# Chautauqua Wildfire Mitigation Plan
# Phase 2
# Final Report

August 30, 2023

SHF Grant #2022-M2-001
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form+works
design group, LLC

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**FINAL REPORT**
**August 30, 2023**

**Deliverable #9**
**SHF Grant #2022-M2-001**

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# I. EXECUTIVE SUMMARY

The Colorado Chautauqua was established as a National Historic Landmark (NHL) in 2006. In order to achieve NHL status, properties need to have national significance and a high level of historic integrity. With regards to NHL status and historic integrity the National Park Service provides the following explanation:

> *Historic integrity is the ability of a property to convey its historical associations or attributes. While the NHL and National Register of Historic Places (NR) programs use the same seven aspects of integrity to evaluate properties (location, setting, design, materials, workmanship, feeling, and association) NHLs must retain them to a higher degree than required for a NR listing. If a resource has been more than modestly modified or deteriorated since its period of national significance, it may meet the NR threshold for integrity, but not the higher NHL standard* (National Historic Landmarks Glossary of Terms, 2023).

There are 102 historically contributing resources within the Chautauqua NHL district. Loss of historic integrity (through alteration, addition, or demolition) is the most common reason for the withdrawal of the National Historic Landmark designation. The designation may be impacted by changing construction materials that alter the appearance of the structures, loss of character-defining features, or significant changes to the cultural landscape. Wildfire is a risk that can impact Chautauqua's NHL designation. A wildfire mitigation plan can reduce that risk. Prior to moving forward with any alteration that may alter the appearance, building stewards or owners should check with their landmark authorities when considering fire mitigation treatments to ensure they comply with local ordinances, design guidelines, etc.

**Most of the recommendations focus on actions that should be taken well before a wildfire threatens Chautauqua, not during an incident where the presence of well-intentioned actions of individuals serve to impede responders from safely fighting the fire.**

PRE-PLANNING ACTIVITIES

The first historic protection for Chautauqua was created by the City of Boulder in 1978 when the Chautauqua Park Historic District was established, a local designation. In 1989, the City's Landmarks Preservation Advisory Board and the Colorado Chautauqua Association Collaborated to devise and adopt design guidelines that aimed to further protect the historic character of the site. The Colorado Chautauqua became a designated National Historic Landmark on February 10, 2006. To maintain the character and status of Chautauqua and prepare for a potential wildfire, it is essential that certain information be known – what is there, what are the priorities to protect, do drawings of key buildings exist, how and when should people evacuate the site for personal safety, which fire authorities and/or emergency managers should have this information, and what does Chautauqua do in case it is impacted by a wildfire? The following tasks are recommended as pre-planning activities. Details are provided in the

Phase I report included as an Appendix to this document (see APPENDIX E: PHASE 1 CHAUTAUQUA WILDFIRE MITIGATION PLAN). Several of these items have now been completed; others are in the planning phase.

- Conduct a cultural resource inventory
- Maintain and distribute list of priorities
- As-built documentation on priority buildings
- Establish evacuation plan & trigger points
- Develop a communication plan
- Develop a recovery plan

## LANDSCAPE AND FUEL MITIGATION ACTIVITIES

The two primary means of significantly reducing the immediate risk to Chautauqua are by fuels mitigation and creating defensible space. Fuel mitigation involves removing or trimming vegetation to reduce the total volume of material (the fuel load) that can burn while reducing the horizontal and vertical continuity of the fuel to lower the likelihood of the fire being able to spread without interruption (as across a grassy meadow). Horizontal fuel continuity is vegetation or other fuel that is continuous, or touching, across the horizontal plane, e.g., there is little or no separation from tree to tree, shrub to shrub, or grasses in a large meadow. Similarly, vertical fuel continuity is a lack of separation vertically, e.g., grass to shrubs to tree branches to the crowns of the trees would be a typical example.

In addition to working within Chautauqua's boundaries, work with adjacent property stewards is necessary, primarily Open Space and Mountain Parks (OSMP), to coordinate fuels reduction adjacent to the Chautauqua property. For example, the heavy fuel load in the OSMP property south of Chautauqua, the strip of OSMP property east of Bluebell Road that touches Chautauqua property, and the ravine area west of Chautauqua Reservoir Road should be priorities for collaborative fuels reduction effort as a fire that spreads from OSMP property threatens Chautauqua and a fire that originates on Chautauqua property threatens OSMP land.

The following recommendations apply to ongoing fuels mitigation and defensible space activities. Details are provided in the Phase I report (see APPENDIX E: PHASE 1 CHAUTAUQUA WILDFIRE MITIGATION PLAN).

- Remove dead trees
- Prune trees / vegetation
- Reduce tree spacing
- Remove slash
- Remove common ground junipers

BUILDING ENHANCEMENTS

There are many building enhancement and alteration methods currently in the marketplace that advertise their wildfire protection benefits. However, for the NHL designation, careful consideration is needed prior to making any major changes. Therefore, the first analysis of any building enhancement should look at: does it offer increased protection from wildfire risks? If so, is it a reversible treatment? (i.e., can it be removed without damage to the historic material?). Then consideration must be given to how it looks visually and how it may alter the experience of the historic integrity.

The two primary means of reducing the risk focus on continued building maintenance and limiting access for flying embers into vulnerable areas, such as roof; floor; and deck framing that could be ignited by flying embers entering into open areas or through vents. Both aspects are discussed in the Phase 1 report. Retrofitting vents and deck framing with a 1/16 inch to 1/8 inch metal mesh grid creates a barrier to the pathway for burning embers to enter the building. This report also identifies other products on the market for vent protection for consideration. Fiberglass or plastic mesh should not be used for retrofitting vents, as they will melt or burn, providing an additional fire fuel source and allowing internal access to the burning embers. An 1/8 inch metal mesh screen was installed behind the wood lattice below the Mary H. Galey Cottage during the Rehabilitation Project undertaken by CCA. Fire-retardant treated wood was also utilized as part of that project and is discussed later in this report. Another critical maintenance item is to ensure the space under open decks is free of debris and vegetation and is not used for storage.

The visual impact and cost implications of these recommendations would need to be considered and discussions had with History Colorado, Boulder Landmarks Design Review Committee, and CCA to determine approval. The following recommendations apply to building enhancements. Details are provided in the body of this report and in the Phase 1 report.

- Continued building maintenance: keep gutters and downspouts clean, inspect structures for any exposed wood (rafters, siding, trim, etc.) and maintain paint coatings/finishes at exterior wood
- Install metal mesh screening on deck screening and ensure areas below decks are not used for storage and are kept clean of debris and vegetation
- Install fire-proof vents (in lieu of metal mesh) and gutter covers

Although frequently discussed by various stakeholders, removal and wholesale replacement of historic wood cladding and trim, which is a character-defining feature of the buildings at Chautauqua, with fiber cement (or fire-treated wood siding products) is NOT recommended as it is drastic, invasive, costly and affords limited and currently difficult to demonstrate protection at the risk of jeopardizing the National Historic Landmark status under the current Secretary of the Interior's Standards for the Treatment of Historic Properties. Retention and continued maintenance of the historic materials at Chautauqua is required to maintain the district's high level of historic integrity.

ACTIVE FIRE PREPAREDNESS PLANNING

For general wildfire preparedness, the three primary means of reducing the risk of loss during a wildfire focus on water supply, protective envelopes, and the potential for applying short-duration Class A foams by responding fire resources. Firefighting relies heavily on a reliable water supply. There are hydrants at Chautauqua connected to the municipal system, however during an event the water pressure may be reduced; overall coverage is limited to hydrant locations; and there may be additional limitations based on the availability of firefighting personnel to be stationed at the site. Availability of a portable pumps system, sprinklers heads, and portable water storage tanks would provide a means of protection that can be independent and customizable to an oncoming fire threat. Building wraps are similar to personal fire shelters that wildland firefighters carry when conducting fire operations. While not ideal because of the challenges with installing the wraps, it is recommended for consideration. The third means is through the use of foams, the limitations of which are discussed in the body of this report. Foams as they relate specifically to historic wood structures require further consideration and study prior to full endorsement. The following recommendations apply to fire planning activities. Details and limitations are provided in the body of this report.

- Consider portable pump/sprinkler systems & portable water storage tanks
- Consider building wraps for key structures (not practical for the larger structures)
- Discuss / further study the use of Class A foam and practicality for application/deployment at Chautauqua with Boulder Fire Department

# II. PROJECT INTRODUCTION

The project consultant team was led by Natalie Lord, RA, LEED AP BD+C, of Form+Works Design Group, LLC. Form+Works Design Group was started in 2017, to specialize in Historic Preservation Architecture in Colorado. Ron Anthony, FAPT, of Anthony & Associates, Inc. provided expertise in the preservation of historic wood structures, the field of wood science and wildland fire.

This report is a compilation of information available at the time of its writing and is not exhaustive of all products / manufacturers / treatments available, but rather a look at a select number of examples of currently available / advertised wildfire mitigation treatments for consideration in relation to historic wood-framed buildings in high-risk Wildland Urban Interface (WUI) landscapes. Specialized historic preservation consultation with preservation authorities who review or approve a project shall still be critical to evaluate individual projects and possible wildfire mitigation solutions based on their historic materials / appearance / integrity / significance / etc. The following is a summary of information compiled and updated from the Part 1 Wildfire Mitigation Plan (see APPENDIX E: PHASE 1 CHAUTAUQUA WILDFIRE MITIGATION PLAN), but provides a helpful introduction and background information:

# A. WILDFIRE RISK OVERVIEW

Risks from wildfire drive the importance of developing and implementing a mitigation plan for any cultural resource that could be impacted by wildfire. Reducing risks is more urgent as fire season now extends through all months of the year in Colorado and fire behavior becomes more extreme. However, not all wildfires are of such intensity or result in the degree of destruction seen in the news. The vast majority of wildfires are controlled within the first few days after ignition. Mitigation efforts often contribute to minimizing the damage from these incidents. For extreme incidents, such as the Marshall Fire in 2022, few mitigation efforts prior to the fire, if any, could have reduced the damage. It is not those fires that we address with a mitigation plan but the much more frequent lower-intensity fires. The goal of mitigation is to keep the small fires small.

## 1. BASICS OF FIRE BEHAVIOR

It is not the objective to present a dissertation on fire behavior but only to provide sufficient information for stakeholders to understand why there is a risk to their cultural resource from wildland fire. Additionally, the goal is not to make stakeholders fire behavior experts but rather to give them a clear, concise understanding of the factors that impact fire behavior and things stakeholders can do on site to reduce the risk of loss or damage due to fire. Most of the recommendations focus on actions that should be taken well before a wildland fire threatens a historic resource, not during an incident where the presence of well-intentioned actions of individuals serve to impede responders from safely fighting the fire.

The Wildland Urban Interface (WUI) is a transition zone between largely unoccupied land and human development. It is a geographic zone where structures or other human development, interspersed with undeveloped wildland or vegetative fuels, are present. According to the U.S. Fire Administration, between 2002 and 2016, an average of over 3,000 structures per year were lost to WUI fires in the United States and the WUI area continues to grow by approximately 2 million acres per year (U.S. Fire Administration, 2022). While the number of losses is significant, the number of structures and cultural resources saved, in part, through mitigation efforts is far more significant.

Fuels, weather, and topography are the key factors in wildland fire behavior. As shown in the well-known fire triangle in Figure 1, it is the interaction of these three variables that responders must address when allocating resources to protect life and property.

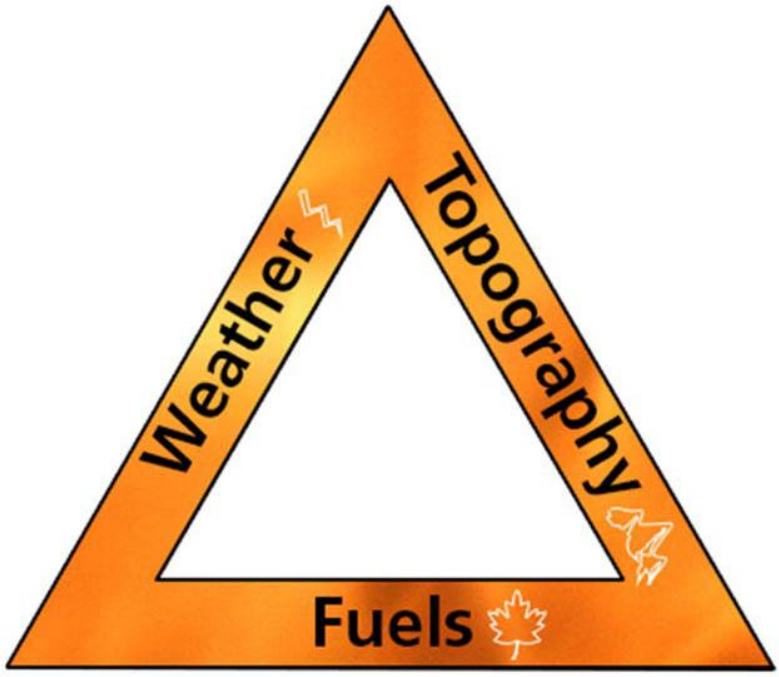


*Figure 1: The Fire Triangle*

What is fuel? Fuel is anything that is combustible. Most commonly, vegetation is the primary fuel for wildfire. The vegetation may be grasses, trees, shrubs, and plants that make up the landscape. Fuels are categorized by size and how rapidly they can adapt to changes in relative humidity and temperature (affecting the moisture content of the fuel). Grasses are considered fine fuels because they are easy to ignite and will dry very quickly (within hours) as temperatures increase and relative humidity decreases. **Structures are also fuel.** While the materials used on the exterior of the structure affect the probability of ignition, the contents on the interior are subject to ignition from radiant or convective heat from a fire.

What is topography? Topography is the form and features in a landscape. Canyons, mountains, steepness of slope, and elevational differences are examples of topographic features that will influence fire behavior. In most cases, the topography of a site cannot be altered or controlled. On sites that have only slight grade changes (i.e., relatively flat in nature), fire behavior would be influenced more by fuels (structures, vegetation, etc.) and wind during an incident than the topography of the property. However, in areas where topography varies significantly in terms of steepness of slope, elevation, aspect, and other features that can significantly affect fire behavior, particularly, the fire intensity and rate of spread.

What is weather in the context of wildfire behavior? Temperature, relative humidity, and wind are the primary weather factors that affect fire behavior. Precipitation, exposure to ultraviolet radiation, and lightning are other factors that can influence fire behavior. Understanding the impact of changes in weather patterns, primarily higher temperatures, lower precipitation, and high wind speeds in many fire-prone areas is key to anticipating fire behavior on a given site.

Many of the recent devastating wildfires in Colorado (and elsewhere) have been the result of extreme winds which carry embers (a phenomenon called spotting) much further distances than during fires from only a few decades ago. It is typically the embers during a wind-driven fire nearby that are the greatest risk to a site or structure. According to the National Institute of Standards and Technology embers can travel several miles ahead or away from a wildfire (Brewer, et al., 2021).

## REDUCING THE RISK BY MODIFYING POTENTIAL FIRE BEHAVIOR

The two primary means of significantly reducing the immediate risk to structure in the WUI are fuels mitigation and creating defensible space. Fuel mitigation involves removing or trimming vegetation to reduce the total volume of material that can burn (the fuel load) while reducing the horizontal and vertical continuity of the fuel to lower the likelihood of the fire being able to spread without interruption, as across a grassy meadow (see  (Campbell, 2020)Figure 2). Horizontal fuel continuity is vegetation or other fuel that is continuous, or touching, across the horizontal plane, e.g., there is little or no separation from tree to tree, shrub to shrub, or grasses in a large meadow. Similarly, vertical fuel / ladder fuels continuity is a lack of separation vertically, e.g., grass to shrubs to tree branches to the crowns of the trees would be a typical example.

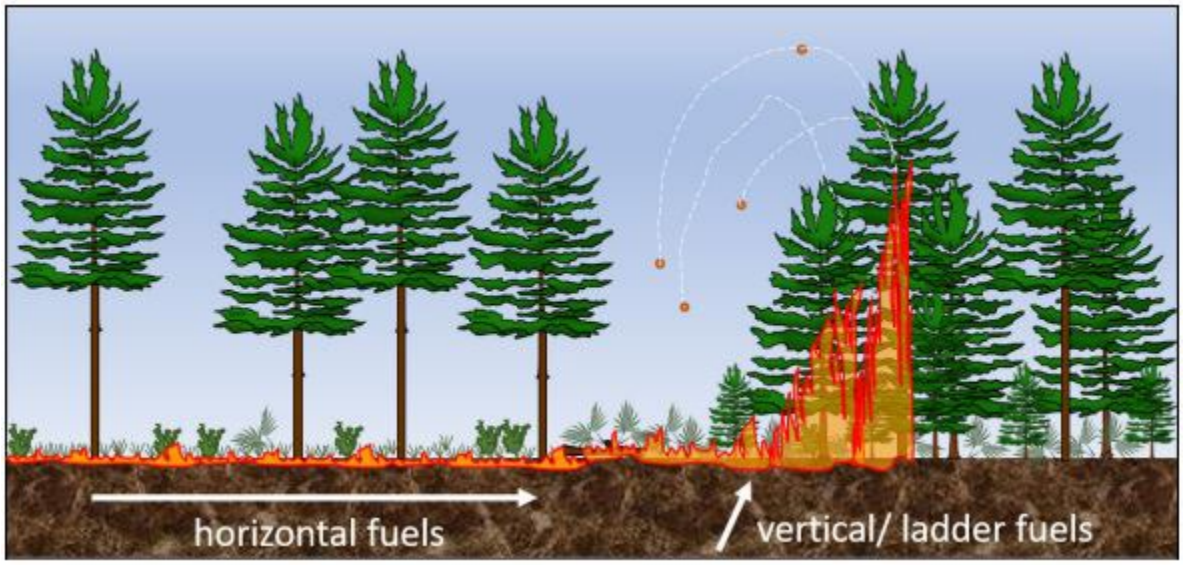


*Figure 2: Diagram Horizontal Fuel and Vertical/Ladder Fuels (Campbell, 2020)*

The volume of fuels that needs to be reduced and removed through trimming or cutting is typically quite extensive and for historic buildings where the surrounding landscape is a defining feature, this can be a difficult thing to execute. However, when considering the survivability of a significant historic building a critical look at drastically reducing the surrounding fuel load and horizontal and vertical continuity is often the best defense.

Defensible space around a structure to reduce the likelihood of significant damage or loss of the structure is a concept that has been promoted for decades, along with an understanding of the

role of building materials on the risk of damage or loss due to fire. Figure 3 and Figure 4 show examples of what are promoted as best practices for establishing defensible space around newly planned residential structures in fire-prone areas prior to construction. These recommendations are good guidance for many single structures in the WUI but not so appropriate for sites with closely spaced buildings and with designated landscape and/or site features that have a historic designation or may be eligible for one. For this reason, consultation between cultural resource specialists, wildfire personnel, and building stewards is likely to result in a compromise when evaluating and determining a fuels mitigation plan and creating defensible space around a historic building or site, rather than the idealized mitigation approaches conveyed in Figure 3 and Figure 4.

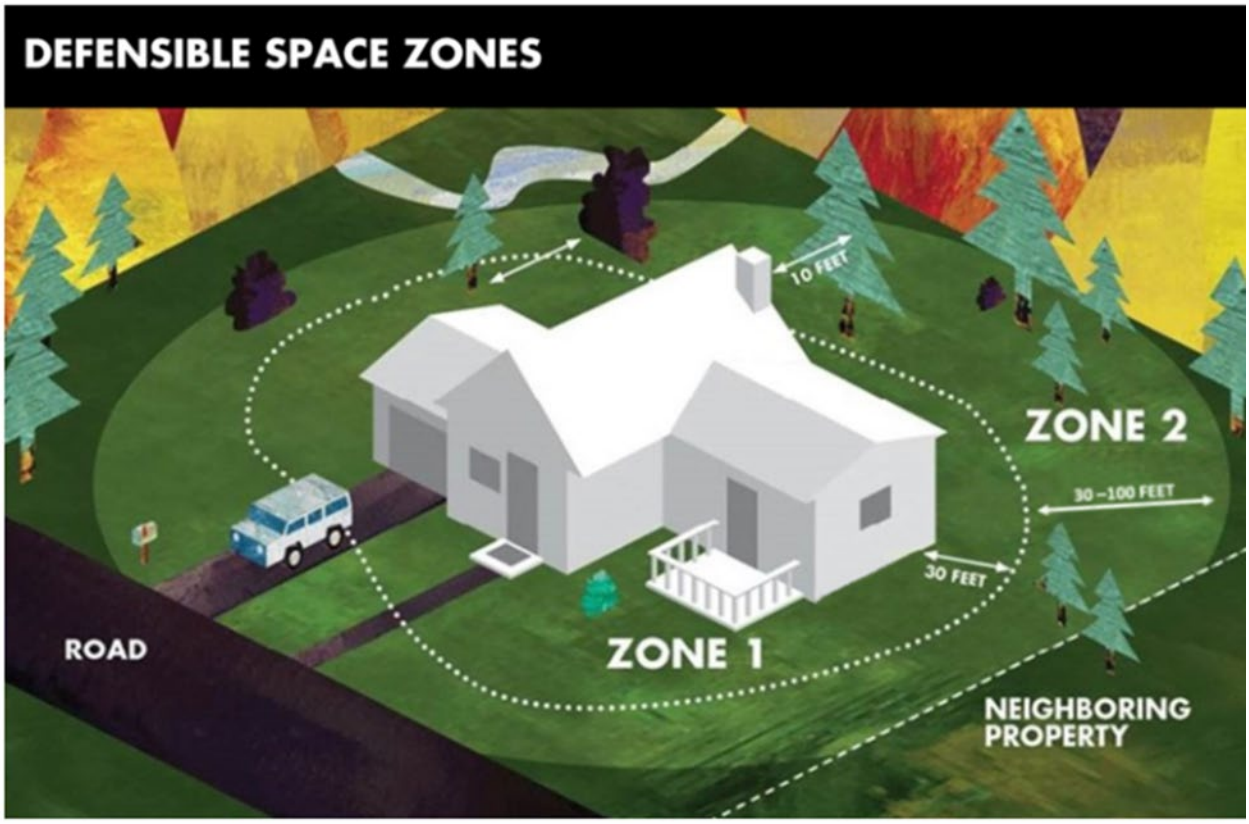


*Figure 3: Idealized defensible space that is recommended around a single residential structure. This approach is often not feasible for cultural resource sites due to proximity of other structures, heritage trees, or other features that are significant to the cultural landscape.*

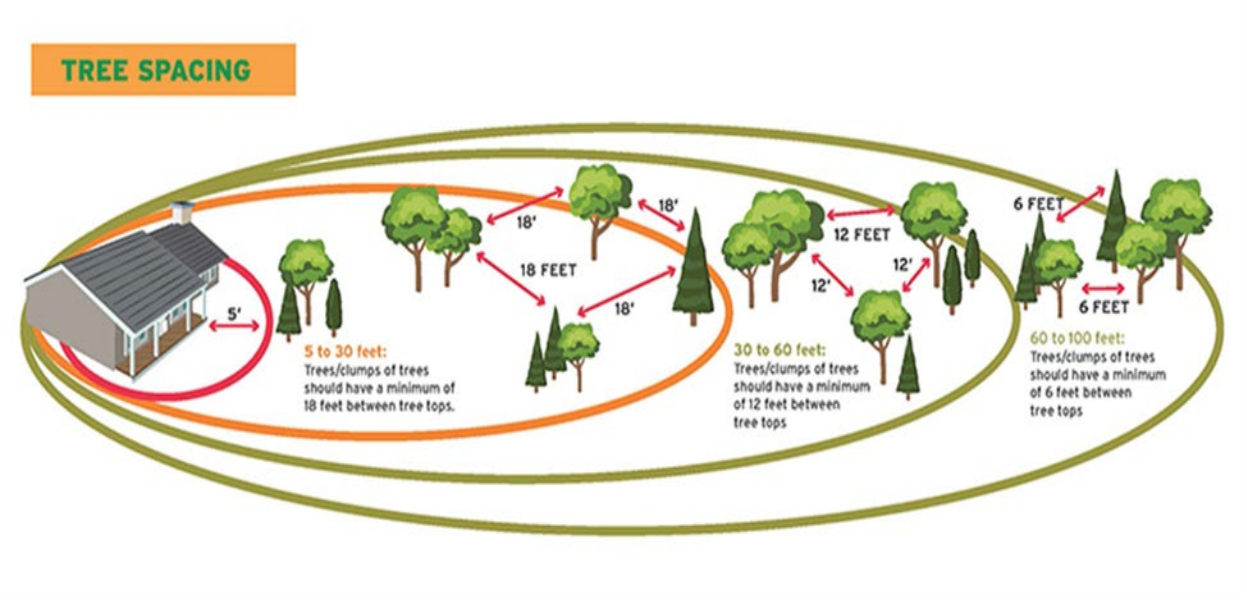


*Figure 4: Defensible space as recommended by removing or trimming vegetation to eliminate horizontal and vertical fuel continuity to reduce the risk of the fire spreading and making fire operations more challenging and less safe. As is the case for Figure 3, this approach is often not feasible for cultural resource sites due to proximity of other structures, heritage tress, or other features that are significant to the cultural landscape. (Wildfire Mitigation and Preparedness, 2023)*

## HEAT TRANSFER AND IGNITION

Fuel ignites from a variety of means during a wildfire. Historically, most people are concerned with surface fires where there is direct flame contact. More recently, wind-driven fires of extreme intensity are becoming more frequent and far more destructive than surface fires. In either case, fuels adjacent to a building (vegetation, wood, and structures) that are in direct contact with the flame front may ignite. However, it is easy to confuse heat transfer and ignition during a wildfire. Said another way, “it might get hot, but it doesn’t necessarily burn.” Reducing the fuel load, by conducting fuels mitigation and creating a defensible space, can reduce the possibility of a building burning even though it may “get hot.”

Heat transfer occurs through convection, radiation, or conduction. Convection is the movement of hot air due to heating of the air molecules. Convection is the primary means of fire spread by pre-heating fuels in advance of the fire, including the upper crowns of trees. Radiation is the movement of heat energy as waves pass through the air. The heat is transferred when the wave reaches a physical object that conducts heat. Radiant heat from a wildfire can ignite combustible materials inside a structure from several hundred feet away in extreme events. Conduction occurs when heat is transferred from molecule to molecule through direct contact, such as when one touches a hot skillet, see Figure 5.

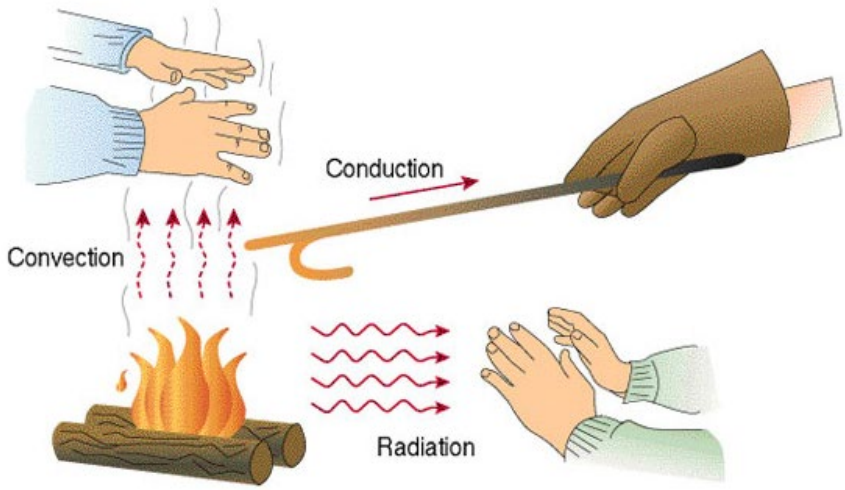


*Figure 5: Diagram of Convection, Conduction, and Radiation Heat (Shirley, 2015)*

Firebrands, or embers, are airborne burning materials that can cause ignition when they come in contact with unburned fuel. Embers can be from vegetation (pinecones, sticks, leaves, etc.), structures (roofing, siding, even roof sections, etc.), or other burning materials. Wind can carry the embers long distances, farther than convection or radiation can transfer heat for combustion, and upon landing can ignite vegetation or get into openings (e.g., uncovered vents) in structures and start fires on the interior before the flames ever reach the structure, see Figure 6. While embers have always been a concern during wildfires, the wind speeds and gusts recorded in relatively recent fires can travel, or spot, well over a mile in extreme wind events where gusts exceed 60 to 80 mph. Most structures lost to wildfire are the result of embers causing ignition of the structure itself, or traveling from ignition of the landscape or elements nearby, thus reinforcing the need for fuels reduction and mitigation.

*Figure 6: Illustration of Firebrand / Embers Traveling from Fire to Structure (Walls, 2023)*

Ignition occurs when a combustible material reaches a temperature sufficient to support combustion of that material. A general rule is that the majority of fuels will ignite during a wildfire at a temperature of approximately 500 degrees Fahrenheit. Embers (firebrands) that travel through the air due to wind or air currents (such as a convective column, see Figure 7, often seen on large wildfires) are the most common source of structure ignition through spotting. If the embers are large enough to retain heat or are burning when they land on a combustible material, an ignition can occur. Addressing the probability of ignition to or in a structure is critical to reducing the potential impact of embers, particularly during wind-driven fires. Erratic winds can put embers in tight openings that, through conduction, will result in an ignition. Continued maintenance of structures is critical to prevent embers from getting into openings. Ensuring that paint is maintained on exterior woodwork and conducting regular visual inspections to determine entry points for embers should be part of routine maintenance, see Figure 8.

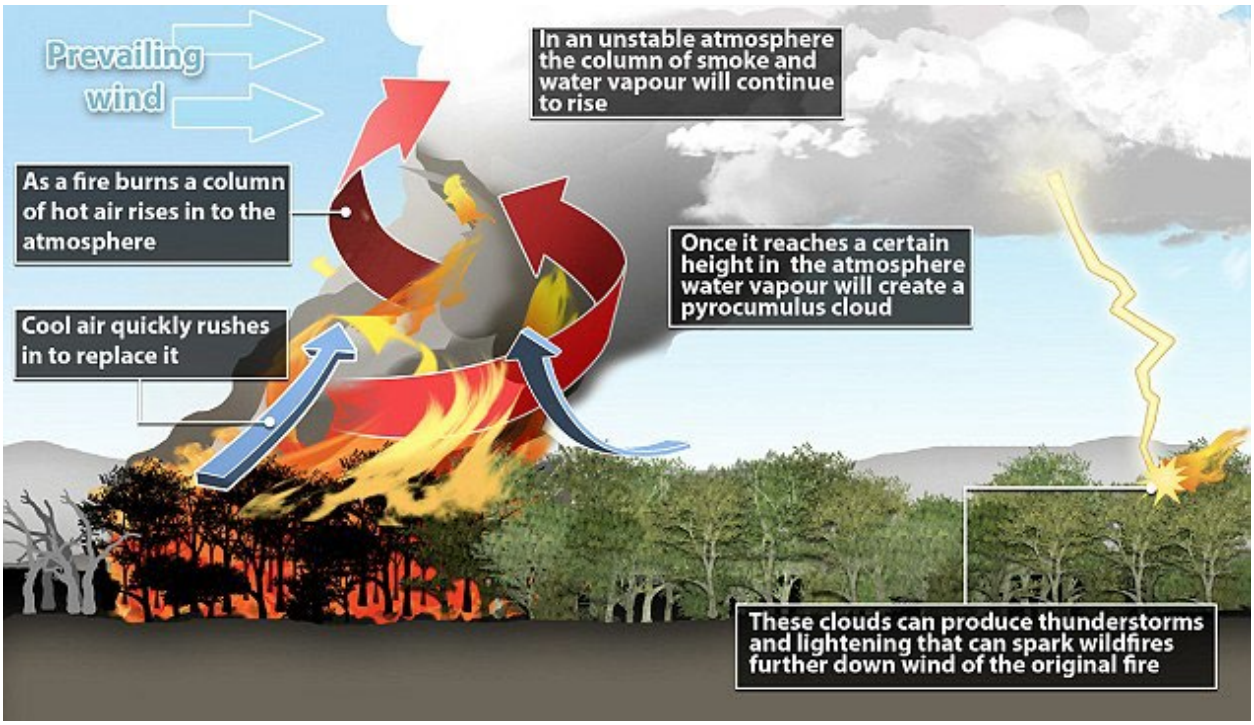


*Figure 7: Diagram of a convective column (Pedrógão Grande Fire Timeline, 2018)*


*Figure 8: Deteriorated fascia board that provides an entry for wind-blown embers can result in an ignition on the interior of the structure.*

The above brief introduction and discussion of fire behavior; ignition sources and pathways; fuel loads and fuel mitigation, aims to provide a general introduction and method for evaluating risks to a wood-framed building. A building with close, overhanging trees and dense shrubs and grasses right up next to the base of the building, provides direct pathways for fire to approach a building. If these can be removed or greatly reduced, a building has a better chance. Maintenance of exterior materials is also critical to reducing pathways. As wildfire risk becomes a top concern for building owners, many look to building material “hardening” options to reduce risk to ignition. Wildfire “hardening” means taking steps to reduce vulnerability to embers and heat that accompany most wildfires (Harden Your Home, 2023). A web search will reveal a multitude of companies offering building materials that are formulated to resist ignition. For a new building being constructed in a WUI zone, there are many options to building a more resistant structure. For a historic property in the WUI zone, whether it be currently designated, eligible for designation or likely to be eligible in the future, greater care, consideration and consultation with historic authorities is required prior to replacement of the building’s materials. For designated structures, their materials are often a defining feature of their integrity. Removing original materials would risk potential and current designations.

