clear guidance on proper loss handling.

Adjusting/Claims Handling Costs: Another benefit of structured sampling and cleanup protocols is anticipated to be greater efficiency with claims handling itself. Having clear processes and thresholds for replacement categorization should reduce inefficiencies in assessment, estimating, communications, etc. Increased efficiency yields lower operations expenses which should provide insurers resultant savings.

5.1.3.2 Differential Conclusion

While the proposed sampling/testing method presented in this study may have higher costs than the current sampling/testing method, the study indicates these costs may be offset by increased accuracy in claim handling, reduction of redundant contractor work due to initially missed hazards, and lower overall risk to the insurer. The study also finds that widely accepted standard protocol lends confidence to policyholders, reducing uncertainty and the likelihood of frivolous claims. While more losses may default to being categorized as replacement scenarios, this study suggests that in many cases this expense would eventually be incurred by the insurer regardless, but only after mishandling had occurred. This study finds that proper testing and categorization from the start would reduce wasted adjusting time and prevent lawsuits and related damages for insurers. This analysis also indicates that proper handling of fire claims (attributable to the new economic analysis method) would result in the vast majority of claims *not* exceeding ALE limits. This study finds that disputed fire claims very often exceed ALE limits and the prevention of ALE limit caps being realized should save insurers significant costs in this coverage category as a result. In conclusion, while this study suggests that higher *initial* claim costs would result from the proposed method for sampling/testing/categorization, it also anticipates these initial costs to be largely be offset by savings from efficiency (reduced ALE), and reduced risk, legal exposure, legal/expert costs, and administrative costs.

5.1.4 Fire/Smoke Coverage & Premium-Related Considerations

In short: While it was only possible to conduct a qualitative evaluation. the study found that current fire/smoke coverages are fully available for Homeowners Insurance, that premiums may not increase as a result of the methods proposed in this report, and that there is no reason to expect a reduction in available coverages.

Regarding Premium Impacts: While the study did not include a detailed data call, involving fire claim counts specific to the State of Colorado for single family detached homes, and while this did limit the ability to analyze premium impacts or perform actuarial analysis, as described in **Appendix E Premium Analysis Plan and Explanations**, the study qualitatively analyzed a variety of anticipated differentials for fire claims. Under the hypothetical cases assessed using the recommendations of this study, those differentials anticipate an increase in initial sampling, testing, and reporting costs, as well as a presumption that more properties would be categorized as replacement scenarios vs. repair scenarios, on the presumption that the economic analysis is used. Given these parameters, the study found that these increased costs will be offset (perhaps completely) by increased claims handling efficiencies and accuracy, lower legal expenses/damages/related costs, and savings with ALE. Further, the certainty of having a defined sampling protocol and cleanup standards will minimize the potential for frivolous or opportunistic claims.

Regarding Coverage Availability for Fire and Smoke at Present: For fire and smoke, this study found no concerns with total coverage for structures/contents that have been affected by fire or smoke in policies. While representing a small snapshot, all currently offered policies reviewed provided fire/smoke coverage without exceptions.

Anticipated Effects the Proposed Method may have on Coverage/Premiums. : This study finds that the proposed methods may not have an adverse impact on coverage availability or premium costs. The study concluded that increased initial costs are thought to be offset by improved efficiencies in administration of claims, fewer disputes, lower legal costs, less testing through the life of the claim, and shorter ALE durations These savings areas, while not known in their full details, are understood to be substantial. As more information is developed on such things as COCs that may serve as surrogates for cleanup, state supported cleanup standards, and increased understanding of long-term health effects, it is expected these protocols may serve to lower potential insurance costs by bringing more certainty to the residential wildland/range and WUI fire cleanup process.

6.0 LIMITATIONS

This study is based on the review of hundreds of resources, multiple interviews with non-profit organizations, trade groups and industry experts and feedback gained in three (3) stakeholder meetings. Even with this broad base of research, this study only represents a snapshot of the industry at this point in time. As research and science evolve, that information may inform differing results and recommendations.