# III. SOI STANDARDS

The Secretary of the Interior's Standards for the Treatment of Historic Properties (SOI Standards), provide guidance for owners, managers, architects, contractors, and project reviewers in order to best care for historic properties and maintain their integrity. A summary of the four treatments is provided below. There has been recent discussion at the professional level with the National Park Service whether the Standards should be updated to respond to more current challenges and risks to historic structures. An example of updated guidelines for flood adaptation, provided below, illustrates the identification of the need and the follow-through response to such threats in order to increase the survivability of historic buildings. Issues related to the treatment of historic properties as it relates specifically to wildfire are not adequately addressed in the current Standards. Further, the use of alternative materials is a very dynamic topic as new products enter the market, particularly related to alternatives to wood products.

The SOI Standards address four treatments: preservation, rehabilitation, restoration, and reconstruction (Part 68 The Secretary of the Interior's Standard for the Treatment of Historic Properties, 2023) . Per 36 CFR Part 68, the federal regulation establishing the standards, "one set of standards…will apply to a property undergoing treatment, depending upon the property's significance, existing physical condition, the extent of documentation available, and interpretive goals, when applicable. The Standards will be applied taking into consideration the economic and technical feasibility of each project." The following are the definitions for the four treatments:

***Preservation****: the act or process of applying measures necessary to sustain the existing form, integrity and materials of an historic property. Work, including preliminary measures to protect and stabilize the property, generally focuses upon the ongoing maintenance and repair of historic materials and features rather than extensive replacement and new construction. New exterior additions are not within the scope of this treatment; however, the limited and sensitive upgrading of mechanical, electrical and plumbing systems and other code-required work to make properties functional is appropriate within a preservation project.*

***Rehabilitation:*** *the act or process of making possible an efficient compatible use for a property through repair, alterations and additions while preserving those portions or features that convey its historical, cultural or architectural values.*

***Restoration:*** *the act or process of accurately depicting the form, features and character of a property as it appeared at a particular period of time by means of the removal of features from other periods of time by means of the removal of features from other periods in its history and reconstruction of missing features from the restoration period. The limited and sensitive upgrading of mechanical, electrical, and plumbing systems and other code-required work to make properties functional is appropriate within a restoration project.*

***Reconstruction:*** *the act or process of depicting, by means of new construction, the form, features and detailing of a non-surviving site, landscape, building, structure or object for the purpose of replicating its appearance at a specific period of time and in its historic location.*

When evaluating the applicable four treatments, each project needs to be considered on its own. For structures that are in active residential or public use, the Rehabilitation Standards are likely the most applicable, although careful consideration would be needed prior to each project pursuit. The Rehabilitation Standards provide flexibility for updating and adapting historic buildings for continued use by the public. The SOI Standards ten principles for Rehabilitation are:

*(1) A property will be used as it was historically or be given a new use that requires minimal change to its distinctive materials, features, spaces and spatial relationships.*

*(2) The historic character of a property will be retained and preserved. The removal of distinctive materials or alteration of features, spaces and spatial relationships that characterize a property will be avoided.*

*(3) Each property will be recognized as a physical record of its time, place and use. Changes that create a false sense of historical development, such as adding conjectural features or elements from other historic properties, will not be undertaken.*

*(4) Changes to a property that have acquired historic significance in their own right will be retained and preserved.*

*(5) Distinctive materials, features, finishes and construction techniques or examples of craftsmanship that characterize a property will be preserved.*

*(6) Deteriorated historic features will be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature will match the old in design, color, texture and, where possible, materials. Replacement of missing features will be substantiated by documentary and physical evidence.*

*(7) Chemical or physical treatments, if appropriate, will be undertaken using the gentlest means possible. Treatments that cause damage to historic materials will not be used.*

*(8) Archeological resources will be protected and preserved in place. If such resources must be disturbed, mitigation measures will be undertaken.*

*(9) New additions, exterior alterations or related new construction will not destroy historic materials, features and spatial relationships that characterize the property. The new work will be differentiated from the old and will be compatible with the historic materials, features, size, scale and proportion, and massing to protect the integrity of the property and its environment.*

> *(10) New additions and adjacent or related new construction will be undertaken in such a manner that, if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.*

The wildfire mitigation treatment options provided in this document were evaluated based on the above ten principles. The intent of this document is to provide a list of options for wildfire mitigation for wood-framed structures that will not negatively impact their historic integrity, thus risking the loss of their historic designation status or eligibility for designation. As illustrated by the ten principals above, “distinctive materials” are a key feature of a historic building’s identity. Historic roofing, siding, windows, and doors are often what stand out to the onlooker to identify it as old.

In November 2019 the National Park Service issued a document “The Secretary of The Interior’s Standards for Rehabilitation & Guidelines on Flood Adaptation for Rehabilitating Historic Buildings” (Eggleston, Parker, & Wellock, 2019). This more recent update to the Standards shows recognition of a need for adaptation of preservation standards in response to this specific weather event. Per the document:

> *The goal of the Guidelines on Flood Adaptation for Rehabilitating Historic Buildings is to provide information about how to adapt historic buildings to be more resilient to flooding risk in a manner that will meet The Secretary of the Interior’s Standards for Rehabilitation. Resilience in this publication means the capacity of a historic property to withstand and recover from a flooding event.*

Although a similar document does not currently exist as a guideline for wildfire adaptation for rehabilitating historic buildings, parallels to the Flood Adaptation document can be drawn.

> *The treatments described here are a means of preserving historic properties located in flood-prone areas and making them more resilient to flooding hazards. Flood events can be particularly destructive to historic buildings and therefore may require greater adaptive treatments. While many of these treatments can be undertaken with minimal effects on the historic character of a property, some may require more change than would normally be acceptable. Such treatments are generally not appropriate when a historic building does not have a flood risk. The treatment selected should always be one that minimizes changes to the building’s historic character. Adaptation treatments should reduce the risk of flood damage as much as possible, but should do so without destroying significant historic materials, features, or spaces.*

Assuming a similar goal for wildfire adaptation for rehabilitation historic buildings, this more recent document can perhaps provide a framework for a similar document for historic buildings at high risk for wildfire. The process for evaluation for historic buildings with high flood risks does require more consultation with preservation specialists and detailed evaluation would be

necessary to develop a specific treatment plan. Information on this process from the Flood document would give insight on what this might require for projects in high risk WUI areas:

> *Before undertaking any work to adapt a historic building to be more resilient to potential flooding, research about the actual flood risk as well as about the historic property must be undertaken. Proposed alterations to the property will need to be adequate to address the identified risk.*
>
> *Property owners should take into account the characteristics of the potential flood. These characteristics include the direction the water will likely flow the expected speed and depth of the water, the duration of the flood, …..The applicable Federal, state, and local code requirements and regulations must also be considered.*
>
> *…Prior to planning or undertaking any work, the spaces, features, materials, and finishes of the historic property affected by the flooding or the proposed adaptive treatment should be documenting. The property's existing capacity to sustain and recover from flooding, as well as its physical condition and use, should be evaluated. Those spaces, features, and materials that are important to the historic character and significance of the property should be identified for retention and preservation.*
>
> *…Planning and risk assessment for potential flooding should therefore be undertaken proactively, and properties should be maintained in good condition, monitored regularly, and appropriately documented as part of any treatment plan for the property….When a new adaptive treatments are needed, they should be carried out in a manner that will have the least impact on the historic character of the building, its site, and setting. In adapting a building to be more resilient to flooding risks, the goal should always be to minimize the impacts to the building's historic character to the greatest extent possible. It is helpful to record the decision-making process for future evaluation.*
>
> *All planning and assessment for reducing flood risks should include the following:*
>
> - *Identify the historic property's flood risks and vulnerabilities and any existing capacity for resilience.*
> - *Monitor the condition of the property and regularly reevaluate its flooding risks and vulnerabilities.*
> - *Document the historic property. The Secretary of the Interior's Standards for Architectural and Engineering Documentation or Preservation Brief 43: Preparation and Use of Historic Structure Reports can serve as a guide.*
> - *Review and understand the compliance requirements of the local floodplain ordinance and related local regulations.*
> - *Identify and assess all feasible adaptation treatment options to determine how they will address the flooding risk.*
> - *For each treatment option, evaluate the impacts of any potential alterations to the historic property's character defining spaces, features, and materials, and its site and environment.*

- *Consideration should be given to how local communities have decided to adapt to the risk of flooding hazards and treat historic properties impacted by these risks. Also consider the future viability of community infrastructure, such as roads, sewers, and other utilities and services.*
- *Select the time frame for which the adaptation treatment is expected to adequately reduce the risk. This could be tied to the length of a mortgage or some other point in the future.*
- *Always select an adaptive treatment that minimizes the impacts to the historic character and appearance of an individual property and/or a larger historic district.*

The document includes a series of planning and assessment recommendations, the following select recommendations have similar application projects in high risk WUI areas:

- *Assessing the potential impacts of known vulnerabilities on character-defining features of the building, its site, and setting. Reevaluating and reassessing potential impacts on a regular basis.*
- *Maintaining the building, its site, and setting in good repair, and regularly monitoring character-defining features.*
- *Using and maintaining existing historic and non-historic characteristics, features, and materials of the historic building, its site, setting, and larger environment (such as a site wall that keeps out flood waters) that may help to avoid or minimize the impacts of flooding.*
- *Undertaking work to prevent or minimize the loss, damage, or destruction of the historic property while retaining and preserving significant features and the overall historic character of the building, its site, and setting.*
- *Ensuring that, when planning work to adapt for flooding, all feasible alternatives are considered, and that the options requiring the least alteration are considered first.*
- *Considering adaptive options, whenever possible, that would protect multiple historic resources, if the treatment can be implemented without negatively impacting the historic character of the overall historic property, district, or archeological resources, other cultural or religious features, or burial grounds.*

Conversely the document includes a list of things that are not recommended:

- *Carrying out adaptive measures intended to address the impacts of flooding that are unnecessarily invasive or will otherwise adversely impact the historic character of the building, its site, or setting.*
- *Failing to plan for flood risk and to make a treatment decision, even if the decision is that no intervention is currently necessary.*
- *Failing to consider other properties nearby in planning flood adaptations, therefore increasing the risk or exposure to neighboring properties.*

The following evaluation of wildfire mitigation options based on conformance to the SOI Standards and effectiveness on historic structures was not based on laboratory research but rather on a review of published technical literature (as opposed to marketing information). The questions asked when reviewing various products / treatments were (1) how effective the treatment in is protecting a structure (or vegetation), (2) does technical test data exist on the impact on historic fabric (in this case, wood; e.g., does it change the color of raw wood), and (3) is there a long-term effect (e.g., is it reversible).

# IV. PHYSICAL INTERVENTIONS FOR HISTORIC WOOD-FRAMED BUILDINGS

Wildfire management during an incident generally includes tactics to directly attack the edge of the fire. In addition, fire suppressants and retardants are used to enhance the capabilities of water, with many suppressants used as short-term retardants to reduce the fire intensity so that firefighters can directly engage the fire. Most people are familiar with the red retardants that are dropped from aircraft. To fight fires that threaten values at risk, crews may also use suppressants, such as gels that carry water and superabsorbent polymers (such as those found in diapers). These gels are frequently used as short-term retardants on buildings in the path of encroaching fires, but they lose effectiveness once the water entrapped in them evaporates – something that may occur in less than an hour during normal wildland fire conditions.

Foams, gels, and retardants have been applied to structures during a wildfire, either intentionally or inadvertently, as a passive approach to protect a structure. Responders apply foam, gel or retardant shortly before arrival of the flame front or, in some cases, building owners are proactive and apply coatings to their structure long before a fire occurs. The goal during a fire is to attempt to prevent the loss of the structure to the fire; but not to consider the effects of the foam, gel, or retardant on the historic fabric of the structure. Even slight changes in color are not considered when requesting a retardant drop from an air tanker adjacent to a structure. Any of the conventional chemical treatments will generally retard the fire intensity or progress (rate of spread) and, perhaps, allow for firefighters to apply direct attack techniques to protect the structure. If that is successful, the fire-fighting operation may move on, and it is left to the owner or building steward to deal with the after-effects.

The National Center for Preservation Technology and Training has conducted research on the effect of a limited number of fire chemical products on historic materials and reports that:

> *Repetitive swelling and contracting of the exterior of wood can exfoliate the surface. This changes the wood texture, which leaves the surface with a fuzzy appearance and increases the potential for future soiling and accelerated decay. Additionally, it has been observed that paint or varnish is stripped from wood as fire chemicals dry on the*

*material. Soluble salts and swelling liquids found in fire chemicals have the potential to reduce the mechanical properties relating to the stability of wood.*

*The effects that fire chemicals have on heritage building materials are interconnected. Saline water and the deposition of salts within and on the materials cause much of the deterioration to cultural resources exposed to fire chemicals. Fugitive color agents can leave a resource looking unattractive or out of place. Due to the many hazards of fire chemicals to cultural resources, it is necessary to clean them appropriately. This entails identifying an effective yet gentle method for removing fire chemicals that does not compound or enhance the harmful effects of fire chemicals* (Eldredge, 2022).

Note: The above source referenced report, *Fire Suppressants and Cultural Resources,* by Katherine Eldredge (2022) is an internal draft report referenced with permission from the National Center for Preservation Technology and Training. The official report has not been released to the public and all information referenced should be considered as a draft status until formal publishing has occurred.

The after-effects can be quite varied but may include color changes, changes in texture, or damage to the historic fabric, among other detrimental effects. What is typically unknown are the effects on the material itself - whether the application of a chemical (foam, gel, retardant, or, discussed later, intumescent paints) alters the fundamental properties of the wood in ways that reduce the service life of the wood. **For virtually all the fire chemicals discussed below, technical data do not exist that answers the question of whether the wood is altered (harmed) by applying the chemical such that the historic nature of the wood and the structure is negatively impacted.** There is limited information that the chemicals act only on the surface of the wood but whether it is truly reversible requires that technical research be conducted to determine whether that is the case.

Is there a debate to be made that without applying foam, gel, or retardant that the structure may be lost to the fire, and would that not be preferable to reducing the service life of the wood siding from, say, 40 years to 10 years? Yes, but that is not the goal of this report. The review of various product categories in this report focused on the data that is currently available and, in general, it was found that data on the effects on historic wood are lacking. Manufacturers are generally sympathetic and interested in exploring the effects but recognize that their primary market is not historic structures. As this report is not intended to recommend any specific brand or product, the following is not an exhaustive list by any means but does look at information and types of physical interventions from a handful of manufacturers.

# A. INTRODUCTION ON FIRE CHEMICALS[1]

Class A foam and fire-fighting gels (sometimes called water-enhancer gels) are chemicals added to water to enhance the fire-fighting effectiveness of the product. Fire retardants are chemically based products that alter the combustibility of the fuel to which the retardant is applied. The goal of any of these families of products is to assist prior to or during fire-fighting operations by slowing the progress of the fire or reducing its ability to ignite vegetation or construction materials.

There is very limited technical data on the effect of foams, gels, and retardants on historic materials, including wood. This makes it challenging to recommend specific products when the possibility of detrimental effects on the historic fabric are unknown. One might assume a Class A foam applied to wood cladding could simply be washed off the surface with water, and manufacturers advertise this to be the case. However, the question of whether the foam penetrates into the wood, particularly exposed or uncoated wood, and results in a shortened service life or impacts the ability of the wood to retain a traditional coating, such as a paint or stain, has not been answered. As mentioned, reduced service life is likely much preferred to losing the structure but again, that debate is not the focus of this report. Rather, the topic addressed is what potential treatments or products are available and does their use meet the SOI Standards for the Treatment of Historic Properties based on currently available data.

## 1. Class A Foams

Foam additives have been used for firefighting since the early 20th century. Modern foams were first used primarily as fire-extinguishing agents for flammable and combustible liquids classified as Class B fuels. Class A foams were developed in the 1980s for fire suppression of Class A fuels, which comprise solid combustible materials such as brush, wood, and paper, and are used to control wildfires and structure fires. Class A foams are versatile fire chemicals applied to protect the material against fire, suppress an existing fire, and prevent reignition by extinguishing embers.

Fire-fighting Class A foams combine water, foam concentrate, and air to create a homogenous foam blanket over the material surface. The foam concentrate is formulated with surfactants that have an affinity for carbon, resulting in improved foam penetration into carbon-rich combustible materials such as wood. The ability of a surfactant to decrease the water surface tension leads to increased wetting effectiveness and water saturation of Class A fuels compared to water. When in the foam form, water can remain on vertical and horizontal surfaces without beading and runoff for a considerable time, thus being better able to absorb heat. However, this is generally limited to hours prior to the arrival of a fire. Moreover, a foam blanket of an actively

[1] The authors would like to thank Suzana Radivojevic, PhD for her assistance and contribution to the research on fire chemicals.

burning structure smothers the fire by preventing air from contacting the fuel, eventually lowering the fuel temperature to below its ignition point. This is often seen in photos or films of structure fires in an urban setting and is used by most fire departments. The protective action of a foam blanket is manifold since it combines the benefits of reflection of the radiant heat due to the white color of the foam, provides a physical barrier formed by a mass of bubbles that act as an insulating blanket, and provides an increased moisture content to Class A fuels.

Foam concentrate generally comprises surfactants (e.g., hydrocarbons, detergents, siloxanes, and proteins), and various additives, such as organic solvents (e.g., trimethyl-trimethylene glycol and hexylene glycol), foam stabilizers (e.g., lauryl alcohol), and corrosion inhibitors (The use of PFAS and fluorine-free alternatives in fire-fighting foams, 2020). Foam solutions are generated by mixing the water with the foam concentrate at a prescribed mixing rate prior to application, which is then aerated during application to create a foam blanket. These are some of the chemicals that are effective for firefighting but have unknown effects on the wood fabric.

Class A foams are versatile fire-fighting chemicals used for direct fire suppression, fire prevention by surface pretreatment of threatened buildings and surrounding vegetation with a protective foam blanket, and the post-fire mop-up (Group, 1993) (Liebson). They can be applied manually or automatically with conventional discharge devices and compressed air foam systems or dropped from the aircraft using standard water fog or air-aspirating foam nozzle equipment for greater foam expansion capability. Modern foam concentrates allow the mixing of fresh, sea or brackish water in the water stream. In indirect attack fire prevention, foams provide an effective method for protecting surfaces in front of the fire by introducing moisture into wood and creating a foam blanket while allowing the fire to reach the structure. Pretreatment with a blanket of Class A foam is often necessary or advised for exposure protection of structures. In addition, Class A foams are also used during the overhaul/mop-up process to reduce water usage and increase water absorption by fuels by emulsifying hydrophobic materials such as resins, waxes, and oils present in wood or wood finishes (Chemguard, Specialty Chemicals & Equipment: Use and Benefit of Class "A" Foam Concentrate in Water, 2005). Finally, high expansion Class A foams designed for use with air-aspirating or forced air devices are available for application to confined and inaccessible areas such as basements and attics (Fighting).

Adding even a small amount of a Class A foam concentrate into a water stream has been reported to increase the water fire-fighting effectiveness up to five times (Foam-Gel-Fire Retardant Comparison Chart, 2010). However, most foams remain effective for a relatively short time following application, reportedly 8-16 hours.

There are examples of Class A foams that have been used to protect historic wood buildings and structures from wildfires. During the wildfire at The Rock Creek Station State Historical Park in Nebraska in April 2023, historic buildings were coated with "fire-resistant foam" prior to fire reaching the historical park grounds, and "the historical park's buildings were not damaged, though the fire came within feet of the structures" (Richter-Ryerson, 2023). Details of the fire intensity (which would impact the ability of the fire to impact the structure) was not provided and follow up on removal success of the foam was not discussed.

Class A foams may provide several advantages for historic buildings and structures threatened by wildfires. Class A foams are typically used at low concentrations of active components, typically 0.1%- 1% by volume of water, and are thus inexpensive while providing substantial water savings. In addition, the foam has high visibility due to its white color, which helps discern the treated areas and surfaces. Since biodegradable, environmentally safe (reportedly) foam concentrate formulations are available on the market, their selection could be recommended for use in protected or sensitive natural environments which often coincide with locations of cultural resources. Class A foams are considered non-hazardous, non-corrosive, and non-flammable when applied in recommended concentrations but these assumptions have recently been subject to debate. Foam concentrate is water soluble and can reportedly be removed by rinsing with water, which allows for the treatment's reversibility when applied to historic wood materials. It has been shown that the foam residue on treated wood surfaces of cultural resources is either invisible or appears as a water stain that should be removed by cleaning using distilled or deionized water within 30 minutes following the exposure to prevent foam drying (Eldredge, 2022).

The drawbacks of Class A foams are that they require water and are difficult to apply under windy conditions and when numerous structures are in close proximity. In addition, following application, Class A foam loses effectiveness with time due to water evaporation and can be blown away by the wind even before the wildfire front arrives.

Class A foam products are at present generally optimized for maximum fire-fighting efficacy, minimal environmental and human exposure risks, and are biodegradable under natural and sewage treatment conditions (Chemguard, Specialty Chemicals & Equipment: General Foam Information, 2005). However, there is no available published research or technical data on short- or long-term impacts on the properties and appearance of historic wood fabric associated with the application and removal of Class A foams. Additionally, there is a lack of scientific data and case studies documenting the effects of Class A foam products on the visual appearance and properties of wood in historic structures. Wood swelling has been suggested in connection to Class A foams (unclear if this is normal swelling due to introduced moisture or a change in wood swelling behavior contributed by the Class A foam chemicals) (Eldredge, 2022).

Surfactants with "degreasing ability" are intended to facilitate penetration of Class A fuels (in our discussion, the wood) by the water. As a result, they are able to emulsify oily substances such as paints, grease and wax and potentially cause damage to both uncoated and coated wood surfaces (Chemguard, Specialty Chemicals & Equipment: Use and Benefit of Class "A" Foam Concentrate in Water, 2005). Class A foam is formulated with synthetic detergent hydrocarbon surfactants, which can emulsify grease, petrochemicals, or paints and deplete wood extractives from uncoated wood (Fornell, 1991). This can potentially have a permanent effect on the appearance and composition of wood and wood coatings. As the foam breaks down, the aqueous foam solution can become absorbed by the material on which it was applied. In the case of uncoated wood surfaces, there is a potential for increased moisture content (secondary mechanism of action).

Examples of Class A foam products:

- Chemguard (Chemattack, Class A Plus, Directattack, Extreme) (Class A Foam Concentrates, 2023)
- PHOS-CHEK WD881 (Phos-Check WD881, 2023)

### 2. Water-enhancing Gels

Water-enhancing gels are based on superabsorbent polymers (SAP) that can absorb and retain extremely large amounts of water and other liquids relative to their mass. They were first developed in the 1950s and became widely used in products and applications ranging from diapers and surgical pads to waste stabilization. Water-absorbing SAP in fire-fighting gels can absorb water hundreds of times their mass by forming tiny "bubblets" that encapsulate water in a polymer shell, similar to fire-fighting foam bubbles, which contain air. However, water-containing bubblets can absorb more heat and are more efficient than air-containing bubbles.

Water-enhancing gels can be used for structure protection as a short- to medium-term retardant applied on buildings and surrounding vegetation in the wildfire path and are very effective for a direct attack in wildfire suppression. Gels are, along with foams, classified as "water enhancers" and termed "water-enhancing gels" when used as a fire suppressant for direct application.

Water-enhancing gels are typically applied with ground-based equipment. They remain effective until water evaporates from the gel. Although they can be re-hydrated and their fire resistance potentially restored, there is a risk of gels being washed off the material during attempted rehydration and the failure of the product to regain its original consistency (Water Enhancers Fact Sheet, 2017). Depending on the fire and weather conditions, the protection lasts from one to 48 hours, but during wildland fire conditions, they were reported to lose efficacy within an hour (Yu, et al., 2019) (Water Enhancers Fact Sheet, 2017) (FireIce Pro (Dry Concentrate), 2023) rendering it ineffective for application in clusters of structures. Newer formulations are resistant to winds and effective for over 6 hours (Barricade Fire Blocking Gel, 2023).

Fire-retardant gels (FR gels) are primarily cross-linked polyacrylates and polyacrylamides. Products are often marketed as eco-friendly and nontoxic to aquatic or terrestrial organisms at recommended application rates. FR gels are manufactured as clear or colored with orange or blue fugitive colorants added as effectiveness indicators. Orange and clear gels can be removed by rinsing with water, and blue gels must be cleaned up with an oil-based solvent (After the Fire: Cleaning Up Fire Retardant and Fire Suppressants, Undated). Some polymer ingredients break down in the environment over time and with UV exposure. Many products are classified in technical literature as stable, non-reactive and non-corrosive. However, mixtures outside the recommended ratios have increased the potential for some types of corrosion.

Records documenting the use of fire-fighting gels on historic resources or their impacts on historic wood fabric are generally unavailable. While the water-enhancing performance of the fire-fighting gels is evidently superior to that of Class A foams, their use on historically designated buildings should be approached with caution since they have been reported to cause damage or irreversible change to the building surfaces and other negative effects may be anticipated based on their properties. Some gels can cause discoloration such as white stains

and paint peeling during the removal of solidified gel. Recent research on the removal of wildland fire chemicals from cultural resources conducted by the NCPTT, shows that they can appear as a blue stain, or water stains on wood, or as deposits with white streaks with a sheen and dry gel clumps on numerous various historic materials (Eldredge, 2022). In addition to adverse effects on historic wood resulting from changes to the original fabric's color and appearance, removing the dry gel from the wood surfaces can be difficult, costly, and carries a high risk of further damage. Technical literature suggests that some products can be removed by rinsing the surface with clean water (Foam-Gel-Fire Retardant Comparison Chart, 2010) (FireIce Pro (Dry Concentrate), 2023). While cleaning of gels from historic wood can be accomplished with water if done immediately after exposure before the gel completely dries (usually one hour), removal of dry gel requires more elaborate and time-consuming methods such as use of poultice that are more appropriate for small areas (Eldredge, 2022). Gel-coated surfaces are slippery and can create hazardous conditions during mitigation and building cleanup.

Examples of Water-enhancing Gels:

- Thermo-Gel (Fire Retardant - Thermo Gel and Phos Check Foam, 2023)
- PHOS-CHEK® INSUL-8 (Phos-Chek Insul-8, 2020)
- FireIce Pro (Dry Concentrate) (FireIce Pro (Dry Concentrate), 2023)

### 3. Fire/Flame Retardant Coatings

Fire/flame retardant coatings (often called fire retardants) impregnated into or used to coat wood have a long history of use as preventive treatments to improve fire resistance. This requires application to products during construction or repairs and has not typically been used in historic structures, other than wood shakes and shingles. More recently fire-retardant treated wood has been used when repairing existing structures or new construction (as is the case at the Mary H. Galey Cottage at Chautauqua). Some of these projects are evaluated later in this report.

The mechanism of action of common fire-retardant chemicals is based on their ability to reduce the flammability of wood and other combustible materials by either physically blocking the fire (by cooling, creating a protective charred layer, or releasing water and/or carbon dioxide while burning) or by initiating a chemical reaction that stops the fire. The most widely used fire retardants in wildfire suppression are based on mono- and di- ammonium phosphates and fortified with corrosion inhibitors, thickeners, and fugitive colorants that fade with exposure to sunlight and elements. They can be dropped from aircraft for direct attack or applied on the ground, especially for an indirect attack.

Fire-retardant coatings comprise several groups with different modes of action. The charred layer-producing fire-retardant coatings are formulated with water-soluble salts such as diammonium phosphate, ammonium sulfate, and sodium borate (Ross, 2010). They are designed to facilitate wood decomposition to charcoal and water rather than volatile combustible

gases. Water-soluble fire-retardant coatings are typically based on silicates, urea resins, or polyvinyl emulsions. Oil-based fire-retardant alkyd and pigmented paints can contain chlorinated paraffins and antimony trioxide as fire-retardant components and inert materials, including zinc borate, mica, kaolin, and inorganic pigments (Ross, 2010).

Many fire-retardant finishes are water-soluble and intended only for interior use. In some instances, fire-retardant chemical coatings are recommended for the exterior wood surfaces of historic structures such as timber bridges to reduce the risk or extent of damage from accidental fires and provide protection from wildfires (Lebow, et al.). The main weakness of fire-retardant coatings is their inability to insulate the substrate, which remains susceptible to damage by fire. Although water-borne formulations leach out from exterior wood surfaces, this process can be lengthy and cause undesired effects on wood properties. When used as a preventative measure, the purpose of the fire retardant is not to save the structure but to provide sufficient time for occupants to exit and firefighters to conduct a search to verify that the structure is unoccupied.

Examples of Fire/Flame Retardant Coatings:

- Fire retardant paint additive: Flamecheck M-111PA (Flamecheck M-111PA, 2023)
- Flame Control No. 10 for Cedar Shakes and Shingles (Fire Retardant Paints, 2023)

### 4. Fire Retardants

Aerial fire retardants dropped from aircraft are used during fire-fighting operations to provide a fireline (break in fuel), reduce the fire intensity, or suppress the fire. Fire retardants have a long record of use to control wildfires. A fire-retardant foam blanket applied with a compressed air foam system was used in the 1988 Yellowstone National Park wildfires and credited with protecting the Old Faithful Inn and most other park buildings from heavy damage (17 Structures at Old Faithful Catch Fire, 1988). Aerial fire retardants are not recommended for direct drops on structures because the weight will damage or destroy the structure.

Conventional fire retardants have in recent years come under public and regulatory scrutiny due to the growing evidence of their adverse effects on the environment, especially in naturally sensitive areas. As a result, their use is not recommended near cultural resource sites (Big Bend National Park Texas: Wildland Fire Management Plan, 2005). Fire retardant chemicals can be absorbed by the historic wood fabric or deposited on the surfaces during their application. Their residues on historic materials including wood have been reported to be colored (pink or orange), have a dull appearance with shiny flecks of crystalline deposits, often with cracked and raised layers (Eldredge, 2022). Being primarily water soluble, hygroscopic, inorganic salts, they are capable of increasing wood swelling, migrating to the surface with water movement resulting in efflorescence, interfering with adhesion of wood finishes, promoting corrosion of metal fasteners, to name a few potentially negative effects (Catelli, 2016) (Kim DW, 2014) . In addition, there is a risk of coloring agents and other additives in fire

retardant formulations causing the surface discoloration of wood material. To avoid or minimize adverse effects on wood in cultural resources, it is recommended that the surfaces are cleaned with deionized or distilled water before the fire-retardant dries completely, typically within an hour of the application (Eldredge, 2022).

A recently developed technology combines the delivery system of gels and foams with the efficacy of conventional fire-retardant. It utilizes bio-based hydrogel polymer (cellulose and colloidal (nano)silica), acting as a thickener and a delivery system for ammonium phosphate salts as an active fire-retardant component (Young Jr., 2023). As a result, the product has improved adherence and durability on vegetation and other surfaces compared to conventional fire retardants. It is marketed as a pretreatment formulation recommended for precision application from the ground early in the fire season (Phos-Chek Fortify: Season-Long Preventive Protection Against Wildfires, 2023). This formulation is a chemically stable uncolored water-soluble gel-like fluid. The treatment remains effective until a significant rain event of one inch or more. It has been used on the historic Reagan Ranch in California (Green, 2021). However, it is unclear if it was applied to the structure or only to ground vegetation.

Example:

- PHOS-CHEK LC95W (Phos-Chek LC95W, 2023)

## B. INTUMESCENT COATINGS

Intumescent coatings expand during heat exposure, forming a low-density insulating film that protects the wood substrate from heat. The coating intumesces - bubbles and foams - at high temperatures and then hardens into a charred film. This protective carbonaceous film insulates the wood surface from heat and retards combustion. However, the charred film's efficacy is limited compared to natural wood char, and its main role is slowing down the spread of the flame. The charred film generally delays the onset of wood substrate burning and can reduce the risk of premature structure failure (Puri & Khanna, 2017).

Most intumescent paints are intended for internal use, with minor exceptions, such as application of a topcoat (latex paint) or in small enclosed exterior areas of structures. They are not intended for exterior cladding or logs. There is often confusion around the appropriate use of intumescent coatings because of the fire tests that the products have been evaluated under. This is also the case with some other fire chemicals as well as alternative products described later (treated wood siding products). The most common tests are the American Society of Testing and Materials (ASTM) E84 and E119 (ASTM 119-20 Standard Test Methods for Fire Tests of Building Construction and Materials, 2023; ASTM E84-21a Standard Test Method for Surface Burning Characteristics of Building Materials, 2023). The purpose of these tests is to determine the relative burning behavior of products or assemblies, often categorized by a flame spread, smoke index or a fire rating, such as 1-hour or 2-hour. These criteria are listed in building codes for determining fire resistance. Both tests state

*This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products or assemblies under actual fire conditions.*

The disclaimer referring to *actual fire conditions* is what distinguishes the usefulness of passing or failing a particular fire test and appropriateness as a means of protection from wildfire. A laboratory test under controlled conditions is not the same as the uncontrolled conditions experienced during a wildfire. It is this distinction that must be considered to determine the appropriateness or value of using a particular product. Most manufacturers acknowledge this as a limitation of their products. Nonetheless, questions are often raised by building or site stewards about various products and, for this reason, product types are discussed in this report but not generally recommended for cultural resource sites. The key is that products may provide limited additional protection from fire of low-to-moderate intensity or short duration, but they are not fireproof.

Intumescent coatings for wood are available as various pigmented paints, clear varnishes, pastes and additives to acrylic and latex paints. They comprise a dehydrating agent, a char former, and a blowing agent. Common dehydrating agents are polyammonium phosphate, char formers include starch, glucose, and dipentaerythritol, and the blowing agents are usually urea, melamine, and chlorinated paraffins (Ross, 2010).

The treatment of wood in historic buildings must be carefully assessed because intumescent paints alter the original appearance of unpainted wood. For an intumescent paint to be effective, it must be applied to unpainted/uncoated wood. Therefore, for previously painted historic wood, the historic coatings would need to be fully stripped to expose the bare wood prior to applying the intumescent paint. This may be considered a reversible treatment, but intumescent paint removal poses similar challenges to common paint removal and can be costly, difficult, and result in surface damage and loss of the original appearance of wood. Where the wood surfaces are significant historic features, such as in log buildings, these treatments are unlikely to be appropriate.

Clear intumescent coatings are better suited for historic wood that was not painted as they preserve the original appearance of wood while providing a level of fire protection. Studies have indicated that coatings subjected to outdoor weathering are of limited durability and must be frequently reapplied, suggesting they may wear away over time. Further study and analysis of intumescent paint is warranted prior to recommendation as a treatment, at the time of this report, it is not recommended as a potential treatment as a wildfire mitigation technique. Further consideration would be needed to evaluate the effectiveness balanced with the appearance and reversibility of such a treatment.

Examples of Intumescent Coatings:

- FlameOFF® Fire Barrier Paint (FlameOFF, 2023)
- Flame Control Fire Retardant Paints (Fire Retardant Paints, 2023)

- Firefree Coatings (intumescent): Firefree 88, Firefree Wildfire System, Firefree Class A (Firefree products provide high performance fire protection., 2023)
- FBL-100 Intumescent Coating System (ICS) (FBL-100 , 2023)

## C. BUILDING WRAPS / FIRE SHIELDS

Wrapping a whole building with fire blankets, also known as structure wraps (thermal shielding), is a viable way to prevent structure ignition. The intent of the wraps is to protect a building from radiant and convective heat and defeat burning embers from contact with the structure during a wildfire.

The first of many U.S. patents for fire blanket concepts was issued during World War Two (Wagner, 1944). Fire blankets have been used both for fire suppression and protection. For example, US Forest Service has used the Aluminized Structure wrap (cabin wrap) to protect historic buildings, including log cabins, when threatened by wildfire (Firezat, 2023) (Miller-Carl, 2008). There are different ways to secure the wrap. It can be installed utilizing sandbags, tire wire, chains, rocks, double sided tape, pony clamps, pipes or bars, and dirt. However, the downside of these methods is the consideration for resistance to wind. Wildfire conditions often coincide with significantly high winds. As a result, installers often resort to stapling the wrap on the building. For a basic single level 3–4-bedroom home it is estimated that a novice installer crew of 4 or 5 people can install it in 5-6 hours. Once trained the installation time can be as little as 2.5-3 hours. One of the major concerns is the quantity of staples and impact on historic wood. One installation reported that it took 6-7 hours and 15,000 staples to secure a wrap to the building (Griggs, 2014). A method for reducing the quantity of staples has been tested by various agencies where chicken wire is utilized to secure the wrap, requiring less staples to install, but resulting in additional installation time in order to form the chicken wire tightly against the structure.

A recent scientific study of various blanket technologies confirmed that they can protect an isolated structure from a relatively short wildfire attack, but that further technological developments are needed to adapt this method for application in severe fires. The study by Fumiaki Takahashi concluded:

> *The performance of fire blankets to block heat has been investigated experimentally in the laboratory and prescribed wildfires. Two-layer thin fabric assemblies blocked up to 92% of the convective heat and up to 96% of the radiation (with an aluminized surface). Multiple layers (or thicker single fabric) increase the heat-blocking efficiency by enhanced insulation against the convective heat exposure. On the other hand, multiple layers do not improve the performance against the radiation because the reflection and emission heat loss from the high-temperature front surface dominate the heat transfer mechanism…..The best performed fire blankets may be able to protect building*

*structures if the heat exposure is relatively short (<10 min). This condition would happen when a wildfire front passes an isolated structure, e.g., a historic cabin. If the heat exposure continues, the fire blanket may more likely to be deteriorated or destroyed, while the building materials are being pyrolysed and failed eventually. This situation would be the case for the structure-to-structure ignition. Therefore, for longer exposures (10min to more than 1 hour), better fire blankets (materials, layer assemblies, etc.) would be needed. The key success factors in protecting the WUI structure are (1) the fire blanket's heat-blocking capability, (2) endurance under severe heat-exposure and high-wind conditions, and (3) proper installation to prevent hot-gas and firebrand penetration. Therefore, additional studies are needed in the future in the areas of advanced material/layer developments, blanket deployment methods, and multi-structure protection strategies* (Takahashi, 2019).

The controlled laboratory experiments and real-fire exposure tests for wooden structures of various sizes were conducted for four types of fabric materials: aramid, fiberglass, amorphous silica, and pre-oxidized carbon, each with and without an aluminum surface. The fiberglass or amorphous silica fabrics laminated with aluminum foil had the best performance due to high radiation reflection and emission and good thermal insulation by the fabric.

1. FireGuard (FireGuard, 2021) , Aluminized Fiberglass Fabric Wildfire Protection

FireGuard is an aluminized fiberglass fabric (AFF), aka Aluminized Structure Wrap (ASW), and this manufacturer lists three options. Option 1: Purchase and store ASW rolls on your property and wrap your structure. Option 2: FireGuard will fabricate a custom-made ASW blanket for your house. This option takes approximately 90 days. Option 3: Install a permanent ASW system for your property. This option takes approximately 120 days. FireGuard designs the ASW to fit individual architectural styles and states it offers fast and easy deployment in an emergency.

There is limited product and research provided on this product on their website. Reaching out to the manufacturer, they responded that all the research they have is on their website, which appears to be limited to a video of their product. The video depicts their product installed on a small, hipped roof one-story structure in a wooded landscape and captures an approaching fire. The caption states “Fumiaki Takahashi, Department of Mechanical and Aerospace Engineering, Case Western Reserve University, Cleveland, OH, USA”. The four-minute video, apparently utilized from the Takahashi study, shows a weather station extending from the roof and it appears there are fairly high winds with the approaching fire. Over the course of the video the fire approaches, burns the vegetation and trees around the building, but shows the AFF and structure remain in place throughout. There is no follow-up to show the condition of the building following the removal of the wrap.

Asking the manufacturer about their permanent installation option (Option 3), their response was “there are a number of potentially feasible permanently installed options, including sliding curtains in vertical closets (they said these videos are on the website, however, they were not found), drop down curtains stowed in the soffit, folded sheets on the roof in special flat housings that match the roof tiles, etc. However, these options are highly case-specific and require architectural input for a given structure to configure and finalize.”

Evaluation:

Cost: Material Only (without shipping or installation) = $0.60-1.20 / SF

- Heavy Duty $900 / roll, not including shipping (5 feet by 150 feet x 16 mil thick, 15 oz/sq. Yd, coverage 750 square feet, weight 76 pounds)
- Standard Duty $450 / roll, not including shipping (5 feet by 150 feet x 8 mil thick, 7.4 oz/sy yd., coverage 750 square feet, weight 38.5 pounds)

Pro: On first appearance this seems to be similar to other aluminized structure wrap (ASW) products. There are two weights of this product: heavy duty and standard duty, giving a range of pricing.

Con: There is very limited information from the manufacturer on testing, use, and the differences between the options they provide for products.

Conclusion: This product is slightly more expensive relative to coverage than similar products studied. Unlike other products, there was limited testing information. Their Option 3: Permanent Installation Solution would likely be most convenient from the aspect of personnel and the time it would take to deploy, however, at first glance based on what the manufacturer described for their permanent installations, this would have a great impact on the historic appearance of the buildings and heavy alterations to install seem to be likely. Therefore Options 1 and 2 are likely to be the only approved methods of utilizing this product for wildfire mitigation efforts with regards to complying with the Secretary of the Interior Standards. Another consideration for deployment would be ensuring proper training for building owners / management well in advance of needing to utilize this type of system. Consideration is needed to how training occurs and is maintained with changing owners / staffing to ensure when a wildfire approaches, deployment is possible. Like other products, this system could be considered reversible and has fairly minimal impact to a historic structure when contrasting with total loss of a structure to a wildfire.

### 2. Firezat, Inc. (Firezat, 2023), Fire Resistant Fire Shield

This Aluminized Structure Wrap (ASW) product was adapted following the 1988 Yellowstone National Park Fires when the Park’s historic structures were under threat, but crews were forced to leave. As a last-ditch effort, the firefighters cut up their personal fire shelters, stapled them to the historic structures and the buildings were spared (see APPENDIX D: ADDITIONAL

INFORMATION for brief history of personal fire shelter development). From this incident, the technology developed and studied for personal fire shelters was adapted to create a building wrap for protection during wildfire threat.

*Figure 9: Image of stack of Firezat rolls. Could be stockpiled on-site for use. Image credit: firezat.com, accessed March 21, 2023*

Evaluation:

Cost: Material (without shipping or installation) = $0.83 / SF

- $828 / roll (5 feet wide by 250 feet long, coverage 1,000 square feet, weight 47 pounds)

Pros: Can be installed by homeowners. Minimal damage to structure if sandbags, double-sided tape and chicken wire are used for installation (chicken wire and staples is best method for high wind resistance). There is no utility requirement, but per the manufacturer, it can be combined with other mitigation measures. For example, it can be combined with a soaker hose on the roof below the wrap to provide a water curtain that will deny oxygen, dissipate heat, and saturate wood. Can be left up for days or weeks with zero performance loss. Fully encloses structure from ember infiltration. No negative environmental impact. Reusable for years with care in handling (tears or holes can be repaired with high temp foil tape). Does not support mold

or mildew, resistant to acids, alkalis, and solvents (except hydrofluoric acid). Reflect 96% of radiant heat. Reflect 92% of convective heat.

Cons: Difficult to install in high winds, which is typically when wildfire risk would be highest. Would not be a solution to be left in place year-round for useability of structures and visual impact and the time it takes to install varies depending on the experience and quantity of installers. Limiting the impact to historic structure depends on installation method and care. Stapling directly to historic wood will likely result in damage when the staples are removed. However, if the consideration is between the complete loss of the structure or having staple holes/minor damage that need to be repaired, the latter would be preferred.

Conclusion: This is a temporary protective measure that has a relatively high level of reversibility with regards to the SOI standard, i.e., holes from chicken wire with staple method of install can be filled, although installing the wrap can use thousands of staples that can damage weathered wood that is friable. It has been utilized by the Forest Service, National Park Service, and the Bureau of Land Management, to name a few, and is proven to protect critical structures from embers, radiant heat and direct flames. There are a significant amount of case studies and testing to back-up this product's performance (Firezat, 2023).


*Figure 10: Firezat installation with chicken wire and staples. Building has an existing metal roof eliminating the need to wrap the roof. Image credit: firezat.com, accessed March 21, 2023*

## D. SPRINKLER SYSTEMS

The goal of sprinkler systems is to protect a building from wind-blown embers, radiant heat and direct flame contact. The types of sprinkler systems commonly used in wildfire risk areas include fixed systems mounted to the structure itself (on the roof, under the eaves, or both), site sprinklers mounted around the property and directed at the building and on the landscaping, and portable systems that can be set-up for an oncoming fire.

Some issues noted with sprinkler systems include the need for an adequate water supply to deliver water for the duration needed, which can sometimes be 8 hours or more. The effectiveness of a fixed structural sprinkler system is questionable when a neighboring building is on fire and would provide extended radiant heat or contact exposure. The systems are typically activated either manually or by an automated device. Ember exposure may disable or impact the ability to activate an automated system. The most threatening wildfires occur during high-wind events, and this can influence the distribution of water droplets, altering effectiveness of a system. For these reasons the Wildfire Research Institute recommends that sprinkler systems be a supplement to already proven mitigation strategies like fuel mitigation and regular cleaning of debris from roofs and gutters (Firewise USA, 2022).

In addition to the sprinklers and portable fire pump, collapsible water storage tanks may be an essential component for a successful sprinkler operation. Tanks can be stored when not in use and expanded and filled with water prior to arrival of the fire. The water supply can be domestic supply from buildings, fire hydrants (although hydrants not intended for use by the public) and can be refilled by water tenders during fire operations. They are often used during fire operations to refill fire apparatus that are too far from hydrants or other water sources to maintain continuity in the firefighting operation due to long turn-around times. Tanks can hold a few hundred gallons up to several thousand gallons of water. There is a liability of having an open water tank on site due to the risk of drowning if someone (a child) should inadvertently have access to the tank. There are various manufacturers and types of collapsible water storage tanks, a couple of manufacturers include: Feld Fire (Portable Water Tank - Steel Frame, 2023); Husky Portable Containment (Husky Portable Folding Frame Water Tanks, 2023) and Fol-Da-Tank (Fol-Da-Tank Collapsible Fire Department Frameless Water Tank, 2023). Capacity (sizes) vary per manufacturer and product but range from 250 to 10,000 gallons. Similarly costs vary from $700 to $8,000. Additional consideration would be needed to determine the correct sizing and product to purchase.


*Figure 11: Image of a Husky Portable Water Tank (Husky Portable Folding Frame Water Tanks, 2023)*

There are many manufacturers of sprinkler systems and accessory components. As this report is not intended to recommend any specific brand or product, the following is not an exhaustive list by any means but does look at information and types from a handful of sprinkler manufacturers.

### 1. MARK-3 (Waterax, 2023), Portable Fire Pump

The MARK-3 Portable High-Pressure Fire Pump is the most common portable fire pump utilized on the market. It is a lightweight pump system that has become a favorite of fire agencies and responders for some time. Originally launched in 1964, the pump is known for its high performance, reliability, and durability. In 2015 the system underwent several improvements and passed the USDA Forest Service 100-hour endurance test. This is the system utilized during the Cameron Peak Fire.

The system can be connected in series with other pumps to move water over long distances, maintaining its volume. The MK3-U unit has a maximum pressure of 380 pounds per square inch, a maximum flow of 98 gallons per minute, and a maximum head of 878 feet (meaning the maximum height a pump can raise a fluid up)

*Figure 12: Waterax MARK-3 Website Photo, Accessed May 23, 2023*

Evaluation:

Cost: $5,100 for the Waterax Mark-3 MK3-U (taxes and shipping not included)

Pros: Portable and lightweight. Photographs from the website show a firefighter walking into a forest carrying the pump with straps on his back, see Figure 12 **.** The pump itself would have no physical attachment to structures or site features. Portable sprinkler systems can be set up where they can do the most good under current fire conditions and behavior. They can be positioned well before the arrival of a fire.

Cons: More information is needed to determine how many pumps would be needed and other accessories (sprinkler heads, hoses, stands/brackets, etc.) required to protect a historic building to fully understand the costs of this system.

Conclusion: A portable fire pump system appears to be highly adaptable to specific applications on a historic building or site with many historic buildings. From a Secretary of the Interior's Standards point of view, it would be a non-attached system that could be set up in a manner to protect structures without physically harming them. Except for water damage if deployed, which would be a preferable impact when compared to total loss of a historic structure.

2. Code3 Water (Code 3 Water, 2023), Portable Wildfire Pump

This portable pump system is powered by Honda engines and is available in various sizes/capacities. The rolling cart system was developed for easy and compact storage and deployment. Developed in California for personal residential use, the system has been evaluated for use on large sites, like vineyards, ranches, and wineries. In these situations, multiple pumps can be used and connected to their water cannons, hurricane 270 roof sprinkler, post-mounted sprinkler and fence mounted sprinklers to cover the properties. Their largest product package is the MP-600v.9 Super Cart System which comes with five fire hose reels mounted to the cart, with 900 feet of 1.5-inch fire hose. The package includes three nozzles, a wye splitter and a 6x6 Manifold. The system information says it can run up to twelve fire sprinklers, one or two water cannons or one 2.5” NH fire hose (these are sold separately). This pump makes over 120 PSI of pressure. The pumps have an electric starter with a pull starter in case the battery is dead. The 6x6 water manifold is a splitter from the pump where you can hook up to twelve sprinklers via ¾ inch hoses.

The stand-mounted water cannon is manually operated by a person and says it has almost 100 feet of water spray distance.

The Hurricane 150 roof sprinklers weigh 24 pounds each, keeping them in place on the roof, and provide 140 psi of water from the pump. They cover up to 150 feet radius.

The gasoline tank on the pump systems typically runs for about 3 hours, but there is an optional propane conversion kit that allows for longer running times of the pumps.

*Figure 13: Code3 Website Photo, Accessed May 23, 2023*

Evaluation:

Cost:  MP-600v.9 Fire Pump System Honda GX390, 2 Nozzles, Wye Splitter and 6x6 Manifold, Cart and 900 Feet of hose = $11,999 (without tax and shipping)

Pros: Besides the fence-mounted sprinklers, there is no physical attachment to structures or site features. Sprinkler heads are located on stands that are set up around the site or on building roofs and the hoses are surface run from the pump to the sprinklers. Portable sprinkler systems can be set up where they can do the most good under current fire conditions and behavior. They can be positioned well before the arrival of a fire.

Cons: Requires maintaining a water storage source, such as a tank, river, lake, pond, or swimming pool, to draw from. Consideration would need to be given to the type of system and expandability for single versus multiple building sites.

Conclusion: This system appears to be highly adaptable to specific applications on a historic building or site with many historic buildings. From a SOI Standards point of view, it could be implemented as a non-attached system that could be set up in a manner to protect structures

without physically harming them, apart from water damage if deployed, which would be a preferable impact when compared to total loss of a historic structure.

### 3. Colorado Fire Break (Colorado Firebreak, 2023), Installed Wildfire Mitigation System

Colorado FireBreak is a company that designs and installs a custom installed protection system on your site. The typical system is designed to protect the building and an area of 50 feet around it. It includes wildfire detection sensors and can be activated manually or automatically via a wireless control panel. When activated, the first stage involves FireIce powder is combined with water pumped from an underground storage tank on the site. FireIce powder is a dry powder material that when added to water produces a firefighting water enhancing gel. The standalone powder product, which comes in buckets, is used by many firefighting agencies and can be pumped through their vehicles/equipment when fighting a fire. For the Colorado Fire Break system, when activated the FireIce gel is pumped through multiple fire suppression lines installed on the building and covers the building with the gel. As the fire nears, the control panel activates a second stage. In this second stage, fire suppression lines in the site / tree perimeter spray FireIce over the landscaping. The intent of the second stage is to provide a lower temperature microclimate around the building with increased humidity to create a firebreak around the building. The goal of the Colorado FireBreak System is to be fully self-contained, including storage tanks and power sources. It is customizable for specific building and site needs.

There is also a FireIce Home Defense Unit which is a portable sprayer on wheels that building owners can use on their own.

The manufacturer's reported benefits include: it is non-corrosive, environmentally friendly (approved by the US Forest Service as non-threatening to the environment), non-toxic (safe for use around pets and kids), long-lasting, cleans up easily (rinse with water, but can remain on trees and plants), consistently out-performs the best class A foams, protects from heat as high as 2000 degrees Fahrenheit

Evaluation:

Cost: Basic system starts at $14,000 and more complex systems could be more than $100,000. Each system is custom designed and requires consultation.

Pros: An installed fire sprinkler system can be designed and installed for custom coverage specific to each structure and its complexities. Activation would have more limited requirements and many systems provide remote or automatic activation.

Cons: Unless portable, collapsible storage tanks are used, which would require pre-fire set-up by the owner or a maintenance entity, an installed sprinkler system requires underground storage tanks for water supply and FireIce powder. Disturbance to the site would be required to run supply lines and devices. Permitting and approval would be required. Visual impacts to the

building and attachment methods would be a consideration and require discussions with historic authorities. The cost of this system would be one of the largest considerations.

Conclusion: For very complex, multiple building sites, this type of system does not appear to be the most practical and is likely not the most economical solution. Many questions should be asked prior to considering an installed sprinkler system which could not be determined prior to the completion of this report. Some questions include do the pipes remain empty until the system is activated? If water always remains in the pipes, how do you prevent freeze/thaw for exterior-run piping which would result in breakage of the piping and components? If the pipes are empty, what is the timeframe for water to charge into the system and what is the pressure of this water? Is the pressure high enough to break connections and heads? How is the system inspected and what is the inspection schedule? Additional questions and considerations are likely when evaluating an installed sprinkler system on a historic building or group of buildings.

### 4. Defense System 2 (Frontline Wildfire Defense, 2023), Installed Wildfire Sprinkler System

The Defense System 2, from Frontline Wildfire Defense, is an automated wildfire sprinkler system for buildings that is custom designed for individual site conditions. When activated, the system saturates the building with water and a Class A firefighting foam delivered via surface-mounted piping and heads. The foam reportedly breaks down water surface tension and allows water to be absorbed more quickly and more deeply by combustible items on a building and property. The foam is approved by the US Forest Service and utilized by firefighters. It is environmentally friendly, biodegradable, non-toxic and advertises to easily wash away after being applied during a fire (see INTRODUCTION ON FIRE CHEMICALS).

The system offers manual and remote activation options. A typical system will use the building's primary water source first; if there is a drop in pressure, the system will automatically switch to a secondary water source such as a pool, tank or well. The system is designed to mitigate the risk of ember ignition during a wildfire.

*Figure 14: Defense System 2 Website Photo Control System and Surface-Run Piping, Accessed May 23, 2023*

*Figure 15: Defense System 2 Website Photo Soffit Sprinklers and Foam, Accessed May 23, 2023*

Evaluation:

Cost: Site dependent, requires Consultation with company and estimate.

Pros: See section above for Colorado Fire Break.

Cons:  See section above for Colorado Fire Break.

Conclusion: See section above for Colorado Fire Break.

## E. OPENING PROTECTION: COVERS, INSECT SCREENS, FIRE SHUTTERS

Windows and doors are vulnerable to radiant heat from nearby burning objects such as other structures or vegetation, as well as direct flame contact.  The wood elements of doors and windows including the door panel, window and door frames, and trim are also ignition sources. However, studies have shown that glass is the most vulnerable part of windows and doors. If it breaks, from temperature differentiation or impact from flying debris, embers and flames have a direct path into a building. Depending on the type of glass and level of exposure, breakage can occur in as little as 1-3 minutes when exposed to radiant heat or direct flames (Insurance Institute for Business & Home Safety, Undated). Some solutions studied to help protect window and door openings include covers, insect screens and fire shutters.

Covers typically refer to a fabricated element, custom sized for each opening. These can be fabricated by an Owner out of plywood or other materials. But could also be fabricated by a specialty Contractor. The challenge of custom covers for openings is the storage space needed, the need for a deployment plan and education, and then the time necessary to install.

Research by the Division of Agriculture and Natural Resources at the University of California has shown that insect screens improved the performance of glass under radiant heat exposures. The research evaluated bronze, aluminum and fiberglass with polyvinyl chloride coated screens and all were noted to improve glass performance. Results from the study however showed that of the materials evaluated, bronze screens were the most effective and aluminum were least effective. The research also concluded that screens did not add any protection from direct flame contact (University of California, 2023).

Fire Shutters offer a physical barrier between radiant heat and flying embers and windows and doors. Products on the market include non-rated and fire-rated products. Shutters can be retrofitted over existing windows and doors. Shutters can be mounted on the interior or exterior, but to protect the window or door from damage, an exterior installation would be required. Typically, they are roll-down products that are stored inside a box above an opening and can be

activated manually or connected to an automated system. The following is a look at one rolling shutter manufacturer as an example of products on the market.

1. Enviroblind Rolling Shutters (Environblind, 2021)

These exterior rolling shutters are installed over a building's windows and doors, but do not have an official fire-rating. The shutters provide a physical barrier to reduce radiant and convective heat from entering the building and igniting objects. They also offer a barrier to flying debris or falling objects that might break through windows and doors. The shutters can be operated manually by a push button or on an automated system with an electric motor and hard-wired switch.

*Figure 16: Enviroblind shutter in open position. Image credit: enviroblind.com, accessed March 21, 2023*

*Figure 17: Enviroblind shutter in closed position. Image credit: enviroblind.com, accessed March 21, 2023*


*Figure 18: Enviroblind shutters on various sized windows and doors in closed position. Image credit: enviroblind.com, accessed March 21, 2023*

Evaluation:

Cost:
Pricing for a typical door size of 36” x 84”, Electric Motor and Hard-Wired Installation = $1,650
Pricing for a typical window size of 36” x 48”, Electric Motor and Hard-Wired Installation = $1,390 (priced on March 22, 2023, and does not include packaging, shipping or installation).

Pros: Technically could be considered reversible by SOI Standards, depending on method of installation. Once installed, closing the shutters is user-friendly and quick.

Cons: High visual impact at exterior. The shutters are stored in a metal box mounted above the window or door opening that protrudes from the face of the building. There are also fixed guide rail tracks mounted on each side of the opening for the shutters. If utilized as a single mitigation solution, the risk of ignition remains at key building locations/elements like vents, rafters, eaves, siding, etc.  It is not uncommon to find wood-framed historic buildings that were constructed without headers above window and door openings. Therefore, consideration would need to be given to the product weight and forces on the historic structure and evaluation by a structural

engineer prior to installation would be required. Shutters operated by an automated system could be at risk of not working and those without automation would require manual closure by someone on-site. The smallest unit size is 24 inches when using the electric motor and the largest unit size is 19 feet. The manufacturer has a limited color selection, therefore matching the historic building might be additional cost and aftermarket custom painting may affect the performance of the product.

Conclusion: The visual impact of exterior rolling shutters is significant for a historic building. An interior installation would resolve the visual impact from the exterior but would expose the window or door to damage from a fire. The structural implications for installation would also need to be considered. Without having a cohesive non-combustible exterior envelope (siding, trim, vents, decking, roofing, etc.) the installation of rolling shutters may be superfluous and highly alter the historic aesthetic of a historic building. Consideration could be given to installation of shutters on secondary (rear or side elevations), if those elevations are also at high risk for wildfire exposure. However, this concession would need strong justification and would likely need to be combined with a cohesive non-combustible exterior envelope design (See Cohesive envelope system narrative in AREAS OF FURTHER STUDY).

## F. REPLACEMENT MATERIALS

A major question that has arisen regarding existing buildings constructed in high-risk wildfire areas, is should the existing building materials be replaced with fire resistant materials? This question is a complicated one for historic buildings, where the materials and visual appearance are key aspects to its historic integrity. Loss of historic integrity typically results in the loss of designation as a historic structure.

Opportunities may present themselves with historic buildings, where materials are missing, highly deteriorated, or beyond repair. In these cases, consideration could and should be given to replacement with a more durable product, but the qualification for replacement always centers on answering the question of “does the replacement product match the historic material in size, scale and profile?” and if the answer is no, “how close or far off is it?” Concessions have been made in historic buildings where modern materials are slightly different, but the difference to the untrained eye is negligible.

Whereas, for a historic building where the materials are highly intact, the argument for removal and replacement would be more difficult to justify and obtain approvals. The following is a review and discussion of a selection of available building products and materials that aim to “harden” a building against wildfire.

As discussed previously, ignition of structures is typically the result of flying embers, radiant heat, and/or direct flame. With each material reviewed, the goal was to provide insight on how resistant each product might be to the various ignition sources. Discussion, consultation, and feedback would likely be necessary beyond this point to determine if others agree with these

findings and whether replacement of historic materials (except in the case of missing/deteriorated conditions) is beneficial and justifiable.

Additional questions arose when evaluating the following products. Noted in each section are the tests that manufacturers have conducted and certifications that products have achieved. To temper these results, our team must point out that laboratory testing is not always commensurate with real-life conditions and variables. And our Team is not necessarily able to answer questions that arose from looking at these products, such as: Are results from laboratory testing, like the ASTM Surface Burning Testing and Fire Tests, where direct flame via a torch is applied to a small section of building material, comparable to saying a product has Wildfire Resistance? Unfortunately, we cannot find data to inform this answer.

Therefore, from this perspective, it would be difficult for anyone to recommend removal of historic material and replacement without knowing with confidence that it would result in resistance to wildfire. Is the cost of replacement of all historic elements a benefit when comparing the cost, level of intervention (i.e., not reversible) and actual fire resistance that results from this replacement product?

Without all the answers to questions that arose, the following attempts to merely present what is available for consideration and if possible, conclusions that can be drawn. As mentioned elsewhere, an exhaustive evaluation of every product on the market was not included, but the following captures materials that the authors found and those that partners involved in this report suggested.

### 1. Roofing

A building's roof is the most vulnerable surface to wildfire. It is a large relatively horizontal surface where embers can land. If the roof material is made of a combustible material or if debris (leaves, pine needles, etc.) has accumulated, they can ignite quickly. A building may only be at risk from the flaming front of a wildfire for a few minutes, but blowing embers can be risky for longer periods of time and can travel significant distances.

The performance of a roof during a wildfire depends on several factors including the roof material and its fire resistance rating, the age and condition of the roof, the edge of roof materials (eaves, rafters, gutters, intersections, etc.), vents and penetrations (skylights, chimneys, etc.) (University of California, 2023).

A Class A fire rated roof is recommended for maximum performance and protection. However, it should be noted that old and weathered roofs lose their performance over time. Therefore, it is also recommended that regular inspection and maintenance of the roof is critical.

Class A is the highest rating achievable through rigorous testing and provides the highest resistance to fire. The fire rating system also has Class B, Class C or Unrated designations. An Unrated roof would be the worst/lowest protection available. Fire testing evaluates performance based on flame penetration through the roof covering into the attic space; flame spread over the

surface of the roof covering; and the propensity for the roof covering to become dislodged and generate embers.

Some roof coverings must be installed as part of a “by assembly” to achieve their fire rating, meaning they may require a specific underlayment or installation technique to achieve their fire rating. If the roof covering achieves the fire rating alone it is referred to as a “stand-alone” system.

There are several Class A rated roof materials available on the market. Stand-alone systems include clay tiles, slate, concrete tiles, asphalt glass fiber composition shingles, PVC membrane, and TPO membranes.

There are acrylic and silicone roof coating roof systems that have a Class A fire rating, however, these are “by assemblies” and require a commercial roofing system to achieve their rating.

There are also metal roofs and fire retardant treated wooden shingle / shake roof coverings that require a “by assembly” to achieve a Class A fire rating (Quarles, 2017). While metal roofs are non-combustible, they require underlayment to achieve a Class A rating. For example, if a metal roof is installed directly on a wood deck, the heat transfer can ignite the deck. The underlayment prevents this direct transfer.

A fire-retardant treated wood shingle/shake has a stand-alone Class B rating, but with the installation of a particular underlayment, it can meet the requirements for a Class A rating. Common underlying materials include 72 pound felt or cap sheet and a panelized gypsum product called DensDeck. For fire retardant treated wooden shakes, it should also be noted that reapplication of the fire retardant is required. The duration for reapplication will differ based on the manufacturer’s recommendations but is around 5 years. Another challenge with treated wood shingle/shake roofs is that there is no visible marking/indication that it is treated. Discussions with emergency response personnel have indicated that if they see a structure with a wood shingle/shake roof, they deprioritize it and move on to the next structure. Many jurisdictions do not allow wood shingle/shake roofs, even if they are fire treated. Some historic preservation projects can be “grandfathered” in to retain their historic wood shingle roofs, however, consultation with local building authorities and historic preservation authorities is recommended to obtain all approvals.

There are synthetic materials, such as CeDUR (CeDUR , 2022), that have stand-alone Class A fire ratings that were specifically developed in order to replace wood shingle/shake roofs, but closely match the visual appearance. There are other synthetic material options on the market. Consideration and consultation are recommended with historic preservation authorities, as the dimensions and profiles of these products are not an exact match for historic wood shingles/shakes, but the tradeoff for fire resistance warrants consideration.

Beyond the roof material and rating itself, the next fire ignition risk at the roof level is related to combustible areas at soffits, such as wood fascia trim, exposed wood rafter tails, exposed wood

sheathing, and gutters. Although sheet metal gutters and downspouts are non-combustible, ignition materials such as pine needles and leaves gathered in the gutters pose a threat to exposed wood at the roof level of the buildings. If embers fall into the gutters, ignite the fuels in the gutters adjacent to exposed wood rafters / eaves / soffits and trims, this offers an ignition path. The following is a review and evaluation of potential treatments / alterations:

1. Sheet Metal Enclosures of Open Rafters / Wood Soffits

One potential solution to respond to the ignition risk of wood soffits and trims is to enclose them with sheet metal. There are companies that do this sort of treatment, made more common in California due to their wildfires. A Plus Gutter Systems of Los Angeles and Orange County (A Plus Gutter Systems, Undated) has several photos of work they have completed, see Figure 15 and Figure 16.

*Figure 19: A Plus Gutter Systems of Los Angeles and Orange County, Photo of soffit and fascia retrofitting with sheet metal, Accessed May 17, 2023*

*Figure 20: A Plus Gutter Systems of Los Angeles and Orange County, Photo of soffit and fascia retrofitting with sheet metal, Accessed May 17, 2023*

Evaluation:

Cost: Enclosing soffits and fascia can range from $6-30 per linear foot, depending on the size and complexity of the project. This is a very rough range gathered from multiple online sources based on 2023 information.

Pros: According to installers that offer this type of treatment, the benefits include that it can help satisfy insurance requirements living in fire prone areas, offers protection of your wood from UV rays, provides an additional barrier from wind driven rain, requires no painting, and helps to minimize areas that insects can normally penetrate wood. This treatment would protect wood elements from ignition from flying embers, assuming any venting in the soffits is able to prevent embers from entering.

Cons: This treatment does not protect the exterior wood soffits and trim from direct flames or high radiant heat. As mentioned, if the radiant heat is great enough, wood elements will combust.

Conclusion: This treatment is highly visible and alters the appearance of the building, changing the feeling, materials, design and workmanship associated with historic integrity. Technically this would be nearly reversible from the perspective that the enclosures could be removed, mounting penetrations repaired, and the historic materials remain below. As a standalone treatment, enclosing soffits and fascias would be nearly useless, but as part of a cohesive non-combustible exterior envelope (which would include siding, trim, vents, decking, roofing, etc.) it might warrant further consideration, for the entire structure or for specific elevations at high risk for wildfire exposure. However, this concession would need strong justification and consultation with historic preservation authorities for approval. This application would be a great impact on character defining features for a building like the Chautauqua Dining Hall, which has decorative carved open rafter tails, see Figure 21.