Considerations regarding other ways that homes are damaged in fires were beyond the scope of this study. Examples of which include damage resulting from firefighter activities to look for life and address fire conditions, corrosion resulting from chemical reactions that occur during fires, water used to put out fires, thermal impacts and other forms of physical damage (e.g., wind, etc.).

The analysis of insurance costs implications was conducted in the absence of a formal industry data call. The use of such detailed information could modify the conclusions presented in this study.

7.0 CONCLUSIONS

This study finds that standardization of that assessment process may lead to long term costs savings for the industry.

7.1 Technical Conclusions

It is believed that the lack of standardized testing in the initial stages of the claim process have resulted in excessive costs related to disputes, time out of the house and failed cleanups. This study found that a limited number of fire related COCs warrant consideration in the assessment of wildland/range and WUI fires, and that the use of cleanup standards, that also consider background conditions, is critical to successful re-occupancy of a home. Further, this study finds that economic decisions about when to replace vs. repair fire-impacted houses may favor replacement in cases where widespread, significant impacts from fire related COCs have affected the house. *We request comments from stakeholders on this potential recommendation.*

7.2 Insurance Conclusions

This study finds that the initial testing costs recommended herein may be higher than initial testing (or the lack thereof) being conducted currently. However, as many claims result in supplemental testing and disputes between experts, the use of a standardized approach will likely save money and time. When considering the differential in up-front costs and in decisions regarding repair vs. replacement, this study finds that the overall cost of insurance may decrease because of fewer frivolous claims, fewer battling expert scenarios, reduced ALE, decreased administrative process, quicker resolution of claims and fewer failed cleanups. *We request comments from stakeholders on this potential recommendation.*

8.0 RECOMMENDATIONS

The recommendations provided in this report are described in detail in the previous sections. Primary among them include the following:

- A standard list of fire related COCs including soot, char, ash, SVOCs, heavy metals, and dioxins/furans that serve as surrogates for potential health impacts resulting from wildland/range and WUI fires.
- Standardized testing protocol as the starting point for any claim of impact from fires.
- Cleanup standards that consider background for all fire related COCs.
- Economic evaluation of replacement vs. repair in situations with widespread and significant impact from fire related COCs.

We request comments from stakeholders on these potential recommendations.

8.1 Forward Looking Recommendations

During the course of this study, several recommendations came to light through interviews, stakeholder input and research that fall outside the specific scope of this project but were deemed relevant and are summarized below.

- Conduct a formal data call and seek input from the State's insurance carriers for specific data to be used to calculate a quantitative analysis of cost implications.
- Consider creating a general education campaign that homeowners can use to avoid common mistakes in dealing with the aftermath of wildfires, i.e., things not to do.
- Research the possibility of reduced testing protocol for wildland/range vs. WUI.
- Develop a central database of sampling data to be used to establish accepted background standards in residences in Colorado.
- Assess the potential for insurers to offer an optional, wildfire specific deductible and identify any safeguards needed to protect consumers. The assessment should also evaluate whether a separate wildfire deductible would produce a meaningful premium difference compared to the current all peril deductible structure (excluding hail)."

TABLE 1

CHEMICALS OF CONCERNS REFERENCES

TABLE 2

SUMMARY OF REGULATORY PROGRAMS RELEVANT TO OTHER CHEMICALS OF CONCERNS

TABLE 3
AVERAGE ALE ANALYSIS

APPENDIX A

STAKEHOLDER POWERPOINT PRESENTATION

APPENDIX B

BIBLIOGRAPHY

APPENDIX C

USE OF 0.5 ACRES IN SAMPLING PROTOCOL

APPENDIX D

REPAIR VS. REPLACEMENT ANALYSIS

APPENDIX E

PREMIUM ANALYSIS PLAN AND EXPLANATIONS

APPENDIX F

BACKGROUND RESEARCH FOR COVERAGES AND PROVIDED LIMITS

APPENDIX G

0.5 ACRE DATA: COLORADO LOT SIZE DISTRIBUTION