*Figure 21: Chautauqua Dining Hall Tower, Exposed wood soffits with carved rafter tails (Lord, 2022)*

### 2. Consideration for Removal of or Not Installing Gutters on Historic Buildings

Gutters are a consideration for historic buildings as a means of collecting and directing water away from a building's foundation. Water infiltration poses risks of undermining the structure, decay of materials, etc. Ignition of organic materials that build-up in gutters poses a high structural risk during a wildfire. Although there are solutions such as gutter covers, these products do not guarantee that debris will not find its way and build-up in the gutters. Therefore, for historic buildings at high risk of wildfire exposure additional discussion and consideration should be given to either elimination of gutters entirely or if gutters do not currently exist on the building, not installing them. This treatment would trigger the need for an alternative drainage design at the ground level surrounding the buildings to ensure that protection from water infiltration can still be achieved. Many historic buildings lack continuous foundations, therefore eliminating gutters and downspouts would likely result in increased risk to the integrity and longevity of the historic structures. A holistic approach to preservation of a historic building needs to be considered beyond just wildfire risk reduction and consultation is recommended with historic preservation authorities prior to making a decision.

## 2. Windows & Glazing

See OPENING PROTECTION: COVERS, INSECT SCREENS, FIRE SHUTTERS for additional discussions for Window and Glazing protection. The National Park Service Technical Preservation Brief 9 addresses the repair of historic wood windows. As described in the brief:

> *The windows on many historic buildings are an important aspect of the architectural character of those buildings. Their design, craftsmanship, or other qualities may make them worthy of preservation….The Secretary of the Interior's Standards for Rehabilitation and the accompanying guidelines, call for respecting the significance of original materials and features, repairing and retaining them wherever possible, and when necessary, replacing them in kind.*

Following the sections of the brief that discuss repair of historic windows, there is a section in Window Replacement. The following is discussed in the brief:

> *Although the retention of original or existing windows is always desirable and this Brief is intended to encourage that goal, there is a point when the condition of a window may clearly indicate replacement. The decision process for selecting replacement windows should not begin with a survey of contemporary window products which are available as replacements but should begin with a look at the windows which are being replaced. Attempt to understand the contribution of the window(s) to the appearance of the façade including: the pattern of the openings and their size; proportions of the frame and sash; configuration of window panes; muntin profiles; type of wood; paint color; characteristics of the glass; and associated details such as arched tops, hoods, or other decorative elements…..Armed with an awareness of the significance of the existing window, begin*

> *to search for a replacement which retains as much of the character of the historic window as possible…..Consider energy efficiency as one of the factors for replacements, but do not let it dominate the issue. Energy conservation is no excuse for the wholesale destruction of historic windows which can be made thermally efficient by historically and aesthetically acceptable means. In fact, a historic wooden window with a high quality storm window added should thermally outperform a new double-glazed metal window which does not have thermal breaks….* (Preservation Briefs 9 The Repair of Historic Wooden Windows, 2023)

Like other discussions in this report, there are no provisions for adaptations to the SOI Standards with regards to wildfire prone areas. As mentioned in Brief 9, adaptations for increased energy efficiency include adding high quality storm windows. Projects have received approval for both wood-framed and aluminum-framed exterior storm windows. An aluminum-framed exterior storm window would provide the added benefit of a non-combustible exterior barrier to protect the historic wood window from flying embers. Exposure to direct flame is less likely to offer a considerable benefit, since historic wood siding and trim would remain in place below and around the storm window. There are many exterior aluminum storm window manufacturers on the market. Products utilized and approved for historic projects include, but are not limited to:

- Allied Windows, Inc. Storm Windows (Allied Window, Inc. , 2023)
- St. Cloud Window Secondary Glazing Products (St. Cloud Window, 2023)

There are fire-rated windows on the market that were evaluated as part of this report:

a. Fyre-Tec (Fyre-Tec, 2023), Fire-Rated Windows

This is a manufactured fire-rated steel window. The rolled steel sections have welded corners for strength and durability. The window frames have been listed by Underwriters Laboratories. Styles of windows include horizontal slider, single hung, fixed lite, awning, and casement. UL rated factory glazing options include clear ceramic 1 hour rated glass or ¼ inch wire glass with a 45-minute rating. These rated glazing types can be combined with Low-E glazing (to reduce UV and infrared light) in an insulated glass unit (IGU). Heat activated fusible links are standard on all operating windows which close the windows in the presence of fire. Horizontal sliding windows may also be equipped with a resettable device which may be activated by a fire or smoke alarm, computer, or another electrical signal.

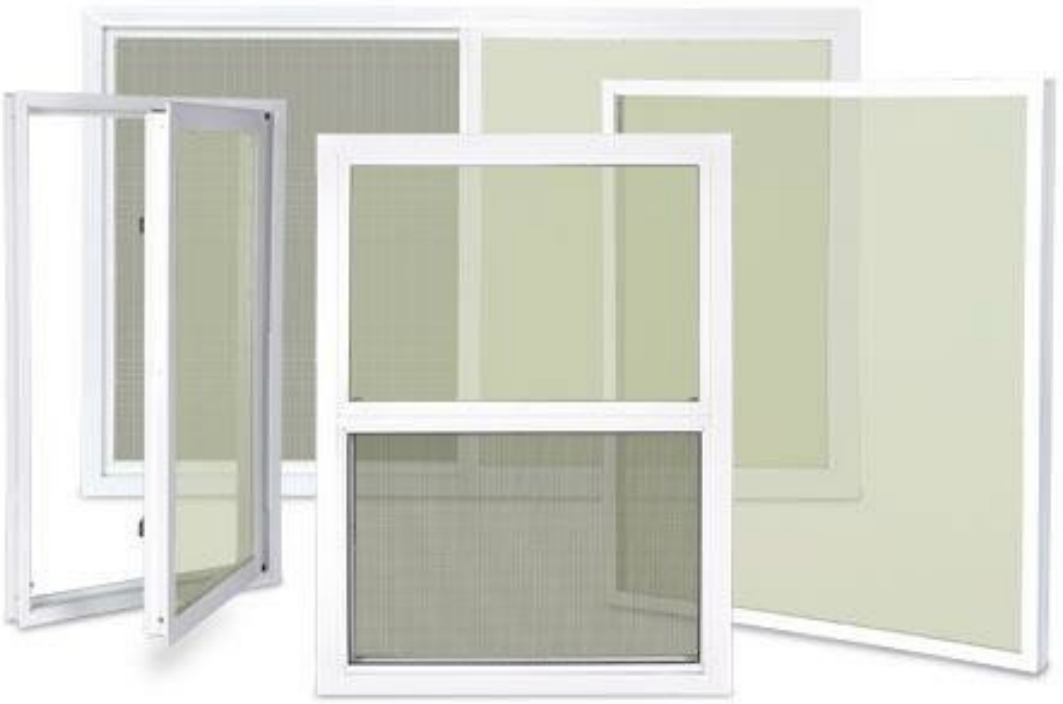

*Figure 22: Fyre-Tec Fire Rated Window Styles. Image credit: fyre-tec.com, accessed March 21, 2023*


*Figure 23: Fyre-Tec Fire Rated Window Sections Compared to Typical Rated Window Frame Construction. Image credit: fyre-tec.com, accessed March 21, 2023*

Evaluation:

Cost: Price for a single hung window typical size 36” x 48” = $3,945

Pros: Fyre-Tec windows have been tested by Underwriters Laboratories and have an official fire rating.

Cons: Replacement windows are rarely a good visual match for historic wood windows and these steel windows would be drastically different from the historic. This product does not come in a double-hung configuration and there is not an ability to match historic muntins for divided light windows.

Conclusion: Without having a cohesive non-combustible exterior envelope (siding, trim, vents, decking, roofing, etc.) the installation of fire-rated windows would be superfluous and highly alter the historic aesthetic of a historic building, especially those with simple single-pane wood windows. Consideration could be given where historic wood windows were previously replaced / are not extant on building elevations that are secondary (rear or side elevations), if those elevations are also at high risk for wildfire exposure. However, this concession would need strong justification and would need to be combined with a cohesive non-combustible exterior envelope design (See AREAS OF FURTHER STUDY for Cohesive envelope system discussion).

### 3. Cladding & Trim

Historic wood cladding and trim that require repair or replacement should be, in accordance with the SOI Standards, the same species, the same cut of wood (flat sawn vs. vertical grain), the same grade, the same defects (a few large knots, many small knots, no knots, etc.) and similar technical requirements. At a minimum, the same wood species and same cut of wood should be required under the umbrella of "in-kind".

Wood products that provide fire resistance may be able to satisfy those requirements, but some cannot. Chemical treatment to provide fire resistance is not possible with all species due to the anatomical and chemical properties of the wood. Non-wood cladding and trim products face the additional hurdle of not being wood, thus, not satisfying a basic requirement of the SOI Standards. Additionally, the appearance can be very difficult to match based on the type of cut or weathered texture of the historic wood.

Nonetheless, in some cases where the materials (in this case, the fire-resistant wood products), might be considered if replacement of the existing cladding and trim is warranted due to reaching the end of its service life. Without the need for replacement, the cost of replacing the cladding and trim should be evaluated based on the benefit of changing to a product that has satisfied the specific tests to provide a degree of fire resistance. As was discussed in the Fire Chemicals section, such tests are intended to provide fire resistance but are not fireproof. Replacement of existing cladding that is in good condition may not be economically viable from

a cost/benefit analysis. The following is a look at some products marketed towards fire resistance:

a. Cedar Valley (Cedar Valley, 2023)

Cedar Valley, a California Company, manufactures western red cedar shingle and shake siding panels for exterior walls. Their panelized system consists of shingles mounted to a fiberglass mat laminated onto a strong plywood backing. The system includes specialty customization options including matching corners and radius flares. Their products are CAL FIRE State Fire Marshal Wildland Urban Interface (WUI) approved for siding after undergoing the California SFM 12-7a-1 Fire Test. This test protocol involves a direct flame exposure at the base of a 4 foot by 8-foot wall sample at a heat output of 8535 BTU/min for a period of 10 minutes. The assembly is then observed for a period of 60 minutes for flaming or glowing on the unexposed side (Chapter 12-7A Materials and Construction Methods for Exterior Wildfire Exposure, 2023).

*Figure 24: Cedar Valley Website Photo, Custom Massachusetts Home Installation, Accessed May 22, 2023*

*Figure 25: Cedar Valley Website Photo, Radius Panel Photo, Accessed May 22, 2023*

*Figure 26: Cedar Valley Website Photo, Custom Combed (Striated) Texture, Accessed May 22, 2023*

Evaluation:

Cost: $7.00 to 8.00 per square foot for material cost only

Pros: A fire-resistant replacement for wood shingle or shake siding is intriguing. Some customization options for this product do exist including radius installation and combed/striated texture.

Cons: Cedar Valley is a manufactured system with a different thickness, size and profile to historic wood shingle or shake siding. Their standard exposures are 7.125-inch, 5.3-inch, and 4.25-inch. Consideration would need to be given to the detailing of this product, especially where it interfaces with trim and other building elements.

Conclusion: This product would be most successful with wholesale removal of historic shake or shingle siding down to the exterior substrate. Installation of a panel system over existing shakes or shingles would likely create a non-uniform result. Wholesale removal of historic siding would be a considerable alteration to the historic fabric. If the exterior siding of a historic building was very deteriorated or predominantly missing, replacement with a product such as this would be opportune, however consultation with historic authorities would be required and consideration would be needed as to how compatible it is with the historic siding in design, color, texture, and materials.

### b. Chemco SaferWood (Chemco, Undated)

SaferWood by Chemco, Inc. in Washington, provides fire resistant treatment wood products including cedar roofing, soffits, fascia, siding, decking and interior lumber and plywood building products. Their SaferWood siding has passed ASTM E-84 (Standard Test Method for Surface Burning Characteristics of Building Materials) and D2898 (Fire Tests for Pressure Fire Retardant Treated Wood) testing and is ICC compliant. The fire-retardant treatment product is Thermex-FR which is listed as safe and environmentally friendly that renders wood resistant to fire. According to the website, beyond the independent laboratory and quality-control testing, the effectiveness has been verified by real-world stories in which applied SaferWood products have been subjected to both structural and wildland fires. The manufacturer provided the following information on testing and the treatment process:

> *PRESSURE TREATMENT*
> *We offer fire retardant treatment of wood (mostly softwoods but a few hardwoods as well as thermally modified wood, however, treatment is required by IBC and IWUIC to be done under a pressure process, per IBC 2303.2.1. Our "SaferWood" treatment is performed in a pressure-vessel, at our facility. Additionally, once treated, wood is required to be KDAT-Kiln Dried After Treatment, per IBC 2303.2.8.*
>
> *FLAME & WEATHER TESTING*
> *Further, to meet IWUIC-International Wildland Urban Interface Code compliance, which SaferWood does and is currently the only exterior fire-retardant to currently do so (ref. ICC-ES ESR-1159), as ignition-resistant per IWUIC Section 503.2, Item 3, FRTW. Compliance with IWUIC requires Fire-Testing per ASTM E84/UL 723 extended 30 minutes after undergoing ASTM D2898 accelerated weathering.*

*PERMANENT PROTECTION*
*Fire retardant treatment of wood, per IBC 2303.2.2, must provide permanent protection to all surfaces of the wood products. The use of paints, coatings, stains or other surface treatments is not an approved method of protection as required. Our treatment is permanent and backed by a limited lifetime guarantee.*

*Figure 27: SaferWood Website Project Photo, Accessed May 22, 2023*

Evaluation:

Cost: Inquiry to the manufacturer was sent to determine rough cost information for this report. The response from the manufacturer was that a rough cost per square foot depends on the species of wood selected and quantity. SaferWood does not sell or distribute the wood elements, they are a treatment service only where the wood species and estimated quantity must be submitted to the manufacturer to obtain a price per square foot cost.

Pros: From preliminary evaluation, the SaferWood treatment appears to offer customization, flexibility and longevity for new wood materials. The treatment does not need to be reapplied; the process makes it inherent in the treated wood.

Cons: The testing, similarly, explained elsewhere in this report, is based on laboratory testing, but is difficult to translate into wildfire effectiveness. The cost of this treatment is unknown. Utilization of this treatment would be applicable for new wood materials that might be installed on a new building or on a historic building where previous materials are missing or deteriorated. But it seems it would be highly cost prohibitive and infeasible to consider such a treatment for existing historic materials where elements would need to be removed from a structure, stripped if painted, and transported to SaferWood's facilities for treatment. If such a process were feasible, it would be irreversible.

Evaluation: With the information available, it is difficult to evaluate this product, especially as it relates to a historic building. For replacement of historic wood features that are missing or deteriorated, it would seem to offer some protection against flying embers and some protection against ignition, although the temperature of ignition is not known. Without greater understanding of costs, it is difficult to evaluate. Further consideration is warranted.

### c. Hewn Fire-Resistant Products (Hewn, 2022)

Hewn, a company in Oregon, manufactures a Class A Exterior Pressure Treated Fire Resistant Siding Product. The product aims to maintain the visual look and feel of exterior cedar siding that resists the spread of fire. An added benefit of their fire-resistant treatment process that they discuss is the aging process is slower and there is protection against ultraviolet degradation, providing for a longer lasting product. The testing they have undergone includes ASTM D-2898 (Standard Practice for Accelerated Weather of Fire-Retardant-Treated Wood for Fire Testing), ASTM D-84 (Standard Test Method for Surface Burning Characteristics of Building Materials) and their product has been verified by International Code Council (ICC ESR-1159 and ESL-1021, which are evaluations on multiple fire-retardant treated wood products, including SaferWood, Mataverde, etc.). Their products are available in standard nominal widths (1x4, 1x6, 1x8, 1x10 and 1x12) and have a thickness of 13/16 inches. The milling profiles available are Tongue and Groove or Shiplap. They have a Flame Spread Index of 25 or less, and a Smoke Developed Index of 45 or less. They have eleven standard finish options ranging from white, red, brown, and grey. There is the option of custom colors. The siding can be installed with the boards oriented vertically and horizontally. Following correspondence with the manufacturer, it became clear that their products are impregnated with Thermex FR, potentially by Chemco SaferWood although this is unclear, similar to other products included in this report.

*Figure 28: Hewn Website Project Photo, Accessed May 22, 2023*

Evaluation:

Cost: starting at $17 / square foot, not including shipping, taxes, etc. Per feedback from the manufacturer, this cost is based on "…*an order that would clad a reasonable size home. Smaller orders can get more expensive due to logistics*"

Pros: From preliminary evaluation, the Hewn Class A Exterior Pressure Treated Fire Resistant Siding Product appears to offer some level of fire resistance. See similar discussions for other products.

Cons: The manufacturer does not offer much data or testing to assist in evaluating this product as it relates specifically to wildfire. Flame spread is low and Smoke development index is low, but it is unclear at this time how these factors can be correlated with wildfire conditions. See similar discussions for other products.

Conclusion: Customization with color is available, however sizes and profiles are limited. With the limited information available, it is difficult to evaluate this product. In theory it would offer some protection against flying embers and some protection against ignition, although the temperature of ignition is not known. Similar to other discussions wholesale replacement seems to be necessary to offer some level of protection (and to what level when considering active wildfire exposure versus laboratory testing is also needing further consideration), however,

wholesale replacement does not currently meet the Secretary of the Interior Standards and would not be approved. Selective replacement of missing or deteriorated wood elements with Hewn products seems futile.

### d. Metaverde Fire Retardant Treated Hem Fir Wood Siding (Nolan, 2021)

Metaverde, a company with locations in Connecticut and California, produces a Fire-Retardant Treated Hem Fir Wood Siding to closely match the natural look of Western Red Cedar Siding. The siding is thermally modified and utilizes Thermex pressure treatment, similar to the other wood siding manufactured products. The standard profile manufactured is a 1x6 Tongue and Groove profile with 1/8-inch joint. Thermally modified wood, as compared to standard kiln dried lumber, is saturated with moisture and the wood is heated to higher temperatures. The moisture keeps the wood more uniform during the drying process and the higher heat “cook the sugars out”. This process is reported to make wood more dimensionally stable, uniform, resistant to insect damage and decay. One downside of thermally modified wood is that it is more brittle. Thermally modified hem fir is 70% less brittle than red cedar and measured on a Janka Hardness Test, is nearly twice as hard as red cedar.

An inquiry to the manufacturer was submitted asking the following questions: Does it have a standalone fire rating? (Like Class A, B or C). Or is there a manner you’ve found to detail the exterior assembly to achieve a rating? Like installing a particular substrate, underlayment and your siding? It appears that you can install it as vertical siding, horizontal siding or as a soffit material, is that correct? The Blog post about the product listed that it only comes in 1x6 Tongue and Groove profile. But I noticed that was from 2021, so I wasn’t sure if any additional sizes and profiles are achievable (even if that would be a custom item)? For example, a lot of historic wood buildings have a clapboard siding profile, so I wanted to see if there were custom options like that? Does the fire-retardant treatment need to be reapplied after a certain period of time? If so, what is the timeframe and what is the process for reapplication? Have you conducted any ignition tests related to temperature? Is there a temperature at which this material will ignite / is resistant up to based on testing? However, a response from the manufacturer was not received. Therefore, evaluation of this product is limited.

Evaluation:

Cost: No response from manufacturer inquiry.

Pros: From preliminary evaluation, the Metaverde ThermaWood FR Hem Fir Siding Product appears to offer some level of fire resistance.

Cons: The manufacturer appears to only offer one siding profile / configuration

Conclusion: See similar material conclusions sections. For replacement of missing or deteriorated wood elements in high-risk wildfire areas, a solution like this could be considered if it matches the material and profile it is replacing.

### e. Montana Timber Products (Fire Treatment for Wood: Defensive Solutions for Fire, Undated)

Montana Timber Products, a manufacturer of wood building materials including wood siding and trim. They offer fire treatment options to their products including a spray-applied fire treatment and their Fireline pressure-treated fire treatment. These treatments can be applied to siding, soffits, fascia, trim, timbers, posts, beams and decking.

Their spray-applied fire retreatment is advertised as a Class A Rated fire retardant that reduces flame spread and smoke development. It has a UL Greenguard Gold Certification and is non-toxic, with low VOC content and emissions. The installation process is to coat, dry and cure onto the wood substrate at their facility and they report that it is permanent and never needs to be reapplied. Although it is a formulated Class A retardant it is not currently Wildland Urban Interface compliant. The Wildland Urban Interface Approved Products listing was established under the California Building Code to offer resources for approved products. The categories include decking materials, exterior windows, exterior siding and sheathing, exterior doors and under eaves (Wildland-Urban Interfaces, 2023). This treatment does not perceivably change the color of the wood when combined with their stains. Although the spray-applied treatment has a Class A rating, it does not meet the requirements to be listed as a CAL FIRE Wildland Urban Interface (WUI) Product. When evaluating spray-applied treatment versus the Fireline pressure-treated treatment, some considerations are that the topical treatment is generally less expensive.

Their Fireline treatment involves a vacuum pressure impregnation process to remove moisture and air from the wood cells and replace it with a safe, environmentally friendly additive. It is then thermally cured, to lock the additives into the wood cells. This process alters the cellular structure of the wood to provide enhanced fire-resistance. Due to the Fireline product penetrating and bonding to the interior structure of the wood, there is no need for retreatment/reapplication. There will be variations in colors as a result of the Fireline treatment and it cannot be controlled. The process adds approximately 6-8 weeks to the lead time of a wood order. The Fireline products have passed a series of fire and weathering testing and credentials, including ASTM E-84, ASTM D-2898, ICC ESR 1159, ICC ESR 1410, and it is listed on the CAL FIRE WUI Product Handbook. The WUI compliance, combined with the Class A rating, makes it the higher level of fire-resistant treatment of the two.

An inquiry to the manufacturer was submitted asking the following questions: Is there an additional lead time for the spray-applied treatment? Are both treatment options available for any wood product? Are there any dimensional and profile limitations? It seems like you offer a variety of sizes and configurations of wood products. And you likely realize historic buildings would have specific profiles and sizes, so I was just curious if there were any issues/limitations for wood. However, a response from the manufacturer was not received. Therefore, evaluation of this product is limited.

*Figure 29: Montana Timber Products Website Project Photo, Accessed May 23, 2023*

Evaluation:

Cost: No response from manufacturer inquiry.

Pros: From information available at this point, both the Fireline and the Spray-Applied Fire treatment offered by Montana Timber Products appear to provide some fire-resistant benefits. The company appears to offer treatment to any type, size and application of wood. The spray-applied treatment reports to have no perceivable change in color to the wood.

Cons: There appears to be additional lead time to these treatment options. Consideration and planning will be needed to account for this if utilized for a project. The Fireline treatment reports uncontrollable changes in color of the wood (according to their materials it is approximately a shade or two darker in color). However, for a painted wood application, this doesn't seem like a problem.

Conclusion: For replacement of missing or deteriorated wood elements in high-risk wildfire areas, a solution like this could be considered. In theory it would offer some protection against

flying embers and some protection against ignition, although the temperature of ignition is not known. Similar to other discussions wholesale replacement seems to be necessary to offer some level of protection (and to what level when considering active wildfire exposure versus laboratory testing is also needing further consideration), however, wholesale replacement does not currently meet the Secretary of the Interior Standards and would not be approved.

### f. Fiber Cement Cladding

Fiber cement is a manufactured product made of cement, sand, cellulose, and other additives. It is advertised as a durable low-cost alternative to more expensive cladding options like wood, brick, or stone. There are various manufacturers on the market including: James Hardie. Nichiha Architectural Wall Panels, Equitone Panels, etc. Some manufacturers offer products that aim to mimic wood siding materials found on historic buildings like wood shakes, shingles, and horizontal clapboards.

*Figure 30: Nichiha Website Photo, Nichiboard Cedar (Nichiha, 2023)*

*Figure 31: Nichiha Website Photo, Sierra Premium Shake (Nichiha, 2023)*

*Figure 32: James Hardie Website Photo, Hardie Pank Lap Siding (James Hardie, 2023)*

*Figure 33: James Hardie Website Photo, Hardie Shingle Siding (James Hardie, 2023)*

Direct comparison of fiber cement siding is extremely difficult as the quality of each product line and manufacturer is not easily decipherable, especially when attempting to contrast it with historic wood siding. Fiber cement siding manufacturer's list benefits of their products such as "does not require regular repainting", "does not rot", "is insect resistant", "fireproof" and "performs exceptionally well in natural disasters". Manufacturer's recommendations on maintenance schedules also vary, however generally they recommend annual cleaning and then repainting every 10-15 years. Similarly, maintenance of wood siding is recommended to be cleaned annually with soapy water and a brush. In contrast, if painted, wood siding may require repainting in as little as 3 years and up to 15 years. The maintenance schedule for wood siding is highly dependent on the color (darker colors fade more quickly than lighter colors) and the quality of paint (higher quality paint performs better for a longer duration). It would be prudent to consider that a dark paint on fiber cement siding would degrade at a fairly similar rate as it would on wood siding, considering they would be exposed to identical sun and weather patterns. Moisture performance of fiber cement siding is questionable. Fiber cement siding has been known to hold moisture and even mold, although higher quality manufactured products may have addressed some of these problems. Wood siding does swell when exposed to moisture, and extended duration of exposure results in rot, but wood itself is typically a breathable material that will, in most cases - if the moisture is mitigated/managed - dry back out and reset to its original profile. The biggest consideration for fiber cement siding in comparison to wood siding is the visual and material compatibility. Although manufacturers advertise their ability to mimic historic wood profiles and dimensions, the smallest exposure available at the time of this report is 4 inches (from HardiePlank) and all board lengths are 12 feet. A manufacturer stamped wood texture on a fiber cement siding board also visually differs from a real wood product. Consideration would be needed based on specific building design features on whether a visual match is achievable with a fiber cement product.

Regarding material compatibility, in a wood-framed building with wood siding, the framing and siding are moving (swelling and shrinking with temperature and moisture changes) at a similar rate. Fiber cement is a more rigid material therefore when installed as a siding on a wood-framed building, consideration should be given to building and material movement and how that might differ. On fiber cement siding installations observed in west and south facing elevations in Colorado, siding nails have been observed working themselves out on fiber cement siding, a potential sign of differential movement of the siding and the wall framing, see Figure 34. For historic preservation professionals considerations such as changing how a building moves and performs is critical to ensuring no harm is introduced that would potentially impact its longevity.

*Figure 34: West Wall of 1957 Ranch in Colorado, Nails Visibly Working Their Way Out of Fiber Cement Siding (Lord, 2023)*

As mentioned elsewhere in this report, when evaluating fiber cement siding as a replacement to wood siding based on performance during a wildfire, an ASTM or similar laboratory test is difficult to translate to actual application. The fiber cement siding would have more resistance to embers and perhaps resist higher temperatures than wood siding. However, with existing wood framing directly below, it is questionable in high temperature fires where materials will combust, that fiber cement siding will make much of a difference. Specific laboratory testing to this effect is not available at this time.

Evaluation:

Cost: The cost of fiber cement siding, trim, etc. varies from between $5 and $14 per square foot and is highly dependent on brand, quality, size, and complexity of the structure. For a more direct comparison, wood siding cost per square foot ranges anywhere from $4 and $16 depending on similar considerations plus species and whether it is going to be painted, stained or will remain natural.

Pros: Costs are similar. The protection against fire, similar to other products evaluated, does appear to offer some fire resistance to flying embers. Although, as mentioned elsewhere, consideration needs to include laboratory testing versus direct wildfire exposure.

Cons: When evaluating against the Secretary of the Interior Standards, the replacement of wood siding with fiber cement siding on a historic structure does not satisfy the requirements. Wholesale replacement of wood siding with fiber cement siding would be required to achieve some semblance of fire resistance, selective replacement in certain areas would leave wood directly exposed to ignite the remainder of the structure. The SOI Standards require historic materials to be retained where condition allows and required replacement “in kind” where missing, rotten, or deteriorated. “In kind” means same material, profile, spacing, and in the case of wood, it also means matching the species and grain as closely as is feasible.

Conclusion: Further development and customization of fiber cement siding in the marketplace will likely continue to expand and perhaps at some point, more information, testing and options will be available to warrant the re-evaluation of this material as a potential wildfire mitigation resource for historic wood buildings. Similarly, if the SOI Standards are updated to respond to Wildfire risks, like “The Secretary of The Interior’s Standards for Rehabilitation & Guidelines on Flood Adaptation for Rehabilitating Historic Buildings”, perhaps this update could further evaluate and consider the replacement of wood siding with alternative materials that offer fire resistance, such as fiber cement siding. However, at this time, fiber cement siding is not a recommended treatment based on the current information, testing data, and inability to meet the SOI Standards as they currently exist.

### 4. Decking & Walkways

A handful of the products discussed in CLADDING & TRIM included replacement options for wood decking with fire-retardant treatment products. See that section for more information. The following is a review of a couple of products on the market for decking and walkways. Refer to APPENDIX E: PHASE 1 CHAUTAUQUA WILDFIRE MITIGATION PLAN for discussion of metal wire mesh enclosure discussion for open deck protections. Similarly, see the section in this report on Vents for information on pricing and installation.

a. HardieDeck (HardieDeck, 2023)

Although currently only available in Australia, HardieDeck is a product developed in reaction to the Bushfires. The material is manufactured by James Hardie but does not appear to be available in the United States. It is made from premium fiber cement, making it non-combustible and has been approved to be installed in Bushfire Attack Level (BAL) rating zones up to BAL-FZ, meaning “direct flame contact from fire front & radiant heat exposure is greater than 40kW/m² (Kilowatt per square meter)”, which is the highest level recognized by the Australian Rural Fire Service (What Are Bal FZ and Bal 40 Requirements?, 2023).

*Figure 35: HardiDeck Website Project Photo, Accessed May 23, 2023*

Evaluation:

Cost: Unavailable in the United States

Pros: Although the fire resistance rating comparison between the United States and Australia is unknown, this appears to be a highly resistant product with the ability for outdoor horizontal installations.

Cons: There is a lot of unknown information at this time. It appears this product is a solid sheathing product. The “gaps” between “deck boards” appear to be solid material. From the photos on the website, the installation at raised deck areas appears to require fully enclosed construction around the sides and bases of the structure, see Figure 26.

Conclusion: This product has some exciting potential as a new construction product in wildfire prone areas. However, with no availability in the United States it is not currently an option for Owners to consider. It also does not mimic wood decking, so from a historic preservation perspective does not seem to be a consideration related to this report. However, with more information about the installation details and methodology it is possible further consideration in the future is warranted. Can this system be installed over and around an existing deck, maintaining the historic materials in place below (similar to the discussions of sheet metal enclosure of eaves and soffits), and provide fire resistance? The question there would be, are wood railings and other elements still exposed, negating the success of this alteration?

### b. TREX (Trex Composite Decking Boards & Products, 2023)

Trex composite decking advertises their product in comparison to wood with benefits that it "won't rot, warp or splinter; doesn't require seasonal painting, sealing, or staining; doesn't fade or stain; and won't become food for termites." Their products have 25–50-year limited warranties. When it comes to fire resistance, their decking product lines of Transcend and Select have a Class B fire rating. The Enhance decking line has a Class C fire rating.

*Figure 36: Trex Website Installation Photo, Accessed May 23, 2023*

Evaluation:

Cost: Range between $5-12 per square feet, depending on product line and color (material cost only)

Pros: Advertised to be low-maintenance and durable. With Class B and Class C rated products, there would be some ignition resistance.

Cons: In areas of large temperature swings (like Colorado) composite decking can expand and contract. The structural framing below the decking is typically wood, and the two materials move at different rates during thermal swings. This can cause warping and cracking of the decking. Composite decking is also less strong than wood decking requiring closer spaced wood framing below, which makes the deck structure more expensive in addition to the decking material being a bit more expensive than a typical wood deck.

Conclusion: Trex's rated products would provide some resistance to ignition. For an existing wood framed deck, removing the wood deck and replacing it with a Trex deck does not seem to be a worthy alteration. The combustibility of the wood framing/structure below would be the same and the dissimilar material behavior is a concern. A similar concern that is not addressed in the marketing material is that with high heat, Trex products will melt.

### 5. Vents

RETROFITTING VENTS: Vents on buildings such as those located in walls, soffits, eaves, foundations, etc. provide a pathway for flying embers to enter a structure and ignite exposed framing or finishes. California websites such as readyforwildfire.org (CAL FIRE, 2019) and firesafemarin.org (Fire Safe Marin, 2023) suggest two hardening options for open vents in buildings, the first is to retrofit all vent openings with metal mesh with spacing between 1/16 inch to 1/8 inch. They warn that fiberglass or plastic mesh should not be utilized as these can melt and burn, providing an additional ignition source.

Evaluation:

Cost: The material cost of 1/16 to 1/8 inch wire mesh is around $0.40 - $1.00 per square foot. Most products are sold in rolls (ranging from 10-100 feet long).

Pros: This solution has a relatively inexpensive material cost. Installation cost would primarily be dependent on labor, but a building Owner could choose to self-perform the install. For vertical installation this would be a minimally invasive solution to adding protection to open vents.

Cons: This solution requires regular inspection to ensure that elements, such as wind, snow or pests, haven't shifted or torn up the wire mesh. As a solution for covering roof vents, the wire mesh retrofitting method is likely not the best. As seen in Figure 28, a fabricated wire mesh

cage around a roof vent requires screws to penetrate through the roof material, adding a new path for water to enter the building. Additionally, in Colorado climates with snow it would be questionable how durable this solution would be to sliding snow on the roof.

*Figure 37: Roof Vent with Retrofitted Wire Mesh Cover (Roof Vent Screens Installation, 2023)*

Conclusion: From a SOI Standards perspective, retrofitting existing vents in historic buildings with metal mesh would be a reversible solution that would minimally change the visual appearance of the building. In all likelihood most onlookers would not notice this alteration. The mesh could be removed with minor repairs required to the historic fabric, like filling holes and repainting. This solution would not be recommended for roof vents, but would be a good solution for vents on vertical surfaces or soffit vents in overhangs, etc.

REPLACEMENT OF VENTS: The second hardening recommendation is to replace open vents with those manufactured specifically for ember and flame resistance. The following is a look at two manufactured options:

a. EMBERSOUT (Embers Out, 2023)

Embers Out is a company in California that developed protective vent filters that can be installed over existing vents in order to stop embers from entering the building and restricting access to direct flames. Additional benefits the manufacturer advertises are that their vents restrict insects and rodents, dust and debris, wind driven rain, snowpack penetration, and wind. Their company lists the following features: they are CAL FIRE approved, made in America, have a lifetime guarantee, and are impervious to corrosion. Their products are paintable, so once installed they can be painted to match a building's exterior. They meet the ASTM EE2886/E2286M-14 standard, which is the American Society for Testing and Materials (ASTM) Standard Test for Evaluating the Ability of Exterior Vents to Resist the Entry of Embers and Direct Flame Impingement. A video on the Embers Out Website shows the testing with flying embers and direct flames with cotton pads on the opposite side of the vent. In both cases, the cotton pads did not ignite.


*Figure 38: Photo from Embers Out Website of Retrofitted Vent Applications, Accessed May 22, 2023*


*Figure 39: Photo from Embers Out Website of Gable Vent Filter, Accessed May 22, 2023*

Evaluation:

Cost:

5.5 inch by 15.5 inch retrofit vent = $54
14 inch by 24 inch retrofit vent = $84

This is the vent product cost only and does not include taxes, shipping, installation and other products necessary (fasteners and sealant) to install (Source Lowes.com, Accessed May 22, 2023).

Pros: Based on the information available, these products provide protection from flying embers and restrict direct flames based on their ASTM testing results. According to the manufacturer's website, this product can be installed over an existing vent, in which case the historic material would remain below the new vent. However, detailed installation details or photos depicting the existing vent in place were not available from the manufacturer. The manufacturer confirmed that custom sizes are available and that direct order from the manufacturer is available.

Cons: Pending review and approval of installation detailing, the downsides of this mitigation solution were not identified.

Conclusion: From a Secretary of the Interior's Standards perspective, if this product is able to be installed with the historic vent retained below, it would be a reversible solution, with the historic fabric retained in place. The visual change to the building would be different from the historic look, but this trade-off may be worth the added protection from flying embers and direct flames. If custom sizes are available, this would be a viable and fairly minimal cost alteration to a historic building to provide resistance to flying embers. It would not be successful at resisting direct wildfire flames as a standalone treatment, but as part of a cohesive non-combustible exterior envelope (siding, trim, decking, roofing, etc.) it might be worth further consideration, especially for specific elevations at high risk for wildfire exposure. However, this concession would need strong justification and consultation with historic preservation authorities for approval.

b. Vulcan vents (A Home's First Line of Defense from Embers and Wildfire Flames, 2023)

Vulcan Technologies, located in California, manufactures the Vulcan Vent, a line of products that stop embers and restrict fire for residential structures, without sacrificing air flow into attics or crawl spaces. They are CAL FIRE approved and pass ASTM E2886 testing to block ember entry. They have also been tested by the International Code Council Listings for 1 Hour Burn Testing (ICC-ESL: 1299, 1455 and 1300). In addition to their manufactured vent types, which include dormer, eave, foundation, gable, and soffit vents, they also offer retrofit options such as mesh screening and honeycomb intumescent coating products that can be installed on any existing vent. Vulcan Vents can be painted to match a building's exterior, however proper care and protection is required to ensure that the paint does not clog the steel mesh or the

honeycomb matrix in order not to reduce/prevent airflow. Vulcan Vents have a patented honeycomb matrix with intumescent coatings on the interior that begin to react when temperatures reach approximately 450 degrees Fahrenheit.  There are standard sized manufactured vents available as well as custom order for specific sizes available from the manufacturer. In addition, you can purchase the honeycomb matrix and stainless-steel ember mesh as a set to be customized in retrofitting of existing vent locations.

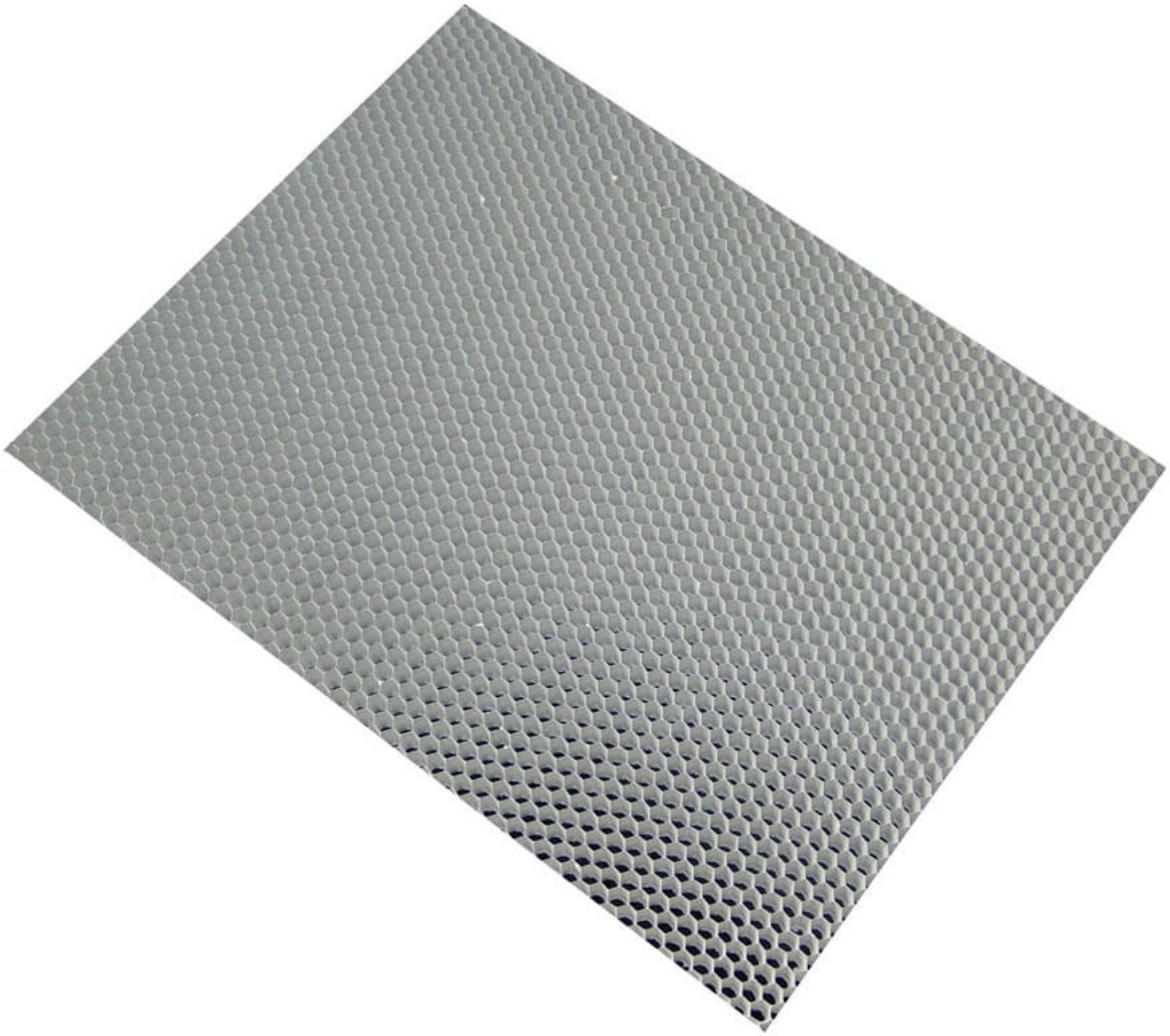

*Figure 40: Vulcan Vent Honeycomb Matrix, Accessed May 22, 2023*

*Figure 41: Vulcan Vent Foundation Vent, Accessed May 22, 2023*

*Figure 42: Vulcan Vent Gable Vent, Accessed May 22, 2023*

*Figure 43: Vulcan Vent Soffit Vent, Accessed May 22, 2023*

Evaluation:

Cost: No response from manufacturer inquiry.
Pros: Based on the information available, these products provide protection from flying embers based on their ASTM testing results. According to the manufacturer's website, their retrofit honeycomb and metal mesh products can be installed to the interior of existing vents, in which case the historic vent would remain in place and the visual impact would be minimal. Custom sizes are available, giving ultimate flexibility for historic vent sizes and configuration.

Cons: Pending review and approval of installation detailing, the downsides of this mitigation solution were not identified.

Conclusion: From a SOI Standards perspective, the retrofit honeycomb and metal mesh product installed to the interior of historic vents would be a reversible solution, with the historic fabric retained in place. The visual change to the building would be minimal and only observable up close. This would be a viable and fairly minimal cost alteration to a historic building to provide resistance to flying embers.

6. Other Building Products:
    a. Armortex Bullet Resistant and Fire Rated Wall Panels (Armortex Bullet Resistant and Fire Rated Wall Panels, 2023)

A product shared for consideration is the Armortex Bullet Resistant and Fire Rated Wall Panel. This appears to predominantly be a bullet resistant product for government and high security applications, that also achieves a 1-hour fire rating. The panel is installed directly onto the interior face of the wall framing and then interior gypsum board or other finishes are installed on top of it. The fire resistance would appear to be for interior furnishings and life safety applications only. As demonstrated by the manufacturer's diagram, the wall framing, and exterior siding would burn completely.

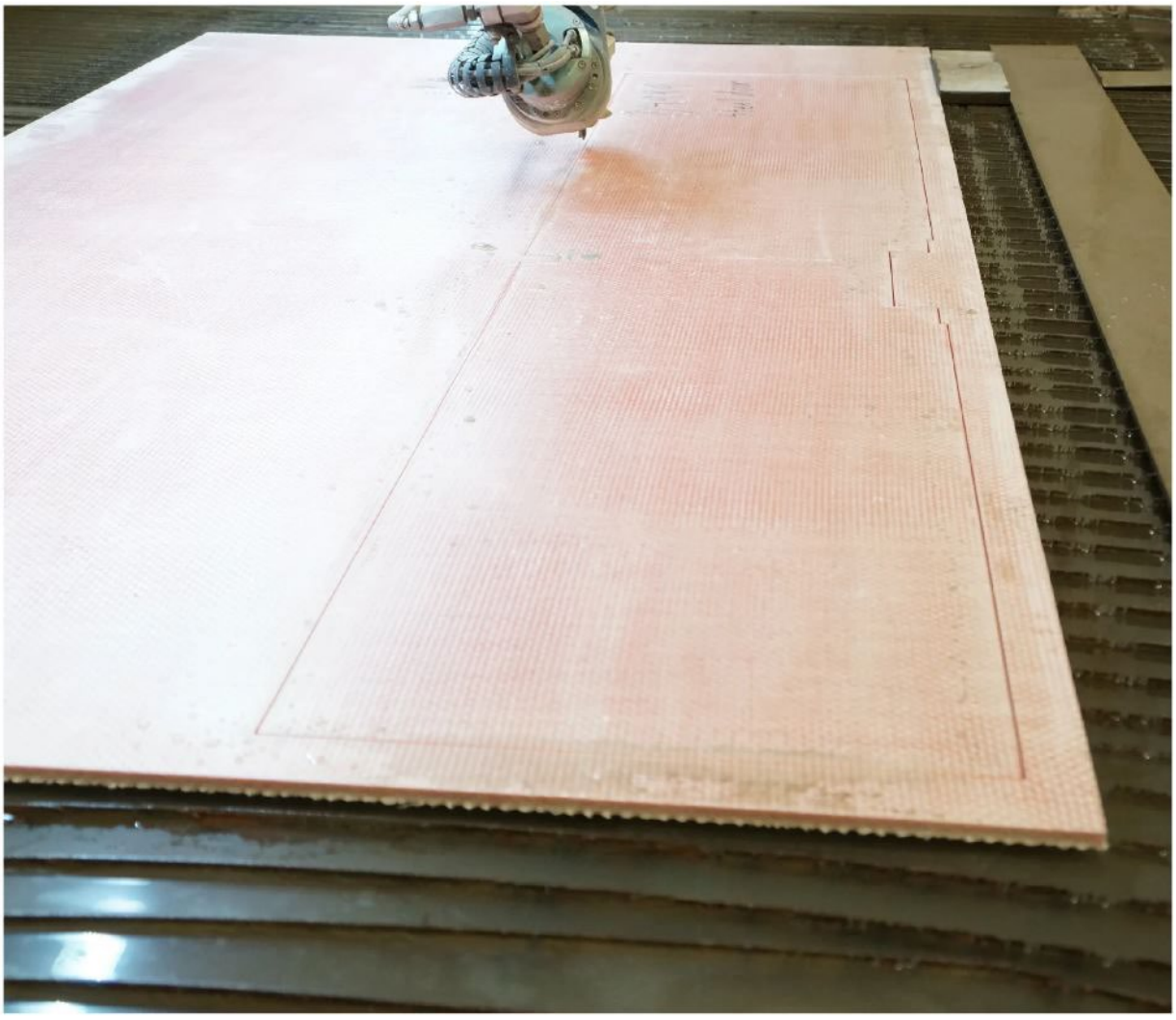

*Figure 44: Armortex Panel Being Custom Cut with CNC Machine, Accessed May 23, 2023*

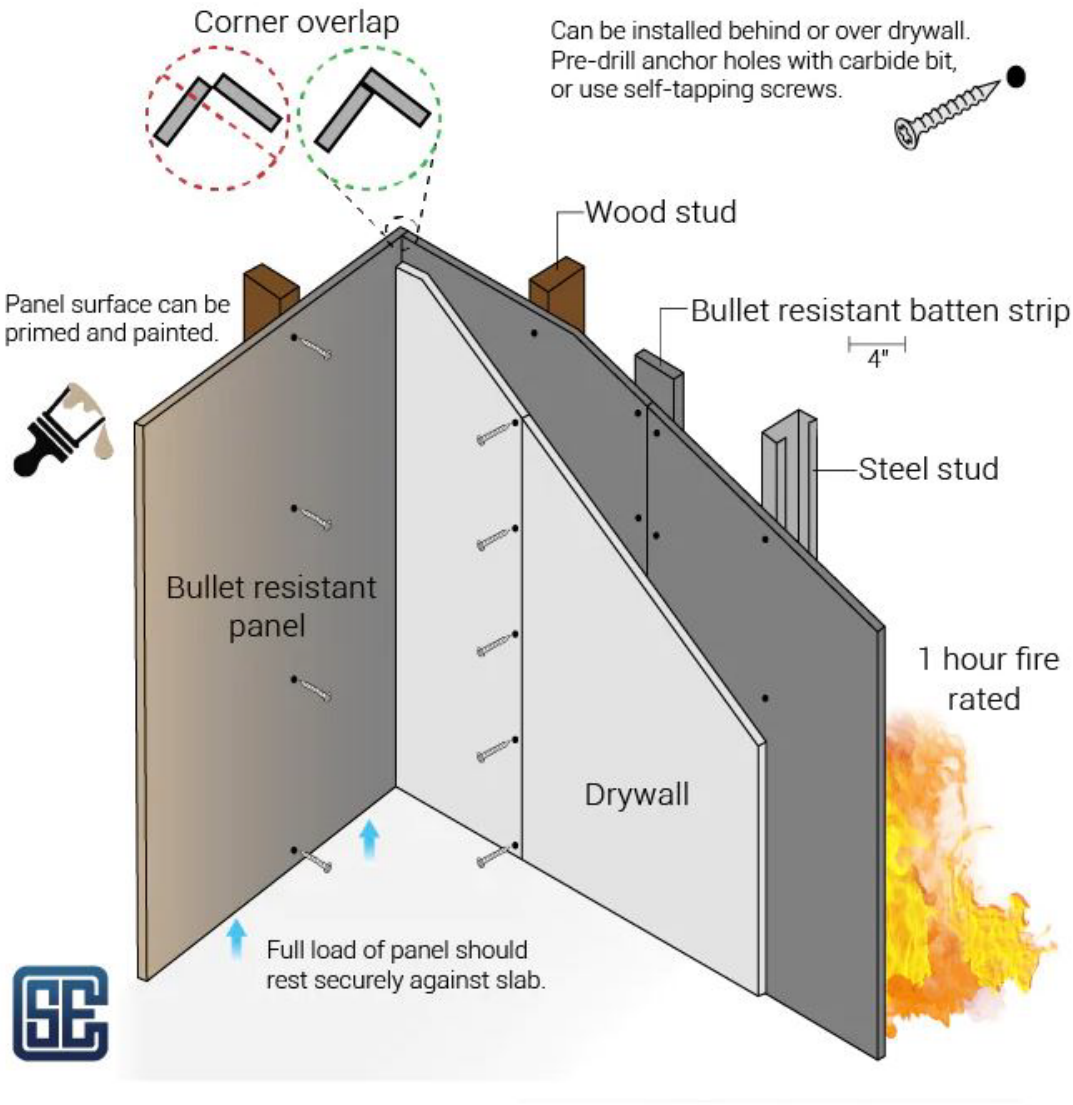


*Figure 45: Armortex Installation Diagram, Accessed May 23, 2023*

Evaluation:

Cost: $800 for a 4 foot by 8 foot panel with 1 hour fire rating and Level 1 bullet resistance (their lowest resistance level offered)

Pros: No notable pros.

Cons: Extremely high cost, for unknown benefit. Would require removal of interior finishes to apply directly to the wood stud framing.

Conclusion: This product does not appear to be a viable consideration for historic building applications. A 1-hour fire rating is achievable with a single layer of Type X 5/8 gypsum board, and comparatively the cost would be approximately $20 for a 4 foot by 8 foot board. If a fire-rating is desired, another less expensive method seems more appropriate.

# V. PHYSICAL INTERVENTION SUMMARY MATRIX

| Product Type | Name | Meet SOI | Relative Cost to Implement | Notes |
|---|---|---|---|---|
| Fire-fighting Foams | Various Manufacturers: Chemguard, PHOS-CHEK WD881, etc. | MAYBE | $ | Short-term effectiveness, difficult to apply at large, multi-building complexes (like Chautauqua) due to the number of structures and close proximity |
| Fire-fighting Gels | Various Manufacturers: Thermo-Gel, PHOS-CHEK INSUL-8, FireIce Pro, etc. | MAYBE | $$ | Short-term effectiveness, difficult to apply at large, multi-building complexes (like Chautauqua) due to the number of structures and close proximity |
| Fire Retardants Coatings | Various Manufacturers: Flamecheck M-111PA, Flame Control No. 10, etc. | MAYBE | $$ | Not a remedial treatment for existing structures except for repairs that can be pressure treated (e.g., structural lumber) |
| Fire Retardants | Various Manufacturers: PHOS-CHEK LC95W | MAYBE | $$ | Short-term effectiveness, difficult to apply at large, multi-building complexes (like Chautauqua) due to the number of structures and close proximity |
| Intumescent Paints | Various Manufacturers | NO | $$ | Does not appear to be effective for protecting the exterior of the structure |
| Building Wrap | Various Manufacturers: FireGuard, Firezat, etc. | YES | $$ | Can be effective, requires training and deployment plan and consideration to install method |
| Sprinkler System: Portable Systems | Various Manufacturers: MARK-3, Code2, etc. | YES | $$$ | Can be effective, needs monitoring during fire operations |

| | | | | |
|---|---|---|---|---|
| Sprinkler System: Installed System | Various Manufacturers: Colorado Fire Break, Defense System 2 | MAYBE | $$$$$ | Consideration to visibility, impact to structure, and performance during freeze/thaw cycles |
| Opening Protection | Fabricated Covers: Plywood or Other | YES | $$ | Consideration of deployment and storage. |
| Opening Protection | Metal Insect Screens | YES | $$ | Replacing existing screening material would have minimal visual impact with increased ember protection benefit. |
| Opening Protection | Enviroblind Rolling Shutters | MAYBE | $$$ | Would require negotiation and approval by historic authorities. |
| Roofing | Class A Roofing: Various Types | MAYBE | $$$$ | Depends on historic roofing material, if it is in place and can be retained / repaired. Consideration of fire risk and negotiation with historic authorities is needed. |
| Windows | Fyre-Tec Fire-Rated Windows | NO | $$$$ | |
| Cladding & Trim | Fire-retardant Treated Wood Products Various Manufacturers: Cedar Valley, Hewn, Metaverde, Montana Timber Products, Etc. | MAYBE | $$$$ | Consideration to matching historic profiles / configurations. Would require negotiation and approval by historic authorities. |
| Cladding & Trim | Fiber Cement Siding. Various Manufacturers: James Hardie. Nichiha Architectural Wall Panels, Equitone Panels, etc | NO | $$$$ | Incompatible material, question of resistance in active wildfire conditions |

| | | | | |
|---|---|---|---|---|
| Decking & Walkways | HardieDeck | NO | N/A | Not available in the US. Incompatible material, question of resistance in active wildfire conditions |
| Decking & Walkways | TREX | NO | $$ | Incompatible material, question of resistance in active wildfire conditions |
| Vents | Retrofitting vents with metal wire mesh | YES | $ | Reversible and historic material can be retained in place. |
| Vents | Manufactured Fire-Rated Vents. Various Manufacturers: Embers Out, Vulcan Vents, etc. | YES | $$ | Reversible. Consideration of detailing would be needed to retain historic material in place. |
| Other | Armortex Bullet Resistant and Fire Rated Wall Panels | NO | $$$$ | |

# VI. APPLICATION RELATED TO CHAUTAUQUA

The Colorado Chautauqua was established as a National Historic Landmark (NHL) in 2006. In order to achieve NHL status, properties need to have national significance and a high level of historic integrity. There are 102 historically contributing resources within the district. Loss of historic integrity (through alteration, addition, or demolition) is the most common reason for the withdrawal of the National Historic Landmark designation. The designation may be impacted by changing construction materials that alter the appearance of the structures, loss of character-defining features, or significant changes to the cultural landscape.

This is the second phase of the Wildfire Mitigation Plan project that began in March of 2022 for the Colorado Chautauqua Association (CCA). The Final Phase 1 document was submitted to CCA on October 25, 2022. Comments were received from the Chautauqua Firewise Coalition and Nan Anderson, a former Chautauqua Board Member. These final comments were incorporated in March of 2023. The purpose as outlined in the Phase 1 document was:

> *With direct adjacency to wildfire prone landscapes and with a mission statement to preserve the historic site, the Colorado Chautauqua Association sought to pursue a Wildfire Mitigation Plan to review past and current wildfire mitigation efforts and inform them on any additional steps, recommendations, and best practices that might be considered. A major consideration for this effort was focused on maintaining the historic integrity of the site and buildings while balancing modern fire mitigation techniques.*

Phase 1 resulted in a summary of recommendations for wildfire mitigation at Chautauqua, including a CCA Cottage / Campus Wildfire Management Checklist, see APPENDIX E: PHASE 1 CHAUTAUQUA WILDFIRE MITIGATION PLAN).

CCA applied for and was awarded a grant through the State Historical Fund in June 2022 to complete Phase 2. The purpose of Phase 2 is to research and evaluate physical wildfire mitigation interventions for historic wood-framed buildings and evaluate them with respect to Chautauqua and conformance with the Secretary of the Interior's Standard for the Treatment of Historic Properties (SOI Standards). This project involved research and consultation with various groups to obtain information. The list of resources researched (SHF Deliverable #3) has been included as APPENDIX C: SHF DELIVERABLE #3 List of Research Stakeholders & Resources.

When evaluating the applicable Secretary of the Interior's Standards in relation to the Chautauqua campus, the buildings are predominantly utilized as they were historically and retain a significant level of their historic integrity. Many of the cottages (CCA and Privately-Owned), Auditorium, and Dining Hall are still utilized as they were historically. A select number of buildings on the Chautauqua campus have been rehabilitated for compatible uses, such as the Academic Hall, Box Office #200, etc. Considering Chautauqua is a living site, with active

uses and users, the Rehabilitation Standards would be the most applicable, although careful consideration would be needed prior to each project pursuit, and a tailored approach to each structure to determine the correct SOI Standards is necessary.

Beyond the SOI Standards as a general application, Chautauqua also has guiding documents that were specifically developed based on the district itself. In 1989 the Chautauqua Design Guidelines were developed and in 2012 the Landscape Guidelines were developed as a supplement to the Design Guidelines at Chautauqua. These documents outline what can and cannot be done within the district in order to maintain the highest level of historic integrity. A review of these guidelines in relation to potential fire mitigation techniques was considered in the following recommendations. Generally speaking, the Design Guidelines elaborate and provide more specifics as the SOI Standards relate to Chautauqua. Some notable pieces of the Guidelines include:

- *1989 Chautauqua Design Guidelines* (Board, 1989)
    - *Public buildings are significant landmarks in themselves. Their original appearance should be as carefully preserved as possible, and any changes related to modern uses should be carefully incorporated so they make a minimal impact to the structure*
    - *Elements that make up Chautauqua's Character include:*
        - *Spacing: Distances between cottages*
    - *Windows:*
        - *Every effort should be made to preserve existing windows by repairing deteriorated sashes and frames…*
        - *If repair is not feasible, and the window must be replaced, match the existing windows as closely as possible. Elements that should be carefully considered are: size; frame material; method of operation; single or double glazing; divided or single panes.*
        - *Window frames should be wood, rather than metal or vinyl clad*
    - *Exterior Materials:*
        - *For repairs or additions, the exterior materials should match the existing materials as closely as possible*
    - *Porches:*
        - *Repairs to the structure of a porch should not change its visual character.*
        - *Porches that need repairs should be repaired, not demolished*
- *2012 Landscape Guidelines* (Bishop, 2012)
    - *Maintain consistent landscape character: The Historic District has a significant urban forest consisting of trees and plantings that contribute to the historic character.*
    - *Selectively thin and prune overgrown vegetation; remove vegetation that blocks significant views into or from the Historic District.*
    - *Replace missing street trees to reestablish the historic street tree patterns.*
    - *Remove trees in inappropriate locations such as those that obstruct views towards cottages.*

The following is a summary of the fire mitigation techniques discussed in this report and summarizes / expands on whether they would or would not be recommended for use specifically at Chautauqua based on the Design Guidelines and the SOI Standards.

1. Fire Chemicals: Foams, Gels, Coatings, and Retardants

As mentioned in the report, there is very limited technical data on the effects of foams, gels, coatings, and retardants on historic materials, including wood. It is unknown if these materials and products are a reversible treatment, meaning they can be removed without alteration to the historic material. Therefore, at this time, they are not recommended for use at Chautauqua because the information currently available does not confirm that they would meet the SOI Standards. However, further study and evaluation of Class A foams is recommended, as similar to the SOI Flood Adaptation document, consideration for wildfire risks to historic buildings is warranted and some irreversibility of Class A foams is likely preferrable to full structure loss.

2. Intumescent Coatings

For painted historic wood, application of intumescent coatings would require fully stripping paint off all wood prior to applying the intumescent paint. This would be a costly and intricate process. There is also a question of whether laboratory testing, such as ASTM E84 and E119 translate to the reality of a wood building with intumescent coatings exposed to a wildfire. Due to these factors, intumescent coatings are not recommended for use at Chautauqua.

3. Building Wraps / Fire Shields

Building wraps / fire shields have successfully protected structures during wildfire, as exhibited by previous applications by the Forest Service, National Park Service, the Bureau of Land Management and others. Although the application method and attachment will require additional investigation to minimize the impact to the historic materials and discussions will be needed to determine how training and deployment will work at Chautauqua, this mitigation technique offers a high level of reversibility. As discussed in this report, there appear to be options for custom-fabricated wraps/shields that could perhaps offer easier and faster deployment during a wildfire. These should be considered further. Although not practical on the larger structures at Chautauqua (Auditorium, Dining Hall, Academic Hall, etc.), building wraps / fire shields are a recommended mitigation technique for consideration.

4. Sprinkler Systems

An installed exterior sprinkler system would be fairly invasive (physically and visually), costly for deployment for large campuses like Chautauqua and would require additional consideration and research to answer some of the questions posed in the report (water source, freeze/thaw performance, etc.) prior to fully endorsing it as a wildfire mitigation technique. Consultation

would be required with historic authorities, however, like installing an interior fire sprinkler system in a historic building, historic preservation does prioritize integrating life safety into historic structures which often have to balance installation impact with the higher benefit of protection for occupants and the structures themselves. With a similar lens, looking at a structure like the Auditorium, where a building wrap / fire shield is unlikely to be deployed successfully during a wildfire event due to the size and complexity of the structure, perhaps an installed sprinkler system would be a preferrable solution. As mentioned, several factors must be further studied to truly understand the cost versus benefit of this mitigation technique.

Portable sprinkler systems, in conjunction with collapsible water storage tanks, offer flexibility and customization during an event. It is hard to predict where a wildfire may come from, and the portable fire pump system allows for adaptation to specific buildings and sites. Storage and deployment training and procedures at Chautauqua would need to be considered. However, this mitigation technique would meet the SOI Standards as it can be set up and fully removed without damage to a building. As discussed in the report, activation of any sprinkler system does pose the threat of flooding / water damage to the historic building, however, this would be preferrable to total building loss. Portable sprinkler systems are a recommended wildfire mitigation technique for consideration. For Chautauqua an initial idea for an appropriate system for the site would be to have three portable pump systems, sprinkler heads and arms, and three 1,000-gallon tanks. During an event these could be filled with a domestic supply (garden hose), or a fire department tender would come and fill the tanks. Training and a deployment plan and staffing would need to be discussed and implemented.

5. Opening Protection: Covers, Insect Screens, Fire Shutters

Due to the visual impacts, fixed fire shutters are not recommended at Chautauqua. Chautauqua could consider fabricating custom covers for building windows and doors, out of plywood or other material, which could be stored and installed during an oncoming wildfire event. The challenges to consider include storage, having a deployment plan and educating the personnel who will install them during a wildfire event. Covers would meet the SOI Standards from a reversibility standpoint as after removal the holes filled/repaired (similar to plywood installed on buildings in anticipation of a hurricane).

For windows and doors at Chautauqua that currently have insect screens, it is recommended to ensure that the screening material is made of bronze, aluminum or fiberglass with a polyvinyl chloride coating as these have been noted to improve glass performance where flying embers were the threat. As discussed, screens do not improve protection for direct fire exposure. Of the materials studied, bronze screens were the most effective and aluminum were least effective. For windows and doors without screens, if they had screens historically but are merely missing, consideration could be given to recreating these features for added protection.

6. Replacement Materials
    a. Roofing

The Buildings at Chautauqua currently have Class A Fire Rated Roof Coverings. The dominant material for roof coverings is asphalt shingle, however the Auditorium has a combination of asphalt shingle and membrane roof covering. It is recommended that Class A Fire Rated roofs are maintained throughout the district.

(1) Sheet Metal Enclosures of Open Rafters / Wood Soffits:

Several structures at Chautauqua, like the Dining Hall, have carved / decorative open rafters and many have open rafters. From a historic perspective covering these character-defining features with sheet metal enclosures at open rafters / soffits would be difficult to justify based solely on the visual aspect and its impact to character defining features. Technically this would be nearly reversible from the perspective that the enclosures could be removed, mounting penetrations repaired, and the historic materials remain below. As a standalone treatment, enclosing soffits and fascias would be nearly useless, but as part of a cohesive non-combustible exterior envelope (siding, trim, vents, decking, roofing, etc.) it might be worth further consideration / discussion. However, this concession would need strong justification and consultation with historic preservation authorities for approval. For the above reasons, it would not be recommended as a treatment at this time but could be revisited as part of a study of wildfire specific adaptations for historic buildings, similar to the Secretary of the Interior's Standards for Rehabilitation & Guidelines on Flood Adaptation for Rehabilitating Historic Buildings.

(2) Removal of or Not Installing Gutters:

Where gutters exist on structures at Chautauqua, their main purpose is to collect and direct water away from the building's walls and foundations. Whether they existed historically, historic preservation professionals recognize the impact water and drainage can have on a building over time. Water infiltration poses risks of undermining the structure, decay of materials, etc. When considering gutters as they relate to wildfires, ignition of organic materials that build-up in gutters poses a high structural risk. Although there are solutions such as gutter covers, these products do not guarantee that debris will not find its way in and build-up in the gutters. Therefore, for historic buildings at high risk of wildfire exposure additional discussion and consideration should be given to either elimination of gutters entirely or if gutters do not currently exist on the building, not installing them. Removal of gutters / prohibiting gutters at Chautauqua would trigger the need for an alternative drainage design at the ground level surrounding the buildings to ensure that protection from water infiltration can still be achieved. Many of Chautauqua's buildings lack continuous foundations, therefore eliminating gutters and downspouts would likely result in increased risk to the integrity and longevity of the historic structures. A holistic approach to preservation of a historic building needs to be considered beyond just wildfire risk reduction and consultation is recommended with historic preservation authorities prior to making a decision. Therefore, regular cleaning and inspection of gutters is the base recommendation for all gutters that currently exist on structures at Chautauqua. Consideration for installation of gutter covers, as long as regular cleaning and inspection continues, is the next level recommendation. Further discussion including feasibility and

cost/benefit analysis should continue to determine if risks from gutter build-up is high enough to warrant removal of gutters and installation of alternative foundation drainage solutions.

### b. Windows & Glazing

Windows and Glazing are one of the most noticeable character-defining features of a historic building. Despite efforts by manufacturers, it is very difficult to match the visual aspects (dimensions, reveals, shadow lines, etc.) of a historic window. Replacement of historic windows at Chautauqua with a fire-rated window would drastically alter the integrity and character of the district, would be costly, and it is questionable whether it would achieve any notable fire resistance when consideration to the remaining combustibility of the structure is analyzed. Therefore, it is not recommended. See above discussion of insect screens and covers for the recommendations for window & glazing protections.

### c. Cladding & Trim

Fire-retardant wood products are available in the market, and it appears there are ample customization options to consider for replacement of historic wood cladding, trim and decking. At the Mary H. Galey Cottage project at Chautauqua, fire-retardant treated wood was utilized for the deck, railing, and underdeck screen wall. The Mary H. Galey deck backs up to the Chautauqua Reservoir Road on the west side of the district. Although the road offers a barrier, the open and densely vegetated land on the west side of the road is not owned or managed by Chautauqua (See EXECUTIVE SUMMARY for discussion of further and continued collaboration with neighboring OSMP areas). For this reason, fire-retardant treated wood offers some level of protection for flying embers and ignition. Direct wildfire exposure is less predictable due to lack of comparable testing. Wholesale replacement of the historic wood cladding, trim and decking at Chautauqua would not be recommended as it would be highly impactful, costly and would need extensive consultation and justification. Wholesale replacement does not currently meet the Secretary of the Interior Standards and would not be approved, but evaluation as a solution could continue as part of a study of wildfire specific adaptations for historic buildings, similar to the Secretary of the Interior's Standards for Rehabilitation & Guidelines on Flood Adaptation for Rehabilitating Historic Buildings.

The use of fiber cement siding at Chautauqua was approved for the new trash enclosure constructed in the district, see Figure 46 and Figure 47. However, it would not be recommended as a treatment for replacement of historic wood cladding and trim on any of Chautauqua's contributing buildings due to it not being a visually compatible material and questions on performance. Wholesale replacement of historic wood cladding and trim does not currently meet the SOI Standard, but similarly to fire-retardant treated wood, further consideration specific to adaptation for historic structures in wildfire areas may be warranted.

*Figure 46: Fiber Cement Siding approved at new Chautauqua Trash Enclosure*

*Figure 47: Chautauqua Trash Enclosure with Fiber Cement Siding*

d. Decking & Walkways

As discussed in Cladding & Trim, replacement of decking and walkways with fire-retardant treated wood may be a beneficial wildfire mitigation technique at Chautauqua, such as with the

Mary H. Galey Cottage. When projects involving replacement of other decks at Chautauqua arise, utilizing fire-retardant treated wood in lieu of standard wood should be evaluated and considered.

Replacement of wood decks with composite decking materials does not seem to offer any wildfire benefit and it does not match the appearance of wood. Therefore, it is not recommended.

Chautauqua should consider the installation of 1/8-inch metal mesh screen installed on all open stilt decks, similar to the mesh that was incorporated in the Mary H. Galey Cottage Rehabilitation Project. The mesh will aid in blocking burning embers from getting under the deck and igniting fuels. The visual impact and cost implications of this recommendation would need to be discussed prior to moving forward, but it would be a reversible solution that could be removed with minor repairs to the wood (filling holes, etc.)

e. Vents

Retrofitting existing vents on the buildings at Chautauqua by installing metal wire mesh over them would be a reversible solution that would minimally change the visual appearance of the building. The mesh could be removed with minor repairs, filling holes and repainting. Therefore, this mitigation technique is recommended.

Manufactured vents discussed in this report appear to have the ability, with consideration to detailing, to be installed while retaining the historic vent in place below or in front of the product. If this is the case, from a Secretary of the Interior's Standards perspective, it would be a reversible solution. Although the visual change to the building would be different from the historic look, the trade-off for protecting from flying embers may be worth the trade-off. Therefore, Chautauqua could evaluate if a manufactured vent is preferred to retrofitting with metal wire mesh.

To summarize the findings of the Part 1 and Part 2 research, after considering the various building hardening and fire mitigation products and materials on the market, with regards to Chautauqua, the top recommendations include:

CONTINUE WITH PRE-FIRE ACTIVITIES

1. Conduct a cultural resource inventory
2. Maintain and distribute list of priorities
3. As-built documentation of historic buildings
4. Establish evacuation plan & trigger points
5. Develop a communication plan
6. Develop a recovery plan

CONTINUE WITH LANDSCAPE AND FUEL MITIGATION ACTIVITIES

7. Remove dead trees
8. Prune trees / vegetation
9. Reduce tree spacing
10. Remove slash
11. Remove common ground junipers

CONSIDER / EVALUATE BUILDING ENHANCEMENTS

12. Continued building maintenance: keep gutters and downspouts clean, inspect structures for any exposed wood (rafters, siding, trim, etc.) and maintain paint coatings/finishes at exterior wood
13. Consider building wraps for key structures. Consult manufacturers to determine proper methods and deployment of training and determine the best solution for successful utilization
14. Consider purchasing portable fire sprinkler pumps, sprinkler heads and portable water storage tanks
15. Consider fabricating custom covers for doors and windows to be installed prior to a wildfire
16. Ensure insect screens at doors and windows are made of bronze, aluminum or fiberglass with a polyvinyl chloride coating material. Bronze is preferred.
17. Install gutter covers or evaluate removal of gutters and downspouts and alternative drainage solutions
18. Consider / evaluate utilizing fire-retardant wood products when replacing exterior decking and wood
19. Consider / evaluate installing metal wire mesh screening at decks and ensure areas below decks are not utilized for storage and are maintained to remove debris and vegetation
20. Consider / evaluate retrofitting existing vents with metal wire mesh or installing manufactured fire-proof vents
21. Evaluate and further study use of Class A foams. Consider their effects on historic wood and balance with fire protection benefits.

# VII. AREAS OF FURTHER STUDY

This research concluded that there are areas of further study warranted as it relates to the built environment and Wildfire hazards.

### UPDATE TO THE SECRETARY OF THE INTERIOR STANDARDS FOR WILDFIRE RELATED RISKS

As discussed in the SOI STANDARDS section of this document, there is need for further consideration at the federal level for wildfire risks to historic buildings and sites, similar to the *Guidelines on Flood Adaptation for Rehabilitating Historic Buildings.* This is a recommended area of further study / discussion.

### EFFECTS OF FIRE CHEMICALS FROM FOAM, GEL, AND RETARDANTS ON HISTORIC WOOD

Based on the lack of data on the effects of fire chemicals on historic wood, this would be a recommended area of further study.

The after-effects when fire chemicals are applied can be quite varied but may include color changes, changes in texture, or damage to the historic fabric, among other detrimental effects. What is typically unknown are the effects on the material itself - whether the application of a chemical (foam, gel, retardant, coatings, or intumescent paints) alters the fundamental properties of the wood in ways that reduce the service life of the wood. For virtually all of the fire chemicals discussed in this report, technical data does not exist that answers the question of whether the wood is altered (harmed) by applying the chemical such that the historic nature of the wood and the structure is negatively impacted. There is limited information that the chemicals act only on the surface of the wood but whether it is truly reversible requires that technical research be conducted to determine whether that is the case. Once this is firmly determined, then consideration for Wildfire Adaptation should be considered. Is slight alteration to the appearance of historic wood preferrable to full structure loss? If application results in reducing the service life of historic wood by a few or many years, is this preferrable to full structure loss? These questions can be further considered once the technical testing information is known on the effects of chemicals on historic wood.

### COHESIVE ENVELOPE SYSTEM ON NON-PRIMARY BUILDING ELEVATIONS

Following the review and evaluation of various materials and products available on the market to “harden” a building against Wildfires, potentially the only viable solution to providing resistance would involve a cohesive envelope system which would need to encapsulate roofing, siding, trim, vents, windows, doors, etc. Wholesale replacement or encapsulation of historic materials via a new exterior envelope would drastically alter the visual character and experience of the building. And for sites like Chautauqua, would likely result in the loss of designation as a National Historic Landmark. Even on a National Register designated building, the argument for this treatment would be difficult to justify to historic authorities. That being said, as illustrated by

the November 2019 SOI “Standards for Rehabilitation & Guidelines on Flood Adaptation for Rehabilitating Historic Buildings”, historic authorities recognize that increased climate and weather risks can necessitate a deeper look at treatment for historic properties. A similar update could be considered for historic buildings at high risk of wildfire and that update could perhaps take into consideration secondary elevations on historic buildings that face the greatest threat from wildfire.

For example, at Chautauqua there are cottages with secondary elevations (back and side) that face open space / landscapes with the highest risk of wildfire approach, i.e., abutting high ladder fuel landscapes. Whereas the primary elevations (front facades) of these buildings face into the district. Design and evaluation of an envelope system that would encapsulate historic materials with fire-rated or fire-resistant materials, in conjunction with installing fire-rated windows and doors, and/or installing operable fire shutters could perhaps be evaluated. Additional strategies such as enclosure of open soffits and removal of gutters could be considered as well. The goal being a cohesive envelope system that would provide optimal protection to these high-risk elevations on a building. The consideration of this treatment would not only need strong justification and careful detailing with review and approval from historic authorities, but consideration would also be needed as to the success of such an alteration.

While something like this would likely assist with increasing the resistance of a building from flying embers, direct flames would not be resisted by this alteration and wildfires with high radiant heat would ignite combustible materials from the inside of the building outward without direct contact from flames. Therefore, the evaluation of whether this level of alteration and the cost of doing so would be unjustifiable for fairly limited overall resistance.

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# APPENDIX B:
# LIST OF FIGURES

# APPENDIX C: SHF DELIVERABLE #3
# List of Research Stakeholders & Resources

# Colorado Chautauqua Association Wildfire Mitigation Plan (Phase 2)

## Deliverable #3 List of Research Stakeholders & Resources

SHF Project: #2022-M2-001

1. Research physical wildfire mitigation interventions for historic wood-framed buildings in relationship to the Secretary of Interior's (SOI) Standards

   This task consists primarily of a literature review and discussions regarding fire behavior, fire mitigation practices, and fire-protection products or strategies for reducing the risks to historic resources. Key considerations when assessing the appropriateness of any product or strategy are conformance to the SOI Standards, including ease of application, feasibility and reversibility, relative cost and efficacy. It is not sufficient that a product or strategy be effective for modern structures but it must be effective when used on historic structures, such as the cottages at Chautauqua.

   Examples of products that may be reviewed include various foams, paints, and coatings:

   Perimeter Solutions Phos-Chek Fortify
   https://www.perimeter-solutions.com/en/fire-safety-fire-retardants/phos-chek-fortify/

   FireIce Pro (Dry Concentrate)
   https://geltechsolutions.com/fireice/

   Pierce Fire-Fighting Foam
   https://www.piercemfg.com/pierce/blog/fire-fighting-foam-systems

   Consumer Fire Products Foam
   http://www.consumerfireproducts.com/why-foam.html
   http://www.consumerfireproducts.com/foam-gels-and-fire-retardant.html

   Primo Supply Fire Protection Gel
   https://www.primosupply.com/Fire-Protection-Gel/products/29/?gclid=CjwKCAjwzY2bBhB6EiwAPpUpZtxwarfC9FMYyuKY8kLWVfWkGqrmx8GDPU_CqGwc73Jkn7O69ZVEbxoCGaAQAvD_BwE

   International Coatings Group - Intumescent Paint
   https://internationalcoatingsgroup.com/?gclid=CjwKCAjwzY2bBhB6EiwAPpUpZk29B6A5G-FgAe7Fd_gvt0Ea_6g23j9RgjKJBggAwUH7TGQmdLdKNBoCVOEQAvD_BwE

Firefree Coatings, Inc.
https://www.firefree.com/?matchtype=e&network=g&device=c&adposition=&keyword=intumescent%20paint&campaign=1486987657&adgroup=63021042608&gclid=CjwKCAjwzY2bBhB6EiwAPpUpZpuefDQzIWIp2sCqBzk9Vq0dAixWkbiHelugfNM-Cgxhjpw8urNANhoCnTEQAvD_BwE

Flamecheck
https://flamecheck.com/fire-retardant-paint/?gclid=CjwKCAjwzY2bBhB6EiwAPpUpZng4UMtyqhC-Vv9gfvmjuh4VEnjp16h9C72qx6jUAfPZjwgdcrLH8hoC56EQAvD_BwE

FlameOFF
https://flameoffcoatings.com/intumescent-fire-resistant-paint?utm_source=Adwords&utm_medium=cpc&utm_campaign=MountainTime&utm_term=fire%20resistant%20paint&gclid=CjwKCAjwzY2bBhB6EiwAPpUpZqIrqn9TDYwhQzTVYGwimrZoUWyO02nhHuA1DrZpUAeFoXdjbUrjthoCsg0QAvD_BwE

FlameControl Fire Retardant Coatings
https://www.flamecontrolcoatings.com/product-catalog/frpaints

ISOLATEK International Intumescent Coatings
https://www.isolatek.com/construction/commercial-products/intumescent-coatings/?gclid=CjwKCAjwzY2bBhB6EiwAPpUpZmEtclCttfJZN5x0nTSEuUFg3zMk_PA9qjbF7HEpXMyXrbkKf72EvBoClrUQAvD_BwE

International Fireproof Technology Inc. Intumescent coating
https://painttoprotect.com/

No-Burn Coatings
https://www.noburn.com/

Benjamin Moore Insl-X
https://www.benjaminmoore.com/en-us/interior-exterior-paints-stains/insl-x

JLS Chemical Coatings
https://en.jlschemical.com/

FX Lumber Guard XT Retardant for Exterior Wood
https://shop.rdrtechnologies.com/Lumber-Guard-fire-retardant-for-Exterior-Wood-p/lgxt5g.htm

Flame Stop Inc. Fire Retardant Spray for Wood
https://www.flamestop.com/shop/fire-retardants/fire-retardant-spray-for-wood/

Zeroflame Fire Retardant Treatment for Wood
https://www.zeroflame.co/Fire-Retardant-Treatment

Other types of fire protections:

Foil building wrap

Firezat Inc. https://www.firezat.com/

Sprinklers (on building and on site)

Code 3 Water
https://code3water.com/vineyards-and-wineries

Colorado Fire Break
Coloradofirebreak.com

Frontline Wildfire Defense
https://www.frontlinewildfire.com/protect-home-with-roof-wildfire-sprinkler-system/
WASP
https://waspwildfire.com/

Fire Safe Marin
https://firesafemarin.org/harden-your-home/exterior-sprinklers-and-coatings/

Ember Wildfire Defense Solutions
https://emberdefensellc.com/sprinklers/

Determining conformance to the SOI Standards and effectiveness on historic structures will not be based on laboratory research conducted during this project but rather on a review of published technical literature (as opposed to marketing information). An example of technical literature to be reviewed would be:

Zabb-Parmley, Samuel. 2021. *Considering Modern Fire Codes in Replacing Wood-Shingle and Wood-Shake Roofing*. APT Bulletin: The Journal of Preservation Technology, Vol. 52, No. 4, Special Issue: Wood (2021), pp. 33-40.

SFPE Task Group on Fire Risk Assessment, 2022. *Risk, Fire Risk, and Fire Risk Assessment. In* SFPE Guide to Fire Risk Assessment.

Other replacement materials suggested for protecting structures during wildland fire (but need to be vetted for conformance to SOI Standards) include:

Replacement Materials (Roofing, Windows, Cladding, Decking and Walkways, etc.) - Natalie

Montana Timber Products Fire Treatment for Wood
https://www.montanatimberproducts.com/product-applications/wood-fire-treatment/?gclid=CjwKCAjwzY2bBhB6EiwAPpUpZmyWatyzOkWLprZvTc34UdFF-foDHJMs75P7Hu39nIcep70RF4OKSxoCRP0QAvD_BwE

Cedar Valley
https://cedar-valley.com/quality-cedar-shingles/?&keyword=fire%20resistant%20wood%20siding&gclid=CjwKCAjwzY2bBhB6EiwAPpUpZuJsGrMXtu-5s_7BGlQ99pq5qHoJrulbMje6WxAZfti5QkvsgpXzlxoCm7sQAvD_BwE

Chemco SaferWood Siding
https://www.chemco.org/saferwood/products/siding/

Hewn Fire Resistant Products
https://hewn.com/fire-resistant-products/

Mataverde Fire Retardant Treated Hem Fir Wood Siding
https://www.mataverdedecking.com/blog/mataverde-introduces-fire-retardant-treated-hem-fir-wood-siding

https://covenantsecurityequipment.com/products/armotex-bullet-resistant-and-fire-rated-wall-panels?currency=USD&variant=38004736884922&gclid=CjwKCAjwzY2bBhB6EiwAPpUpZt2xEgYphblLKp6IqS6JOYV12f8CYUhA2zDB9yrt43hWMTgXGbZ7xhoCPq0QAvD_BwE

Decking / Walkway Replacement Materials:

Trex/ Composite Decking / Ipe / Tropical Hardwood / Grappa / Tigerwood / Spanish Cedar

- Low intensity grass fire, tropical hardwoods are very resistant versus lower-density north American species
- Steps

Vulcan Vents
https://www.vulcanvents.com/

https://firesafemarin.org/harden-your-home/fire-resistant-soffits-eaves/#gsc.tab=0

2. Contact other institutions and agencies, testing labs, manufacturers, wildfire managers, cost estimators, etc., to gather data.

   This task involves gathering information from a wide range of organizations that have considered, discussed, or written policies regarding wildland fire and cultural resource protection.

   - Colorado State Forest Service
     - Ben Pfohl, Supervisory Forester, Fort Collins Office
   - Association for Preservation Technology
   - National Center for Preservation Technology and Training (Ron Anthony has a project with them on wildland fire and cultural resources)
     - Simeon Warren, Chief of Architecture and Engineering, simeon_warren@nps.gov, 318-652-7969
     - Jason Church, Material Conservation, Jason_Church@contractor.nps.gov,
       - Covered Bridge Security Manual
       - Guide for In-Place Treatment of Wood in Historic Covered and Modern Bridges
   - National Park Service
     - Brian Goeken, Chief, Technical Preservation Services – Brian_Geoken@nps.gov, 202-354-2033
     - Justin Henderson – NPS Program Coordinator for NHL in the Intermountain Region in Denver – Justin_Henderson@nps.gov,
     - Morris (Marty) Hylton, CR Climate Change Architect morris_hylton@nps.gov
     -
   - US Forest Service
     - Fire-Retardant Treatments for Wood (Multiple Articles)
     - Effect of Fire-Retardant Treatments on Performance Properties of Wood
       - https://www.fpl.fs.usda.gov/documnts/pdf1977/holme77a.pdf
     - Fire-retardent-treated strandboard: properties and fire performance
       - Forest Products Laboratory – USDA Forest Service https://www.fpl.fs.usda.gov/
     - Long-term fire retardants
       - https://www.fs.usda.gov/rm/fire/wfcs/long-term-fire-retardants.php
     - Development of Field Inspection Practices for Wood Structures on Fire-Prone Lands: Application of State-of-the-Art Condition Assessment Techniques
       - https://www.srs.fs.usda.gov/pubs/63482
       -
   - Denver Mountain Parks and affiliated local responding fire departments
   - Boulder Fire – Rescue, Wildland Fire Division
     - Brian Oliver (Chief)
     - Erin Doyle
     - Jamie Carpenter
   - Boulder County Emergency Services
   - Open Space and Mountain Parks – Boulder County
     - Chris Wanner, Vegetation Stewardship Supervisor
   - City of Fort Collins Historic Preservation

- City of Fort Collins Emergency Services
- Larimer County Emergency Manager
- Mountain community – possibly Leadville or Aspen
- Western Slope community – possible Grand Junction or Silverton
- University of Colorado Boulder
    - Hannah Brenkert-Smith, Research Associate Professor at the Institute of Behavioral Science https://ibs.colorado.edu/people/hannah-brenkert-smith/
    - Karen Hollweg, Director of Community Collaboration on Forest Health, Center for Sustainable Landscapes and Communities https://cslc.colorado.edu/community-collaboration-on-forest-health
- Missoula Fire Science Laboratory https://www.firelab.org
- Council of Western State Foresters https://www.westernforesters.org
- Colorado Division of Fire Prevention and Control https://dfpc.colorado.gov/home/about-us/executive-team

https://ncptt.nps.gov/articles/disasters/wildland-structural-fire/fire-and-cultural-resource-management-fire-preparedness-3/bare-bones-guide-to-fire-effects-on-cultural-resources-for-cultural-resource-specialists/

Info from Firezat
Dan Hirning
Firezat Inc.
San Diego, CA 92130
www.firezat.com/info.html
www.firezat.com/productpage5x200.html
https://www.facebook.com/cabinwrap

dan.h@firezat.com
www.firezat.com
619-324-9025 off
619-847-7556 cell

https://www.getguardianlegal.com/firefighting-foam-gtm-step-1/?intakesource=BP_GLN_FireFightingFoamLegal-AD-WEB&asid=106249980864&aid=648130170460&keyword=fire%20foam%20lawsuit&gclid=CjwKCAjwq-WgBhBMEiwAzKSH6KWgNIRJugIO98hExENDQMI8saTGr-yihCL9lTD2IMLnxcMtSvl0XBoC9QcQAvD_BwE

https://www.usatoday.com/story/news/nation/2013/08/18/idaho-wildfire-hailey-ketchum/2668431/

Wildfire Hazard Areas - Residential Structures and Landscaping | Portland.gov

CSU Fire Landscaping List

# APPENDIX D: ADDITIONAL INFORMATION

## HISTORY OF PERSONAL FIRE SHELTERS

In 1958 Australians began working on the development of a fire shelter. The earliest shelter was made of a laminate of aluminum foil and glass cloth and was bell-shaped. In 1959 the Australians created an A-frame design for the fire shelter and that same year the Missoula Equipment Development Center (MEDC), part of the Forest Service and now known as the Missoula Technology and Development Center (MTDC) began development of a fire shelter. MEDC and the Australians exchanged information and ideas and in 1967 the first large purchase and deployment of fire shelters for the Forest Service was implemented. These shelters were made of aluminum foil and glass cloth laminate with a kraft paper barrier inner liner, this liner was eliminated in 1974. In 1977, carrying a fire shelter became mandatory after three firefighters were killed on the Battlement Creek Fire in Colorado. Starting in 1998 through 2005 redesign and testing was completed to determine the most optimal design and material for personal fire shelters. The finalized design was made with an outer layer of woven silica and foil and the inner layer of fiberglass and foil (Wildland Fire Shelter, Undated).

# APPENDIX E: PHASE 1 CHAUTAUQUA WILDFIRE MITIGATION PLAN

# Chautauqua Wildfire Mitigation Plan
# Phase 1
# Final Report

September 27, 2022

Form+Works Project No. 22-021

form+works
design group, LLC

# Chautauqua Wildfire Mitigation Plan

Phase 1

***September 27, 2022***

Prepared For:

Colorado Chautauqua Association
900 Baseline Road
Boulder, Colorado
80302
Attn: Shelly Benford, Chief Executive Officer

Prepared By:

Natalie Lord, RA, LEED AP BD+C
Preservation Architect and Principal

Form + Works Design Group, LLC
P.O. Box 476
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Ron Anthony,
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Anthony & Associates, Inc.
P.O. Box 271400
Fort Collins, Colorado
80527

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# I. PROJECT OVERVIEW / SCOPE

## A. PURPOSE & NEED STATEMENT:

The Colorado Chautauqua, a National Historic Landmark (NHL) located in Boulder, Colorado, is one of the few chautauquas in continuous use since its inception in the late 1800s. With 102 historically contributing resources, the Chautauqua campus is designated an NHL for its high level of historic integrity and its role in the broad social patterns established by the Chautauqua Movement. In the Nomination to become an NHL, Chautauqua is referenced as “an outstanding representation of America’s first truly national mass educational and cultural movement”; satisfying the criterion of “Properties that are associated with events that have made a significant contribution to, and are identified with, or that outstandingly represent, the broad national patterns of United States history and from which an understanding and appreciation of those patterns may be gained.”

Loss of historic integrity (through alteration, addition, or demolition) is the most common reason for the withdrawal or loss of the National Historic Landmark designation. The designation may be impacted by changing construction materials that alter the appearance of the structures, loss of character-defining features, or significant changes to the cultural landscape. Wildfire is a risk that can impact Chautauqua’s NHL designation. A wildfire mitigation plan can reduce that risk.

Colorado is well known for high wildfire risk. In 2020 alone, the state recorded 25 wildfires that burned 625,000 acres and leveled hundreds of buildings, including historic buildings. The National Historic Landmark District of Chautauqua is a 40 acre site owned by the City of Boulder and is located adjacent to approximately 840 acres of open space owned and managed by Boulder County Open Space and Mountain Parks (OSMP). With direct adjacency to wildfire prone landscapes and with a mission statement to preserve the historic site, the Colorado Chautauqua Association sought to pursue a Wildfire Mitigation Plan to review past and current wildfire mitigation efforts and inform them on any additional steps, recommendations, and best practices that might be considered. A major consideration for this effort was focused on maintaining the historic integrity of the site and buildings while balancing modern fire mitigation techniques.

## B. PROJECT TEAM AND PARTNERSHIPS:

The project consultant team was led by Natalie Lord, RA, LEED AP BD+C, of Form+Works Design Group, LLC. Form+Works Design Group was started in 2017, to specialize in Historic Preservation Architecture in Colorado. Ron Anthony, FAPT, of Anthony & Associates provided expertise in the preservation of historic wood structures, the field of wood science and wildland fire.

This project involved consultation with various groups to obtain information and have discussions. The Colorado Chautauqua Association (Owner) participated in the majority of the discussions. Consultation was conducted with the Chautauqua Firewise Coalition, a group of CCA staff and board members, Chautauqua private cottage owners, and the Boulder Fire Department.

# II. BACKGROUND INFORMATION

## A. WILDFIRE RISK OVERVIEW

Risks from wildfire drive the importance of developing and implementing a mitigation plan for any cultural resource that could be impacted by wildfire. Reducing risks is more urgent as fire season now extends through all months of the year in Colorado and fire behavior becomes more extreme. However, not all wildfires are of such intensity or result in the degree of destruction seen in the news. The vast majority of wildfires are controlled within the first few days after ignition. Mitigation efforts often contribute to minimizing the damage from these incidents. For extreme incidents, such as the Marshall Fire in 2022, few mitigation efforts prior to the fire, if any, could have reduced the damage suffered by many. It is not those fires that we want to address with a mitigation plan but the much more frequent lower-intensity incidents that could damage Chautauqua. The goal of mitigation is to keep the small fires small. Achieving that goal begins with the work that can be done by the Chautauqua stakeholders.

### 1. BASICS OF FIRE BEHAVIOR

It is not the objective of this wildfire mitigation plan to present a dissertation on fire behavior but only to provide sufficient information for CCA stakeholders to understand why there is a risk to their cultural resource from wildland fire. Additionally, the goal is not to make CCA stakeholders fire behavior experts but rather to give them a clear, concise understanding of the factors that impact fire behavior and stakeholders can do on site to reduce the risk of loss or damage due to fire. **Most of the recommendations focus on actions that should be taken well before a wildland fire threatens Chautauqua, not during an incident where the presence of well-intentioned actions of individuals serve to impede responders from safely fighting the fire.**

Chautauqua is located within what is known as the Wildland Urban Interface (WUI), a transition zone between largely unoccupied land and human development. It is a geographic zone where structures or other human development, interspersed with undeveloped wildland or vegetative fuels, are present. According to the U.S. Fire Administration, between 2002 and 2016, an average of over 3,000 structures per year were lost to WUI fires in the United States and the

WUI area continues to grow by approximately 2 million acres per year[1]. While the number of losses is significant, the number of structures and cultural resources saved, in part, through mitigation efforts is far more significant.

Fuels, weather, and topography are the key factors in wildland fire behavior. As shown in the well-known fire triangle in **Figure 1**, it is the interaction of these three variables that responders must address when allocating resources to protect life and property.

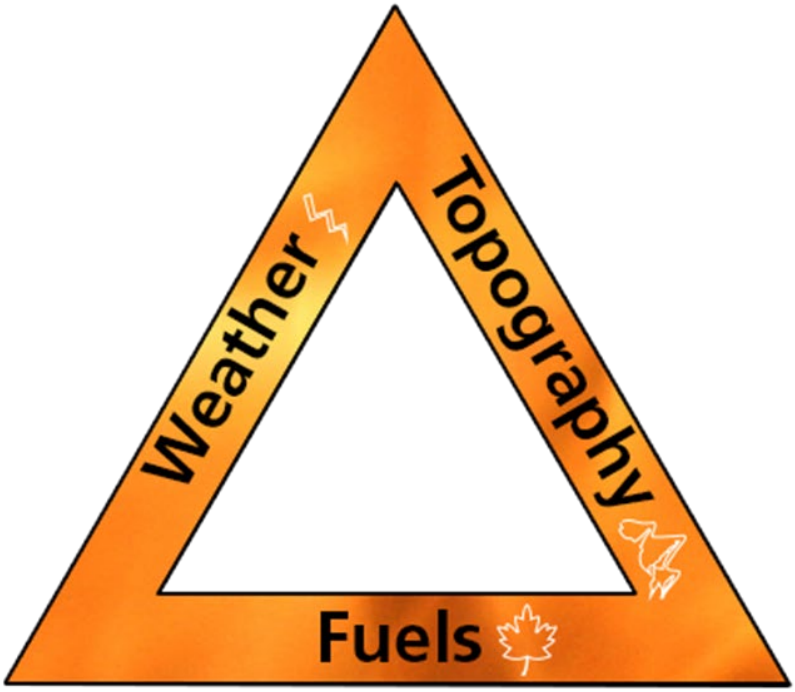


**Figure 1. The fire triangle.**

What is fuel? Fuel is anything that is combustible. Most commonly, vegetation is the primary fuel for a wildfire. The vegetation may be wild, as in the open space around Chautauqua, or trees, shrubs, and plants that make up the cultural landscape of Chautauqua. Fuels are categorized by size and how rapidly they can adapt to changes in relative humidity and temperature (affecting the moisture content of the fuel). Grasses are considered fine fuels because they are easy to ignite and will dry very quickly (within hours) as temperatures increase and relative

[1] U.S. Fire Administration Website, Accessed August 22, 2022. https://www.usfa.fema.gov/wui/what-is-the-wui.html

humidity decreases. **Structures are fuel.** While the materials used on the exterior of the structure affect the probability of ignition, the contents on the interior are subject to ignition from radiant or convective heat from a fire. One of the features that gives Chautauqua a sense of place for people is the closeness of the cottages and vegetation that make up the cultural landscape and, thus, the site has a fairly high fuel load (the volume of combustible material in a given area).

What is topography? Topography is the form and features in a landscape. Canyons, mountains, steepness of slope, and elevational differences are examples of topographic features that will influence fire behavior. In most cases, the topography of a site cannot be altered or controlled. Chautauqua does not have much variation in topography or significant differences in elevation that can increase fire intensity or rate of spread. There is a slight north-facing aspect (the direction the landscape faces), with approximately 200 feet of elevation gain from the north end to the south end of the property (approximately 1750 feet north to south) which is noticeable to anyone walking up the hill. This area is roughly from Baseline Road to the south edge of Boggess Circle. Fire behavior due to this slight grade would be influenced more by fuels (the cottages, vegetation, etc.) and wind during an incident than the topography of the property. However, adjacent to the Chautauqua property the topography varies significantly in terms of steepness of slope, elevation, aspect, and other features that can significantly affect fire behavior, particularly, fire intensity and rate of spread.

What is weather in the context of wildfire behavior? Temperature, relative humidity, and wind are the primary weather factors that affect fire behavior. Precipitation, exposure to ultraviolet radiation, and lightning are other factors that can influence fire behavior. Understanding the impact of changes in weather patterns, primarily higher temperatures, lower precipitation, and high wind speeds in many fire-prone areas is key to anticipating fire behavior on a given site. Many of the recent devastating wildfires in Colorado (and elsewhere) have been the result of extreme winds which carry embers (a phenomenon called spotting) much further distances than during fires from only a few decades ago. It is the embers during a wind-driven fire near Chautauqua that are the greatest risk to the site.

## 2. REDUCING THE RISK BY MODIFYING POTENTIAL FIRE BEHAVIOR

The two primary means of significantly reducing the immediate risk to Chautauqua are by fuels mitigation and creating defensible space. Fuel mitigation involves removing or trimming vegetation to reduce the total volume of material that can burn (the fuel load) while reducing the horizontal and vertical continuity of the fuel to lower the likelihood of the fire being able to spread without interruption (as across a grassy meadow). Horizontal fuel continuity is vegetation or other fuel that is continuous, or touching, across the horizontal plane, e.g., there is little or no separation from tree to tree, shrub to shrub, or grasses in a large meadow. Similarly, vertical fuel continuity is a lack of separation vertically, e.g., grass to shrubs to tree branches to the crowns of the trees would be a typical example.

During and throughout this project, fuels mitigation has been conducted at Chautauqua through the efforts of CCA and that work continues. Much of that work has been along the western

boundary of Chautauqua (**Figures 2 and 3**). Although very beneficial, the volume of fuels that is removed through trimming or cutting should be more extensive. No one appreciates hearing that the volume of vegetation that should be removed is three times what was done but that is the situation with the Chautauqua mitigation work. It needs to be more extensive to reduce fuel load and horizontal and vertical continuity. That can be accomplished while balancing the aesthetic nature of the campus. Open Space & Mountain Parks (OSMP) also conducts fuels reduction, most recently in the drainage to the east of Chautauqua Reservoir Road (**Figure 4**).


**Figure 2. Western boundary where fuels mitigation has been conducted. Note there has been a reduction in fuel load and thinning of some of the horizontal and vertical continuity. However, enough vegetation remains, mostly shrubs, to allow for spread of a fire from the west onto Chautauqua property.**

**Figure 3. Western boundary where fuels mitigation is yet to be conducted. Note the horizontal and vertical continuity of the vegetation which would allow for a fire to easily spread.**

**Figure 4. OSMP property on eastern boundary where fuel mitigation work was done. However, this area would benefit from further removal of vegetation to reduce horizontal and vertical continuity as well as fuel load.**

Defensible space around a structure to reduce the likelihood of significant damage or loss of the structure is a concept that has been promoted for decades, along with an understanding of the role of building materials on the risk of damage or loss due to fire. **Figures 5 and 6** show examples of what are promoted as best practices for establishing defensible space around residential structures in fire-prone areas. These recommendations are good guidance for many residential structures or other buildings in the WUI but not so appropriate for Chautauqua. The designation as a National Historic Landmark needs to be balanced with standard recommended mitigation practices. As is seen in **Figure 8**, it is not possible to achieve the recommended defensible space between buildings at Chautauqua because of the close spacing of structures.

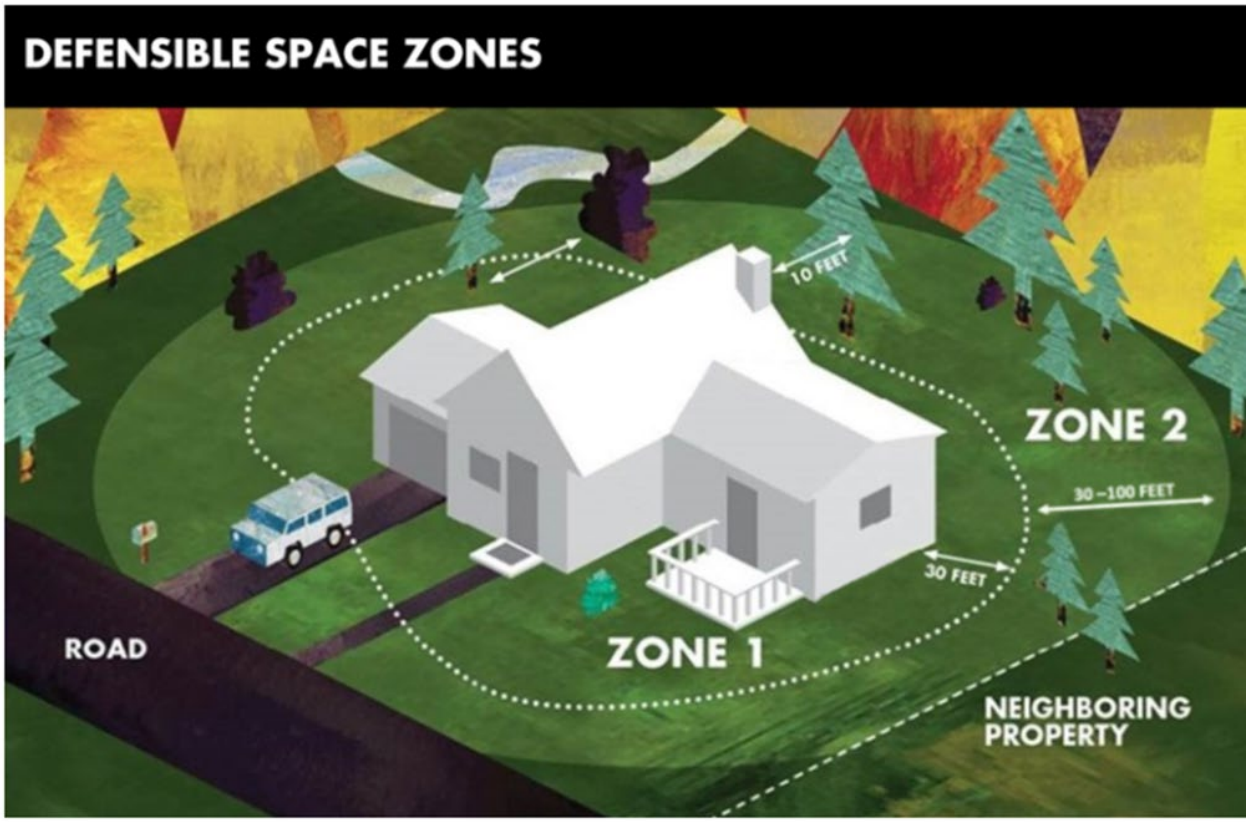


**Figure 5. Idealized defensible space that is recommended around a single structure.**

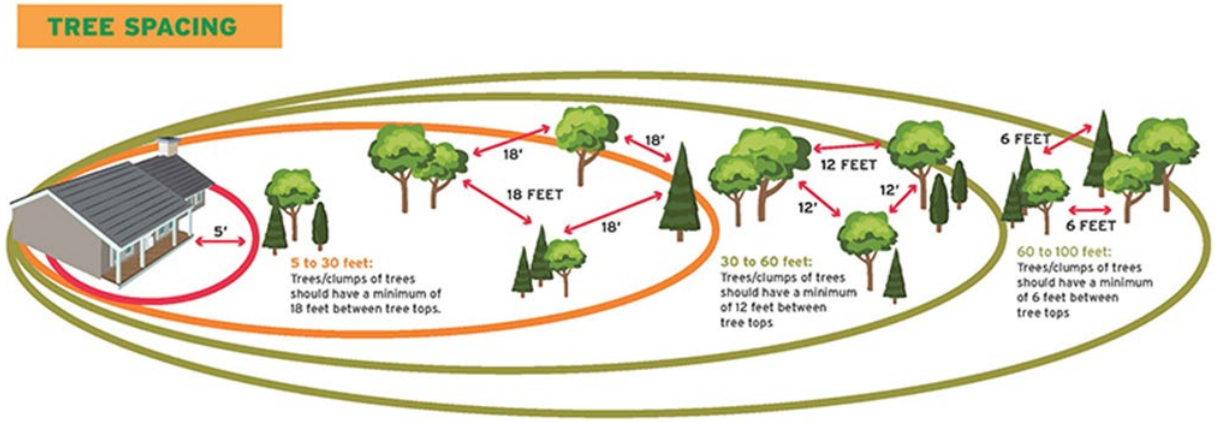


**Figure 6. Defensible space as recommended by removing or trimming vegetation to eliminate horizontal and vertical fuel continuity to reduce the risk of the fire spreading and making fire operations more challenging and less safe.**

These examples of defensible space will, generally, not work well within Chautauqua property. They will be effective around the perimeter, but the cottages and other structures are too close to allow for the recommended fuel reduction without dramatically altering the cultural landscape that is Chautauqua.

## 3. HEAT TRANSFER AND IGNITION

Fuel ignites from a variety of means during a wildfire. Most people are concerned with surface fires where there is direct flame contact. Fuels adjacent to a home (vegetation, wood, and structures) that are in direct contact with the flame front may ignite. However, it is easy to confuse heat transfer and ignition during a wildfire. Said another way, “it might get hot, but it doesn’t necessarily burn.” By reducing the fuel load, fuels mitigation and defensible space can reduce the possibility of something (a cottage) burning even though it may “get hot.”

Heat transfer occurs through convection, radiation, or conduction. Convection is the movement of hot air due to heating of the air molecules. Convection is the primary means of fire spread by pre-heating fuels in advance of the fire, including the upper crowns of trees in the explosive fires seen in the news. Radiation is the movement of heat energy as waves passing through the air. The heat is transferred when the wave reaches a physical object that conducts heat. Radiant heat from a wildfire can ignite combustible materials inside a structure from a distance of several hundred feet in extreme events. Conduction occurs when heat is transferred from molecule to molecule through direct contact, as when one touches a hot skillet.

Ignition occurs when a combustible material reaches a temperature sufficient to support combustion of that material. The rule of thumb is that the majority of fuels will ignite during a wildfire at a temperature of approximately 500 degrees Fahrenheit. Embers (firebrands) that

travel through the air due to wind or air currents (such as a convective column often seen on large wildfires) are the most common source of structure ignition through spotting. If the embers are large enough to retain heat or are burning when they land on a combustible material, an ignition can occur. Addressing the probability of ignition to or in a structure is critical to reducing the potential impact of embers, particularly during wind-driven fires. Erratic winds can put embers in tight openings that, through conduction, will result in an ignition. Continued maintenance of structures is critical to prevent embers from getting into openings. Ensuring that paint is maintained on exterior woodwork and conducting regular visual inspections to determine entry points for embers should be part of routine maintenance (**Figure 7)**.


**Figure 7. Deteriorated fascia board that provides an entry for wind-blown embers can result in an ignition on the interior of the structure.**

## B. CHAUTAUQUA VULNERABILITIES & VALUES AT RISK

### 1. SITE, SIGNIFICANCE AND HISTORY:

The first historic protection for Chautauqua was created by the City of Boulder in 1978 when the city created the Chautauqua Park Historic District. In 1989, the City's Landmarks Preservation

Advisory Board and the Colorado Chautauqua Association Collaborated to devise and adopt design guidelines that aimed to further protect the historic character of the site. The Colorado Chautauqua became a designated National Historic Landmark on February 10, 2006. The designation cites “Under the authority of the Historic Sites Act of 1935, this site has been found to possess exceptional significance in illustrating or commemorating the history of the United States for the benefit and inspiration of the American people”.

As outlined in the National Historic Landmark Nomination form, the Chautauqua Park Historic District has the following resources identified within the property:

| | Contributing | Noncontributing |
|---|---|---|
| Buildings | 87 | 20 |
| Sites | 7 | 3 |
| Structures | 7 | 5 |
| Objects | 1 | 7 |
| | | |
| Total | 102 | 35 |

The nomination outlines the importance of the surrounding site and context noting that “the historic district has a spectacular natural setting at the base of the Flatirons, some of the most dramatic massive rock uplifts along the foothills of the Rocky Mountains.” The nomination discusses the high degree of integrity that Chautauqua possesses due to its location, design, and setting. Workmanship and materials are noted as important aspects of the district’s integrity. The period of significance for the Chautauqua district is 1898-1930.

The nomination discusses the intricate Ownership / Management relationship that makes the Chautauqua District unique. The City of Boulder owns all the land (approximately 40 acres) that comprises Chautauqua Park. Of this land, the city leases 26 acres to the non-profit Colorado Chautauqua Association (CCA). The Auditorium, Dining Hall, Academic Hall, Community House, Columbine Lodge, Missions House, Preservation Office (Primrose Apartments) and 61 cottages are part of the CCA leasehold area. An additional 38 privately-owned cottages are located within the district boundaries. The private owners own the physical improvements on the city-owned / CCA-leased land[2]. **Figure 8** below outlines the property management for the Chautauqua site. CCA manages the majority of the land within the district boundaries, Boulder Parks and Recreation Department manages the land to the north of the district comprising the Chautauqua Green, the playground, and a tennis court. Open Space and Mountain Parks (OSMP) manages the area east of Chautauqua Reservoir Road, south of the district edge and

[2] NPS Form 10-900 Colorado Chautauqua National Historic Landmark Nomination. https://npgallery.nps.gov/GetAsset/5c494c9e-c5c8-4297-813f-fef862e5995f

west of Bluebell Road, with a small section of OSMP to the east of Bluebell between the road and the cottages.

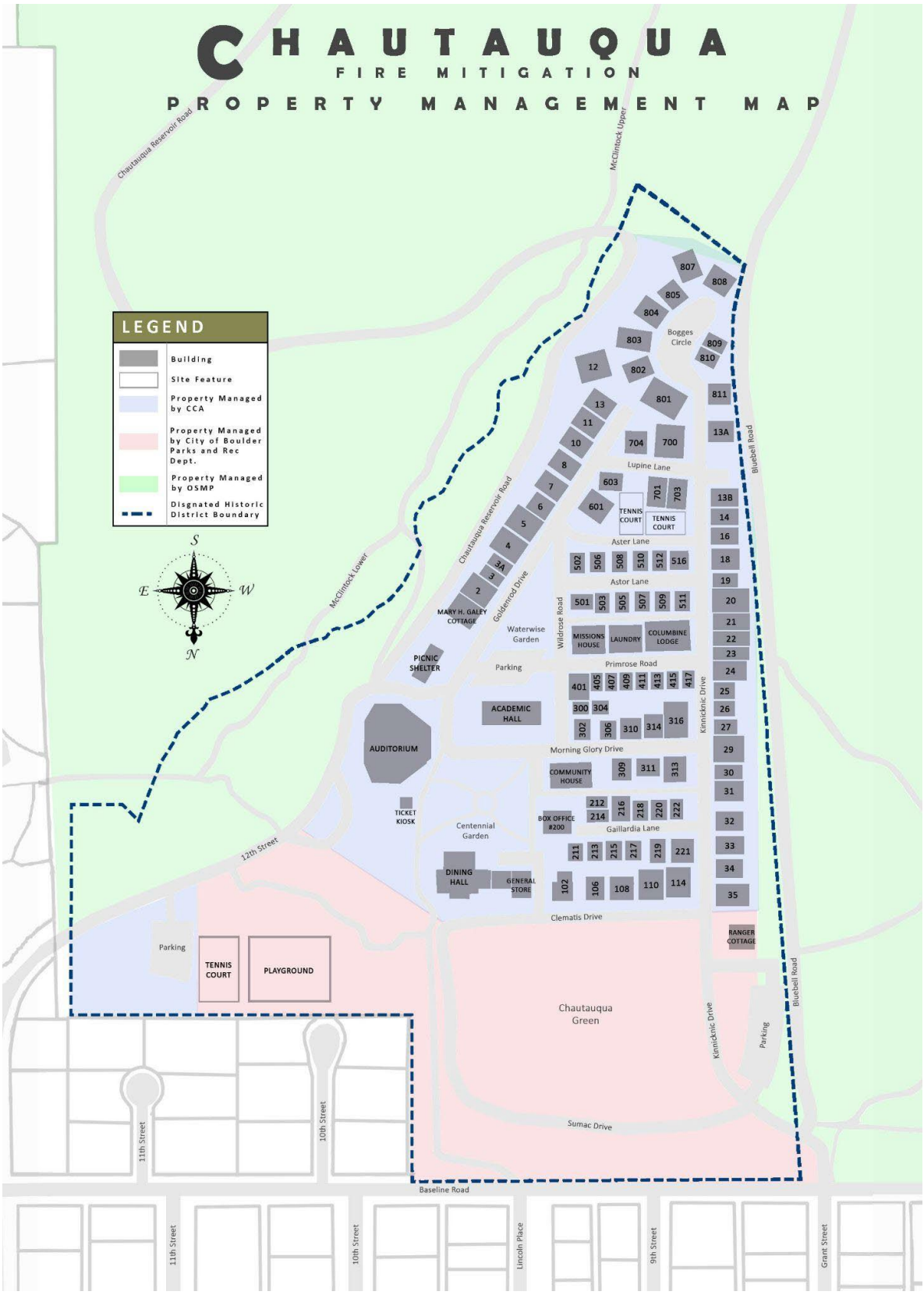


**Figure 8. Property Management Map of Chautauqua.**

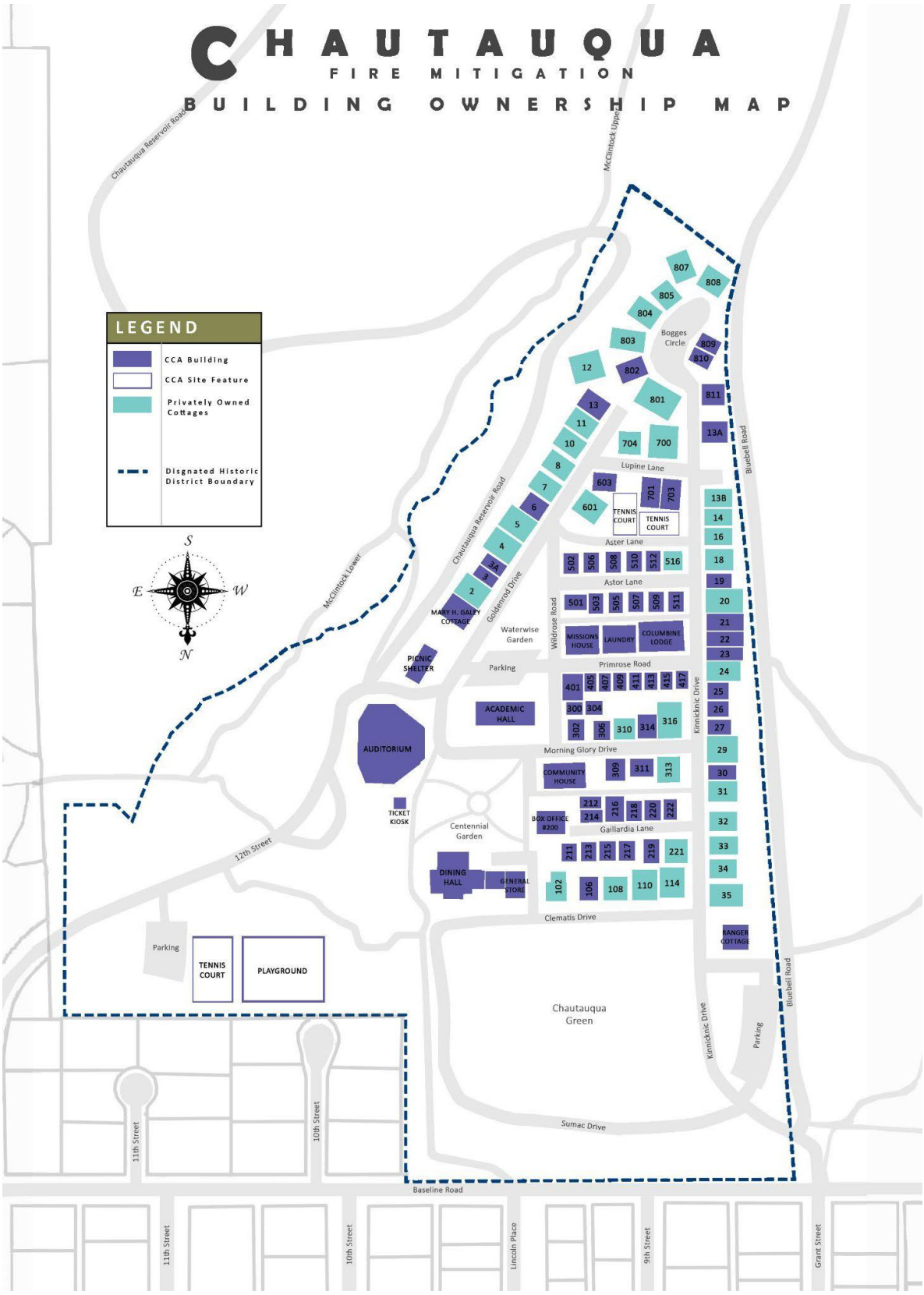


**Figure 9. Building Ownership Map of Chautauqua**

2. PRIORITY BUILDINGS:

As part of this project, the Team worked with CCA to determine a list of priority buildings. The thinking behind this effort was, in the event of an oncoming fire, if firefighters are able to only save a single structure, what would that be? With this starting point the Team then listed the next highest priority structures for firefighters should the opportunity allow for additional structures to be saved. The following is the list of prioritization and location maps, the intent is that this section of the document could be removed as a standalone document to be distributed to local and visiting emergency services:

| | **Name** | **Address** |
|---|---|---|
| **1** | **Auditorium** | **198 Goldenrod Drive, Boulder, CO 80302** |
| **2** | **Dining Hall / General Store** | **100 Clematis Drive, Boulder, CO 80302** |
| **3** | **Community House** | **301 Morning Glory Drive, Boulder, CO 80302** |
| **4** | **Academic Hall** | **298 Morning Glory Drive, Boulder, CO 80302** |
| **5** | **Missions House** | **400 Primrose Road, Boulder, CO 80302** |
| **6** | **Columbine Lodge** | **410 Primrose Road, Boulder, CO 80302** |
| **7** | **Cottage 200 (Box Office)** | **212 Chautauqua Trail, Boulder, CO 80302** |
| **8** | **Mary H. Galey Cottage** | **1 Chautauqua Trail, Boulder, CO 80302** |
| **9** | **The Rest Cottage (#401)** | **401 Chautauqua Trail, Boulder, CO 80302** |

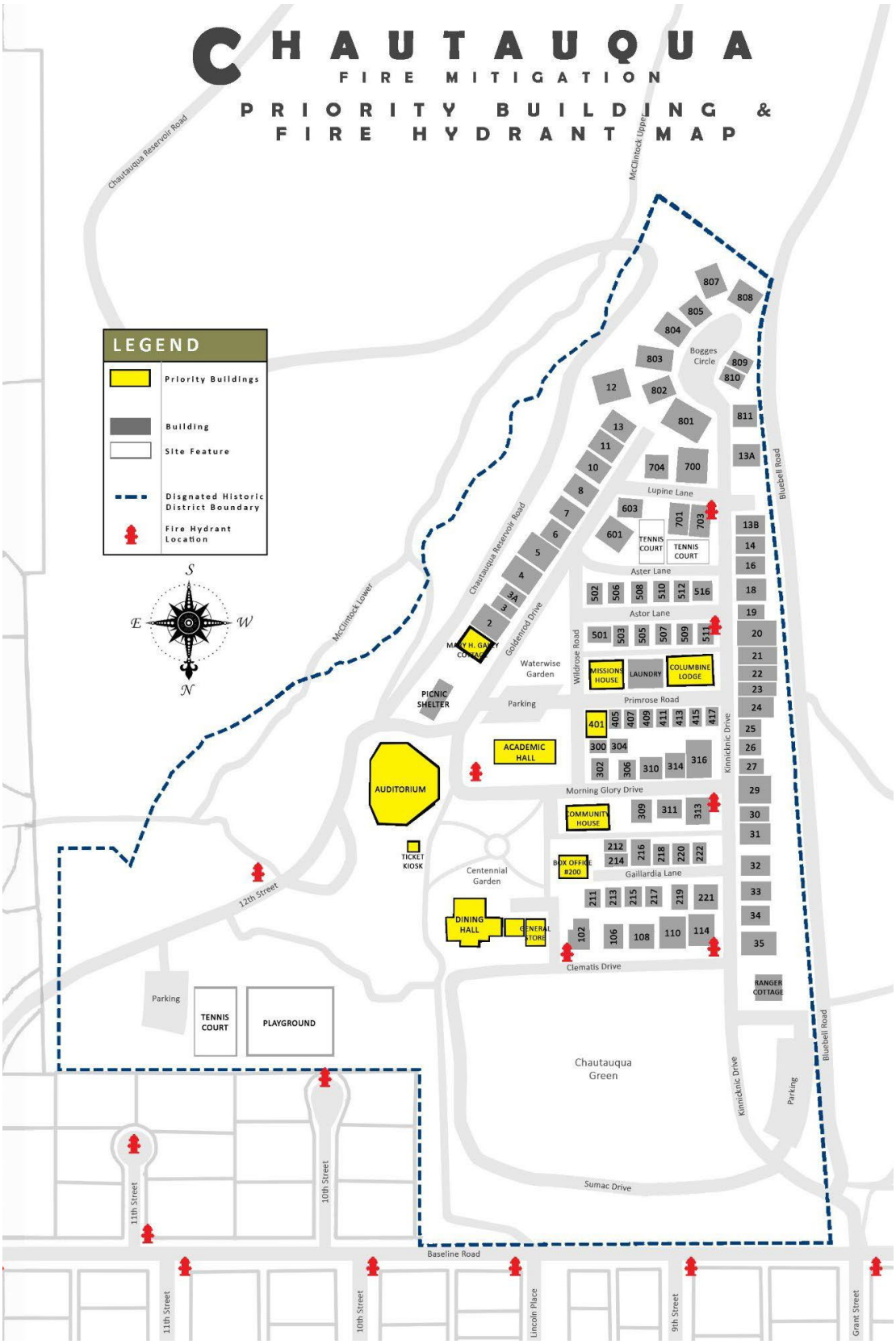


**Figure 10. Chautauqua Priority Buildings and Fire Hydrants Map**

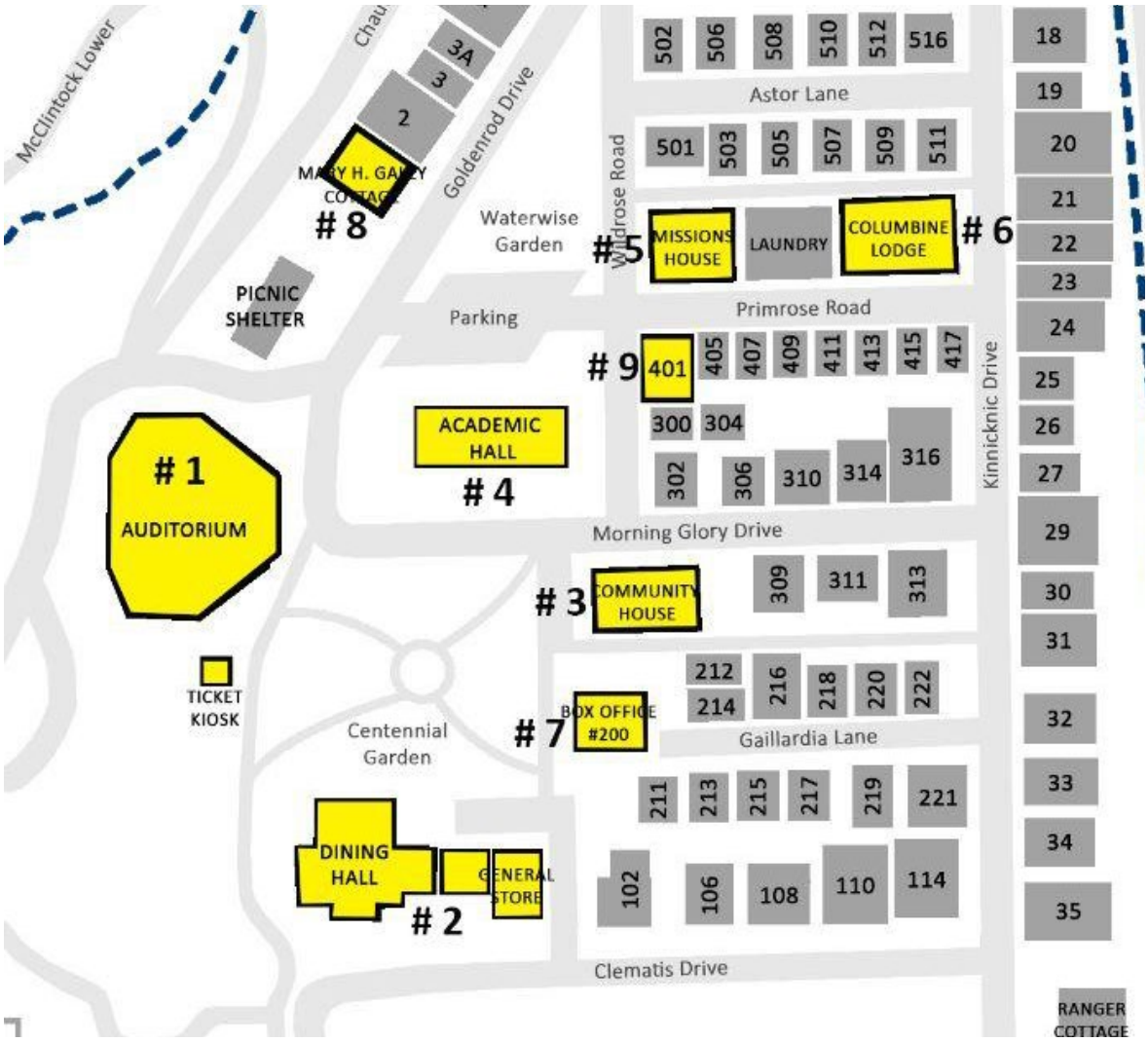


**Figure 11. Order of Priority Buildings**

## 3. DOCUMENTATION AS A MEANS OF MITIGATION:

As noted in the NPS Landmark Nomination, wood-framed construction is a defining feature of the buildings in the Colorado Chautauqua District. Of the buildings on-site, all but the Community House, Columbine Lodge and Cottage #200, have wood siding. The Community House, Columbine Lodge, and Cottage #200 have stucco exterior walls; however, like the other buildings on-site, they still have wood trim, windows, doors, and roof eaves. The materiality of Chautauqua is a character defining feature. Although it may be tempting to call for wholesale replacement of the wood materials to reduce fire risk, this would likely risk Chautauqua from losing its historic designation status.

As-built drawings or LIDAR scanning, as described below, are means of documenting the buildings; in the unfortunate event of partial or total destruction, reconstruction using documentation would be possible. Chautauqua has existing as-built drawings for the Auditorium and Galey Cottage. **It is recommended that at minimum, CCA maintain accurate documentation of the priority buildings on campus. Consideration should be given to documentation of all CCA buildings, sites, structures, and objects identified in the NHL nomination, both contributing and non-contributing.**

Field measuring all of the buildings / structures in the Chautauqua district boundary may be time-consuming and/or cost prohibitive. But there are some modern alternative means of documentation that could be considered.

LiDAR scanning: This method consists of a high-powered laser set-up on a tripod, and it is moved to various locations inside and outside of a building to create a point cloud model. Similar to echolocation, LiDAR involves the laser hitting surfaces and objects around it in rapid succession, at a rate of many thousands of pulses per second, and the time it takes for the light to return to the source is recorded to document exact distances. LiDAR is said to be accurate to within 1/8 inch. LiDAR scanning companies can provide only the point cloud model (see **Figure 12**), but their services are often quite extensive, offering a combination of point cloud / photogrammetry and following through with modeling services to provide an as-built document for a structure.

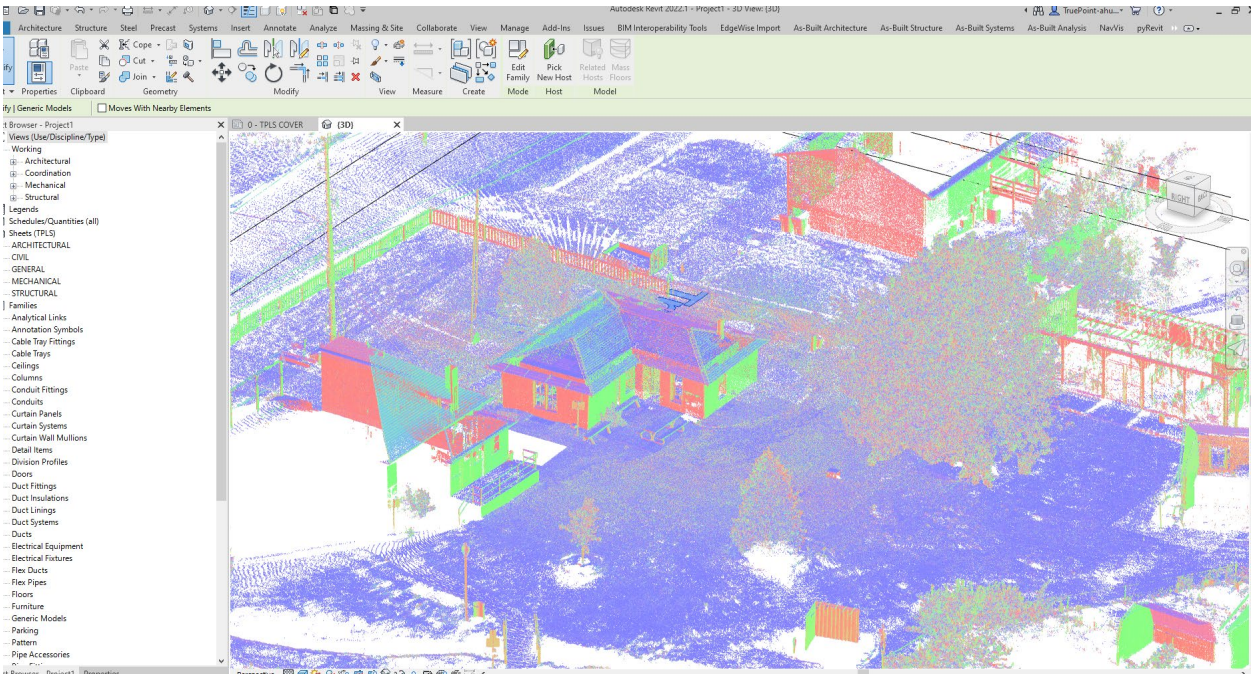

**Figure 12. A point cloud file from a LiDar scan imported into Revit (an AutoDesk program utilized to create architectural and engineering 3D models and drawings of buildings).**

Careful consultation with the LiDAR company is recommended to ensure that the quantity and quality of information received following a scan is achieved. Proper set-up of the point cloud is imperative to ensure that the files are easily used.

Another benefit of LiDAR scanning that is in the early stages of research for Historic Buildings, is that multiple scans can be taken over time and compared to investigate building movement / changes. With proper set-up of GPS location that is part of LiDAR scanning future models from consecutive scans can be overlaid and compared.

The point cloud information would be most critical and important to capture as a preliminary step for the structures at Chautauqua. This digital file could be saved in the CCA digital archives as a first step that would then allow 3-D models and as-built drawings to be created for the buildings in the future if needed.

Photogrammetry: Where LiDAR scanning collects more detailed and accurate depth information, there is another documentation method commonly used today known as Photogrammetry.

Photogrammetry uses high resolution photography and stitches them together to create a 3D map of a building. According to recent conversations with Matterport, a photogrammetry company, the use of their proprietary professional camera produces a 3D image model that is accurate to within about 1 inch. The image file that is created by their camera can then be processed by their company into a point cloud model that could then be imported and used to create as-built drawings.

There are other photogrammetry companies and products, some even able to be created using a smartphone or tablet. But it is important to understand what product and accuracy results from these types of systems. It is our understanding from current research that photogrammetry models produced from smartphone/tablet applications are not usable for accurate as-built drawings but are more commonly used for virtual walkthroughs of spaces, a tool most often utilized in the real estate field.

As mentioned, there are scanning companies that have the ability to produce a LiDAR scan in conjunction with photogrammetry of a building. This may be a consideration for CCA to evaluate the benefits and costs of various methods and results.

## C. MITIGATION EFFORTS TO DATE

### 1. FUEL REDUCTION:

Utilizing grant funding, CCA has conducted fuel mitigation around the perimeter of the property. These efforts were documented in the Meeting Minutes from Meeting #1, May 6, 2022 (See **D APPENDIX**) and Meeting #2, June 21, 2022 (See **E APPENDIX**). Fuels mitigation to reduce fuel load and horizontal and vertical fuel continuity on the CCA property should continue. Establishing a long-term fuels reduction plan for the Chautauqua campus based on vegetation growth and available funds should be part of CCA's strategic planning process.

**RECOMMENDATION: The fuels reduction should be reviewed annually based on progress and increased threats due to higher fuels loads.**

### 2. ADJACENT PROPERTIES:

Work with adjacent property stewards, primarily Open Space and Mountain Parks, to coordinate fuels reduction adjacent to Chautauqua property. For 2022, the heavy fuel load in the OSMP property south of Chautauqua, the strip of OSMP property east of Bluebell Road that touches Chautauqua property, and the ravine area west of Chautauqua Reservoir Road should be priorities for collaborative fuels reduction effort as a fire that spreads from OSMP property threatens Chautauqua and a fire that originates on Chautauqua property threatens OSMP land.

**RECOMMENDATION: Enter into more specific discussions with Boulder Fire Department and the Boulder Office of Emergency Management to get CCA priorities into BFD's Structure Response Plans. The current Structure Response Plans would benefit from updating and could include CCA information. Provide the same information to the Boulder Office of Emergency Management for the City of Boulder/Boulder County.**

### 3. OVERHEAD POWERLINES:

Overhead powerlines are scheduled to be placed underground starting in 2023. Depending on the work schedule, trimming trees in contact with conductors or at risk of arcing is recommended. However, if the underground work is scheduled to begin in 2023, it is likely that the power company would conduct tree trimming.

**RECOMMENDATION: Ensure that placing the electrical services underground is on schedule.**

4. CCA COTTAGE / CAMPUS WILDFIRE MANAGEMENT CHECKLIST:

CCA prepared a Cottage / Campus Wildfire Management Checklist, See **A APPENDIX**, to distribute to private cottage owners and to conduct analysis of CCA owned buildings. Most of the items on the checklist will be assessed in Phase II to consider the return on investment for implementing each item.

## D. CHAUTAUQUA WILDFIRE MITIGATION PLAN

1. PRE-FIRE ACTIVITIES
    a) CULTURAL RESOURCE INVENTORY - Maintain an inventory of the Cultural Resources at Chautauqua. As noted during this project, the buildings themselves are the top priority and concern of CCA. Conduct visual evaluations of each resource to determine what maintenance may be required to reduce risk of fire. Revisit the resources at least every three years to ensure that the inventory and documented conditions are current.
    b) MAINTAIN AND DISTRIBUTE LIST OF PRIORITIES - The list of priority buildings outlined in this document should be revisited at least every three years. Maintain and distribute the list of priorities to assist first responders with protecting assets. At annual fire inspections it is recommended that CCA walk through the priority buildings and ensure Boulder Fire has the list and maps in their Structure Response Plan.
    c) AS-BUILT DOCUMENTATION: Document and/or creating as-builts for all buildings / features in the district. Immediate priority should be given to the list of 9 priority buildings outlined in this document. Next priority should be given to the contributing historic buildings, features, sites, and objects listed in the NHL nomination. However, documentation of non-contributing elements is also recommended, as in time, these elements may be eligible to be included in the list of contributing features. Whatever method, be it field measuring, LiDAR or photogrammetry, the recommendation for Chautauqua is to achieve a high quality and accurate drawing set (or point cloud model) that could be archived for use in reconstruction.

d) EVACUATION PLAN & TRIGGER POINTS: The Boulder Office of Emergency Management (OEM) has established trigger points that will result in issuing specific instructions to CCA. Boulder OEM will provide advisories, warnings, orders, or all clear instructions associated with a wildfire. CCA should maintain evacuation plans for the site. With only two means of egress from the site, 12th Street and Kinnikinnick Drive, and considering there are one-way lanes within the district, having clear evacuation maps is critical. Since short term cottage renters are likely the population least familiar with the site, there is opportunity at check-in to discuss the evacuation plan, map, and Boulder OEM instructions with visitors. Private cottage owners and CCA staff are most familiar with the site, however opportunities at annual meetings should be utilized to revisit evacuation plans and Boulder OEM procedures to ensure everyone has a current understanding. Evacuation of the campus would be challenging because of the number of vehicles and narrow streets. It is imperative that a trigger point, such as a pre-evacuation notice from a fire official, be communicated to residents and visitors so that traffic congestion does not impede the efforts of first responders to protect the values at risk and the rest of the campus.
e) COMMUNICATION PLAN: Notifications of emergency alerts and warnings are communicated through Amber Alerts, Local Emergency Messaging (so-called reverse 911), and Internal SMS initiated by the CCA HR Department. CCA staff announcements and protocols have been established which include walking around the site and knocking on doors. Again, utilizing guest check-in and annual meetings as touchpoints to review and discuss the communication plan is recommended.
f) RECOVERY PLAN: The Colorado Department of Local Affairs (DOLA) has a Resiliency Office that manages Wildfire Recovery. In the unfortunate event of a wildfire that affects CCA, information, resources and announcements will be located here: https://www.coresiliency.com/co-recovery-resources-wildfire

## E. RECOMMENDATIONS FOR STRUCTURES

1. CLASS A FIRE RATED ROOFING: The roofs of the buildings at Chautauqua consist of asphalt shingles. The Auditorium is an exception where a recent roofing project replaced the roof with a combination of Class A rated asphalt shingles and Class A rated membrane roofing. **All the roofs at Chautauqua have a Class A fire rating and all future replacements will be Class A.**

2. REFLECTIVE BUILDING ADDRESS NUMBERS: Reflective building address numbers allow first responders to quickly identify a building when it is dark. This recommendation was discussed early in the Phase 1 Fire Mitigation Project and has been implemented. **Reflective building address numbers are in place on all CCA managed buildings, and the recommendation was passed on to the private cottage Owners for implementation. An additional recommendation for this item is to periodically check that the building address numbers remain visible (remove vegetation growth or replace when lost/damaged).**
3. LANDSCAPING MANAGEMENT
    a) REMOVE DEAD TREES: If a dead or dying tree is identified within the CCA district, it should be removed. **Conduct annual visual inspections within the district and remove the entire tree where dead or dying.**
    b) PRUNE TREES / VEGETATION: **Conduct annual visual inspections within the district and prune tree branches hanging over building roofs and remove all fuels within 10 feet of chimneys.**
    c) REDUCE TREE SPACING: **Thinning of tree density is recommended, but it is also understood that this may not be achievable at Chautauqua due to the cultural landscape**. The Colorado Forest Service recommends crown spacing of trees to be 6-10 feet. Chautauqua has a series of Witness Trees and Donated Trees that are significant. These trees should be identified (via tags attached to the tree) to determine if removal of adjacent non-historic trees could work towards the goal of thinning out the tree density within the district.
    d) REMOVING SLASH: Avoid large accumulations of surface fuels such as logs, branches, slash, and mulch. **Conduct annual visual inspections within the district and remove any slash on the site**.
    e) REMOVE COMMON GROUND JUNIPERS: Common ground junipers are highly flammable. **If any exist within the Chautauqua boundaries, they should be removed.**
4. GUTTERS: Ignition of organic materials that build-up in gutters is one of the greatest structural risks. CCA recently received a grant that will fund the installation of gutter covers at all CCA buildings. This project is planned to proceed in 2022. Gutter cover manufacturers will advertise that their products eliminate the need to clean gutters. However, there is no guarantee that small debris will not find a path and build up to create an ignition point. **Therefore, even following the installation of the gutter covers, as a minimum recommendation, our team recommends checking and cleaning gutters several times per year to ensure they are clear. Gutters should be cleaned in Spring and**

**early Fall and after any major weather event that may knock down leaves, needles and/or sticks.** Because of the maintenance implication for both CCA managed and privately owned structures, our team would propose that additional discussion and consideration should be given to the elimination of gutters entirely. The implication of this effort would trigger the need for an alternative drainage design at the ground level surrounding the buildings in order to ensure that protection from water infiltration can still be achieved. Most of the buildings at Chautauqua do not have continuous foundations, with the majority sitting on stacked stone piers or walls. Introducing water from the roof at the base of the buildings and accounting for poorly draining soil conditions at Chautauqua, eliminating gutters and downspouts would likely result in increased risk to the integrity and longevity of the historic structures. A holistic approach to preservation of the historic assets at Chautauqua needs to be considered beyond just wildfire risk reduction. The design and cost implications of this change would need to be considered and discussions had with History Colorado, Boulder Landmarks Design Review Committee, and CCA to determine the feasibility of this proposal. This would also need to be reviewed on a per building basis from the Secretary of the Interior Standards standpoint. Reviewing some historic photos that exist, a few of the buildings appear to not have had gutters originally, however some did. It would need to be determined if gutter removal would be achievable at some or all of the buildings based on this consideration as well.

5. DECKS: **It is recommended that CCA remove all vegetation, needles, and any stored materials from below decks and within 3-5 feet around decks.** Installation of 1/8-inch metal mesh screen should be considered at all open stilt decks, similar to the mesh that was incorporated in the Mary H. Galey Cottage Rehabilitation Project (**Figure 13**). The visual impact and cost implications of this recommendation would need to be considered and discussions had with History Colorado, Boulder Landmarks Design Review Committee, and CCA to determine approval. However, from the Secretary of the Interior Standards philosophy, adding metal mesh would be a reversible modification to a building that would offer better protection from fire.

**Figure 13. Mary H. Galey Cottage deck enclosure. The enclosure uses fire-retardant-treated wood and metal mesh to reduce combustibility and the likelihood of large embers causing ignition under the deck.**

6. SCREENING VENTS AND EAVES: Installation of 1/8-inch metal mesh screen at exterior building vents should be considered. The Colorado State Forest Service recommends adding 1/8-inch metal mesh screens to open roof eaves. **The visual impact and cost implications of this recommendation would need to be considered and discussions had with History Colorado, Boulder Landmarks Design Review Committee, and CCA to determine approval. However, from the Secretary of the Interior Standards standpoint, adding metal mesh would be a reversible modification to a building that would offer better protection from fire.**
7. BUILDING FOUNDATION / PERIMETER: **Where achievable, it is recommended that all vegetation and mulch be removed from within 5 feet of the building foundation.** Replacement of wood mulch with crushed stone or gravel with a metal landscape edge will help to prevent grass and vegetation from growing back up against the building. **Where achievable, reduce/ regrade around buildings to ensure that a minimum of 6 inches of vertical clearance between the ground and wood siding/trim is established. This recommendation would need to be reviewed on a per building basis to determine if it is achievable with existing foundations/base materials.**
8. FENCING: **For non-historic fencing, it is recommended that combustible fencing and gates within 5 feet of a building be removed or replaced with non-combustible materials**. This recommendation would need to be considered on a per building basis.

## F. ITEMS FOR FURTHER STUDY / DISCUSSION:

1. WINDOWS AND DOORS: Due to Chautauqua's historic designation, wood framed windows and doors would be considered defining features and therefore should be maintained. Similarly, window and door glazing would historically have been single-paned glazing, and this would be considered defining features to the historic designation. Therefore, wholesale replacement of window and door glazing would not be recommended and use of multi-pane glazing, although an industry recommendation for better fire resistance, would not be appropriate at Chautauqua. However, single pane tempered glass could be considered if/when a broken pane would need to be replaced in an existing window or door. This being said, tempered glass is thicker and heavier than traditional single paned glass. Therefore, careful consideration would be needed to determine the impact of replacement. Routing out larger glazing beds in windows and doors would be a non-reversible impact. However, this impact could perhaps be reconciled with the added fire protection for the structure. This could be discussed further with History

Colorado, Boulder Landmarks Design Review Committee, and CCA. **However, at this time, modifications to windows and doors materials or glazing is not recommended as an item to be pursued at Chautauqua, due to the risk of loss of historic designation.**

2. EXTERIOR SIDING MATERIALS: Similarly, to Windows and Doors and as previously discussed, the materiality of the wood exterior siding (including eaves, soffits and trim) on the buildings Chautauqua is a character defining feature. Whereas modern recommendations for fire resistance would suggest replacement of wood exterior siding with fiber cement siding, steel siding, aluminum siding, stucco, brick, or stone, this would significantly change the visual character of Chautauqua and if a campaign to replace materials was pursued, it would likely eliminate Chautauqua's historic designation. **Therefore, replacement of wood exterior elements on the buildings at Chautauqua is not recommended.**

# A APPENDIX CCA COTTAGE / CAMPUS WILDFIRE MANAGEMENT CHECKLIST

Colorado Chautauqua Association Wildfire Mitigation Checklist

Building/Cottage #: _____ Inspection Date: _____ Inspector: _____

| Boulder Fire Department Recommendations | Yes | No | Comments |
|---|---|---|---|
| Keep vegetation green and watered | | | |
| Maintain minimum of 5ft. wide path around perimeter | | | |
| Be sure cottage address # is clearly visible | | | |
| Keep garden hose connected to outdoor hose bib | | | |
| Clean gutters and clear leaf debris off roof | | | |
| Keep tree limbs trimmed and not in contact with roof or ground | | | |
| Keep firewood away from house and cover with flame resistant tarp | | | |
| Clear any vegetation under deck and/or install lattice/screen or rock to prevent growth | | | |

| | | | |
|---|---|---|---|
| Keep barbecue grills a minimum of 5ft. away from building when in use | | | |
| Rake yard and clear out all dead branches/ leaf litter | | | |
| Maintain exterior paint (curling paint is more surface area for fire) | | | |
| Ensure wooden fences are not connected with combustible material (e.g., mulch) | | | |
| Additional Notes: | | | |

# B APPENDIX: PHASE 1 SCOPE OF WORK TASKS

The following outline was identified for the project:

- Meet with Chautauqua Leadership Team and Sustainability & Resiliency Committee to discuss status of ongoing wildfire mitigation grants, on-going vegetation management strategies, cottage/campus wildfire management checklist, and local contacts/resources. (February 11, 2022)
- Walk site with CCA representatives and stakeholders to observe mitigation work to date, buildings and their current functions, overall site conditions, and contiguous Open Space areas, to understand exposure risks and on-going mitigation work. Collect pertinent data: Cultural Landscape Assessment, emerald ash bore treatment/removal plan, donated trees, and witness trees. Establish criteria and conduct initial prioritization of the buildings, collection(s), equipment, and office resources, to inform the wildfire evacuation and protection plan. Review Chautauqua wildfire mitigation resources and partnerships and their areas of responsibility. Identify gaps that require attention for developing an effective mitigation plan.
    - Define the objectives of the mitigation plan for Chautauqua based on information gleaned from #2.
    - Review prior wildfire mitigation plans/proposals/recommendations specific to Chautauqua and make recommendations, or establish priorities and recommendations that are applicable to CCA.
    - Expand discussions with Boulder County Fire and Emergency Services staff that have coordinated with Chautauqua on wildfire issues, with emphasis on how a site wildfire mitigation plan can be communicated through channels if an incident goes beyond the leadership of local resources.
    - Review and refine project approach, schedule, and deliverables for Phase One.
    - Develop the following, in draft form:
        - Wildfire mitigation map – prioritizing remaining vegetation management and sitework
        - Wildfire evacuation plan – addressing the issues of collections, archives, equipment, and office resources
        - Building prioritization plan – addressing which buildings should receive priority protection based on historical significance to CCA, in the context of an advancing wildfire (and how best to achieve that)
        - Review cottage/campus wildfire management checklist, recommend any improvements, develop a communication plan to share overall CCA and Cottager performance. Initiate discussion of CCA's critical resources and criteria for prioritizing their protection.
            - Present draft plans and recommendations to CCA staff, the CCA S&R Committee and the CCA board, for review and comment.
            - Finalize plans, recommendations, and next steps for CCA implementation.

# C APPENDIX: RECENT WILDFIRES IN BOULDER COUNTY

Boulder County has experienced several major wildfires in the last few decades. Although no one can predict if and how a fire may start, understanding causes, behavior and risks may help CCA better assess fire mitigation solutions that may be most effective.

- NCAR Fire: The NCAR Fire started on March 26, 2022 near the Bear Canyon Trail. The fire was manmade and burned approximately 190 acres[3].
- Marshall Fire: The Marshall Fire started on December 30, 2021, and swept through the City of Louisville, Town of Superior and unincorporated Boulder County. The fire spread quickly due to high winds and dry conditions, destroying, and damaging more than 1,000 homes and over 30 commercial structures. The cause of the fire is still under investigation[4].
- 2020 Cal-Wood & Lefthand Canyon Fires: The Cal-Wood fire started on October 17, 2020, and burned approximately 10,000 acres and destroyed at least 26 buildings. It was 100% contained as of November 14, 2020. The Lefthand Canyon Fire started on October 18, 2020. It burned 460 acres of brush and timber approximately one mile west of the town of Ward. It was 100% contained as of October 22, 2020. Snow and cold temperatures were instrumental in putting out much of the heat in the fire area.
- Cold Springs Fire: The Cold Springs wildfire was reported on July 9, 2016, approximately two miles northeast of Nederland, Colorado. The fire was manmade and was officially contained July 14, 2016. It burned a total of 528 acres and 8 homes were lost[5].
- Fourmile Canyon Fire: The Fourmile Canyon Fire was reported on September 6, 2010. Due to low humidity and high winds, the fire spread quickly, destroying 168 homes, and burning approximately 6,200 acres.
    - 29 homes were ignited by crown fire
    - 139 homes were ignited by surface fire[6]
- Olde Stage Fire: The first Olde Stage Fire started November 24, 1990, when a Boulder County resident threw a burning mattress out the front door of his home. 80 MPH winds swept the fire uphill into nearby homes and then down and out onto the plains. The fire burned 10 homes and approximately 3,000 acres. The second Olde Stage Fire started January 7, 2009, when wind blew down power

[3] Campbell-Hicks, Jennifer. “NCAR Fire: Investigators have ‘exhausted all leads’ in identifying suspect”. 9 News Website, Accessed August 22, 2022. https://www.9news.com/article/news/local/wildfire/ boulder-ncar-fire-human-caused/73-815e7b6d-551a-40c4-9fe0-e54b791decd7

[4] Marshall Fire Recovery. Boulder County Website, Accessed August 22, 2022. https://bouldercounty.gov/disasters/wildfires/marshall/

[5] Wasser, Leah. “An Overview of the Cold Springs Wildfire”. Earth Lab Website, Accessed August 22, 2022. https://www.earthdatascience.org/courses/use-data-open-source-python/data-stories/cold-springs-wildfire/

[6] Gabbert, Bill. “Report released on Colorado’s Fourmile Canyon fire”. Wildfire Today. October 14, 2011. https://wildfiretoday.com/2011/10/14/report-released-on-colorados-fourmile-canyon-fire/

lines in two different areas. 60 MPH winds igniting dry grasses led to approximately 3,008 acres being burned[7].

- Overland Fire: The Overland Fire started on October 29, 2003, when high winds blew a tree down into a powerline. The high wind, steep topography and the density of the forest were all contributing factors to the speed and destruction of the fire. It burned 3,500 acres and destroyed 12 homes[8].

[7] Olde Stage Fires. Boulder County Website, Accessed August 22, 2022. https://bouldercounty.gov/disasters/wildfires/olde-stage-fire/
[8] Overland Fire. Boulder County Website, Accessed August 22, 2022. https://bouldercounty.gov/disasters/wildfires/overland-fire/

# D APPENDIX: MEETING MINUTES 01

form+works design group, LLC

## Meeting Minutes 01

Project Name: Chautauqua Fire Mitigation Plan – Phase 1

Project Number: 22-021

Date: May 6, 2022

Time: 9:00 AM

Attendees:

| | | |
|---|---|---|
| Shelly Benford | Colorado Chautauqua Association (CCA) CEO | shelly.benford@chautauqua.com |
| Jason Hill | CCA COO | jason.hill@chautauqua.com |
| Pat Shanks | Board Member of Chautauqua | wcpatshanks@gmail.com |
| Bill Briggs | Board Member and Chair of Sustainability Committee | william.briggs@ucdenver.edu |
| Jeff Medanich | CAA Director of Preservation & Sustainability | jeff.medanich@chautauqua.com |
| Adam Gillespie | CCA Facilities Manager | adam.gillespie@chautauqua.com |
| Jeff Rump | CCA Horticulturalist | |
| Ron Anthony | Anthony & Associates | woodguy@anthony-associates.com |
| Natalie Lord | Form+Works Design Group | natalie@formworksdesigngroup.com |

1. Introductions

2. Fire mitigation efforts to date:

    a. The team discussed efforts that CCA has undertaken utilizing grant funding for fuel mitigation. CCA has utilized volunteers as well as Reinholt Tree Specialists to complete efforts.
        i. CCA received a Colorado Forest Service Grant
    b. CCA has completed fuel reduction on the trail on the east side of the Chautauqua Historic District and has conducted some clearing on the southwest side.
        i. East Trail / Road: Chautauqua's property line terminates on the west side of the existing Trail/Road. The draw to the east of the road is owned by Boulder Open Space and Mountain Parks (OSMP). OSMP has removed dead trees and some brush that had accumulated from the 2013 flood. Additional fuel reduction in the

OSMP area, particularly immediately adjacent to the East Trail / Road was recommended by Ron Anthony. Further discussions with OSMP will be required to consider the process / feasibility of additional fuels reduction near the CCA property lines.

c. The area along the south end of the district has not been addressed and contains considerable fuel that puts the south end of CCA property at significant risk. CCA's property line terminates just south of cottage 807, but CCA noted that there is an addition ¼ mile (approximately) of additional heavy brush / vegetation area that is owned by OSMP. There is no fire break between in that area.
d. The west edge of the property was reviewed during the site walk.
    i. Mowing is maintained at northern most cottages along the west property line, however the West Trail / Road does not provide a full separation between the CCA and OSMP property. There is an area on the east side of the West Trail / Road (from cottages 35 - 20) that is owned by OSMP and CCA has inquired about periodically mowing this strip of grass to reducer fuel load. OSMP has responded that due to natural habitat constraints, this strip of grass cannot be mowed. Ron suggested that further discussions be held with OSMP as part of the CCA Fire Mitigation Plan regarding this narrow strip of land.
    ii. CCA has completed some fuel mitigation efforts at the south end of the West side of the property. These efforts were summarized by Jeff during the site walk and Ron Anthony provided feedback on the need for a prescription for additional mitigation work. CCA intends to continue these efforts utilizing the grant funds they have received.

3. CCA Firewise Coalition:
    a. The coalition was formed by CCA to engage the broader community in CCA's fire prevention efforts.
    b. Goals:
        i. Educate and communicate with stakeholders about wildfire preventions and mitigations at Chautauqua.
        ii. Solicit input and support from important stakeholders regarding wildfire prevention measures.
        iii. Create greater community engagement around sustainability issues at Chautauqua related to wildfire.
4. Prioritization of Site Assets:
    a. The Team discussed CCA's initial thoughts on the prioritization of site assets within the district.
    b. Buildings: The preliminary prioritization of the buildings is as follows:
        i. Auditorium (Including Restroom and Ticket Booths)
        ii. Dining Hall / General Store
        iii. Academic Hall
        iv. Community House
        v. Missions House
        vi. Columbine Lodge
        vii. Cottage 200
        viii. Mary H. Galey Cottage
        ix. The Rest Cottage (#401)
    c. Assets/Artifacts Inside the Buildings: Ron Anthony and Natalie Lord discussed with the group that a list and priority of non-building assets / artifacts is recommended as part of this effort to identify items that are of high priority to CCA. In a scenario where there are a few minutes to remove objects from inside

a building, having a document that identifies those items, their locations, and the place they are to be relocated / stored (somewhere off site) will be critical to communicate with occupants, staff, and first responders.

5. Fuel Removal Project Goals / Additional Considerations Discussed:
    a. Habitat protection balanced with fire protection
        i. Be discerning with fuels removal. No one wants to see clear cutting of the landscape
        ii. Protect apple trees and heritage trees
    b. Determine solutions to protect underside of decks
        i. Ron Anthony discussed the need to keep areas below deck clear, do not store firewood under decks, maintain retaining walls, etc.
        ii. The Team discussed that enclosing the underside of decks with a Hardi-plank- type product may protect the underside better from fire but will provide a barrier for water coming down through the deck. This has the potential to create a microclimate that would deteriorate the historic wood joists and create a challenge for inspecting the historic wood. Anthony and Associates and Form Works will consider what other potential solutions there may be for the open decks.
    c. Water pressure during a fire:
        i. Boulder does regular pressure checks of the hydrants on-site, however Ron Anthony noted that during a firefighting incident, the pressure will drop and may not be adequate. There is little that CCA can do about this.
    d. Forest Health: Ron Anthony discussed that considering forest health further up from the site is another way to help protect the site that could be discussed with OSMP and other partners.
    e. Alternative privacy: Are there specific plantings or other methods for providing privacy to the cottages from the Trails/Roads?
    f. Building Documentation:
        i. The community buildings have existing as-built drawings.
        ii. CCA is not 100% certain what documentation may exist for the cottages.
        iii. Lidar scanning / photogrammetry: consider methods and results for documenting the existing buildings to provide a means for reconstruction as a worst-case mitigation effort.
    g. Replacement of wood with fire rated wood
        i. CCA has utilized "Hoovered" Wood, which provides a 1-hour rating on several projects on the site (at The Mary H. Galey Cottage and the reconstruction of the building between the Dining Hall and the General Store (construction in progress)). The cost of Hoovered wood should be a consideration.
    h. Property Boundaries: CCA is undertaking a site survey to identify the property boundaries.
    i. Electrical Lines: There are areas where the electrical lines are close to or in trees. Electrical lines are scheduled to go underground in 2023.
    j. Maintenance Timeline: The existing fire mitigation grant work is anticipated to be completed over the next two years. Ron Anthony recommended removing approximately ¾ of all brush and removing limbs from trees up 6-8 feet above the ground as part of the fuels reduction strategy. At first this will appear drastic, but

in a few years there will be regrowth. Recommendations for a continued maintenance plan / guidance moving forward will be developed as part of this Fire Mitigation Project.

6. Additional Items Needed:
    a. Utility Maps:
        i. Gas and Electrical Utility Maps are available and can be provided by CCA
        ii. Hydrant Locations: CCA can mark-up where existing hydrants are located on the site.
        iii. Community Wildfire Protection Plan: Jeff Medanich provided a link on 5/9/2022

End of Meeting Minutes

Respectfully Submitted By:

Natalie Lord, RA, LEED AP BD+C

Principal, Form+Works Design Group, LLC

# E APPENDIX: MEETING MINUTES 02

form + works
design group, LLC

Meeting Minutes 02

| | |
|---|---|
| Project Name: | Chautauqua Fire Mitigation Plan – Phase 1 |
| Project Number: | 22-021 |
| Date: | June 21, 2022 |
| Time: | 9:00 AM |

Attendees:

| | |
|---|---|
| Shelly Benford | Colorado Chautauqua Association (CCA) CEO<br>shelly.benford@chautauqua.com |
| Jason Hill | CCA COO<br>jason.hill@chautauqua.com |
| Bill Briggs | Board Member and Chair of Sustainability Committee<br>william.briggs@ucdenver.edu |
| Jeff Medanich | CAA Director of Preservation & Sustainability<br>jeff.medanich@chautauqua.com |
| Ron Anthony | Anthony & Associates<br>woodguy@anthony-associates.com |
| Natalie Lord | Form+Works Design Group<br>natalie@formworksdesigngroup.com |

1. Follow-up on current / continuing fire mitigation efforts discussed at previous meetings/calls:

    a. Fuels Mitigation Work to Date, Planned and Additional Discussions:
        i. Work has continued at CCA to clear out between the Bluebell trail and the cottages as discussed at the May 6, 2022, walkthrough.
        ii. The team discussed the need to create a fuel separation barrier at the south end of the property (where CCA property and OSMP property touch). It was also discussed that CCA needs to be cognizant of the fact that clearing out 75% of the brush and trees in this area, as Ron recommends for effective fuels removal, would create the appearance of a path that would need to be controlled to prevent visitors from traveling through that area.

    b. Trees, Ladder Fuels, and Gutters:
        i. Ron discussed the idea of reducing ladder fuels on the site. Ladder fuel is a firefighting term for live or dead vegetation that allows a fire to climb up from the landscape or forest floor into the tree canopies. Once in the trees, fire can jump when trees are in close proximity to structures and/or when falling embers and/or pinecones catch and fall, landing on/near

structures. From here the biggest risk is debris in gutters catching on fire and igniting the roof. Ron discussed the idea of eliminating gutters and downspouts. Natalie discussed that this would require French drainage systems and/or regrading efforts around the buildings to mitigate water infiltration risks to the historic buildings.

1. **Natalie will research any modern roof detailing solutions that have been developed to mitigate fire risk.**
2. The goal is to keep the fire on the ground by reducing ladder fuels. This is typically done by creating a perimeter boundary. The team discussed that the challenge of this is the adjacent property management / ownership relationships and changing the visual experience of the historic district. Ron referenced the detriment to the historic experience by creating a 100-foot fire break around the property.

ii. Ash – The team discussed that there are approximately 140 ash trees on the CCA site and according to an expert arborist it was likely at least 100 of these trees would die due to emerald ash borer. The team discussed that CCA may want to consider moving ahead with preemptive removal of the ash not only as a fire mitigation effort, but also structural risk to the historic buildings / features.

iii. Highly flammable trees and plants – Ron discussed the need to locate and identify any highly flammable trees and plants and ensure that they are removed within approximately 8 feet of buildings. He mentioned that juniper was one such species that should be removed. Consideration could be given to providing "fire resistive" landscaping recommendations for replacing plants close to structures.

1. A "Landscape Design Guidelines" could be created for private cottage owners to outline these recommendations. Chautauqua uses CSU's Firewise Plant List and this has been provided to private cottage Owners.

iv. Mowing of OSMP Property- The team revisited the previously discussed need to get an agreement in place to allow mowing of OSMP land that borders Chautauqua property. OSMP has communicated with CCA that in the event of an oncoming fire their crews would then mobilize to mow these areas, but as we have learned from the recent Marshall fires, there would not be time during a similar threat to CCA. Ron suggested that communication with OSMP should delineate the understanding of habitat concerns that OSMP has for mowing, but that these need to be balanced with safety for fire fighters and to allow adequate time for people to escape the area.

c. Undergrounding of electrical: It was discussed that this project will move forward in 2023. It will be a phased project utilizing directional boring with a series of potholes. It will be a multi-year effort.

2. Site survey:
   a. CCA confirmed that they are undertaking a site survey to fully understand the exact boundaries of the property. This will be instrumental for mapping out

private ownership boundaries, OSMP, and City owned property. Once completed more formal agreements can be discussed at managing and mitigating fuels on the CCA and adjacent properties. CCA is uncertain when this project will happen as it is dependent on grant funding.

3. Meeting with Perimeter Solutions:
    a. Wes Bolsen, sales with Perimeter Solutions and Brian Oliver, Boulder Fire joined the team to review / discuss the "Fortify" product.
        i. Fortify is an uncolored spray applied product that can be applied to vegetation, power poles, etc. as a fire retardant.
        ii. Wes explained that they recommend application to utility poles, surrounding vegetation and directly on high value buildings.
        iii. The product can be utilized as a pre-treatment and/or to establish a fire line during an oncoming fire. The product consists of white phosphates, so after application there would be a faint white coating as a temporary visual impact, but allegedly a significant rain event would completely remove the product.
        iv. Wes reviewed the "lifespan" of some of the various fire-retardant solutions on the market:
            1. Foam products would likely last between 10-20 minutes so are best utilized when applied immediately before contact with a fire.
            2. Gel products can typically last between 1-2 hours, so again, are best utilized when applied nearly immediately before contact with a fire.
            3. Fortify on the other hand could last up to 3-5 months or until a significant rain event.
        v. Application success: Fortify works on cellulose structures, i.e., wood poles, vegetation and wood structures. It does not work/stick to glass, metals, or stucco.
        vi. The phosphates will burn at approximately 800°C, therefore a high heat fire (like the Marshall Fire) is going to burn through Fortify.
        vii. Wes discussed that some of his clients have retained a trained application team/company that stores the Fortify product and could be deployed in the event of an oncoming fire. The costs of this can range from $3,500 – 10,000/ day
        viii. Application and cost: Wes said that one gallon of Fortify will cover approximate 100 Square Feet of Area for a building and costs about $9 / gallon. The product is applied by spraying the top of a structure/element and letting it run down. For boundary applications, to create a 10-foot wide by one mile long boundary he said it would require about 1,000 gallons of Fortify. For vegetation they recommend two gallons per 100 square feet.
            1. In Arizona applications his clients typically apply the product in March – June and it will last to the first major snow.
            2. The product takes 1 – 1.5 hours to dry, but it is effective immediately at retarding fires. This was demonstrated in the parking lot. It is recommended that you keep pets away for at least

a day just so they do not get the product on their feet and track around. The product is allegedly safe for humans, plants, and animals.

3. Fire departments that utilize Fortify can mix it directly into the Tenders (a firefighting apparatus that transports water) utilizing the recirculation function and it would typically take about 5 minutes to mix in the tank before being able to spray.

b. The demonstration on-site was helpful in seeing the application process and resistance to fire that Fortify provided on mulch, dried grass, and paper. Post-demonstration thoughts / discussions:
   i. Ron noted that there was a sticky feel to the product on the dried grass and that the paper treated with Fortify seemed to be more brittle than the untreated paper sample. He is wondering about any structural changes to the cellulose that Fortify may have.
   ii. Ron also noted consideration should be given to the impact to fire department equipment. Can it be easily cleaned out of equipment and lines?
   iii. Rainfall is very unpredictable in Colorado. It would be difficult to determine the application time period that would be most effective, and it is possible an application would be washed away nearly immediately. wasting the investment.
   iv. Other thoughts from CCA: After review of the product, CCA believes it would be best if the fire department had a means of applying it in case of an imminent danger. With Boulder rainfall it would be difficult for CCA to time the application that would make the investment worthwhile.

4. Next Steps:
   a. Ron will meet with Boulder fire to talk to the emergency manager more in-depth and get a better sense of the County and City Protection Plan.
   b. Natalie and Ron will begin drafting the fire mitigation document for review with CCA.

End of Meeting Minutes

Respectfully Submitted By:

Natalie Lord, RA, LEED AP BD+C

Principal, Form+Works Design Group, LLC