Community Wildfire Protection Plan 2022

Prepared by

Anchor Point Group

Mutual Agreement and Signatures

The Community Wildfire Protection Plan developed by the Town of Castle Rock:

- Was collaboratively developed. Interested parties and state and county land management agencies managing land adjacent to the Town of Castle Rock have been consulted.
- This plan identifies and prioritizes areas for hazardous fuel reductions treatments and recommends the types and methods of treatment that will aid in protecting the Town of Castle Rock from wildfire.
- This plan recommends measures to reduce ignitibility of structures throughout the area addressed by the plan.

The following entities attest that the standards listed above have been met and mutually agree with the content of this Community Wildfire Protection Plan:

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Acknowledgments

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Executive Summary

This Community Wildfire Protection Plan (CWPP) provides a comprehensive, scientifically based, analysis of wildfire-related hazards and risks in the Town of Castle Rock Wildland-Urban Interface (WUI) area. The analysis strives to follow the standards for CWPPs that have been established by the Healthy Forests Restoration Act (HFRA[1]) and the Colorado State Forest Service (CSFS[2]).

This report is the result of an area-wide fire protection planning effort that includes extensive field data, a compilation of existing documents and a scientific analysis of the fire behavior potential of the study area. It is a result of a collaborative effort with the agencies listed on page 3.

Take Home Message

This CWPP provides an analysis of mitigation strategy and tactics designed to protect Values at Risk on which a significant wildfire would have an impact. These values include life safety, homes and other property, infrastructure, recreation, lifestyle, local economic and environmental resources.

Recommendations for mitigation efforts address five broad categories including: public education, structural ignitability/the home ignition zone, water supply, access/evacuation, and fuels management. Recommendations in this CWPP should be brought to the local community involved with the project to ensure the project is valuable and viable for the area. Additional projects are also encouraged; especially as previous recommendations are completed.

The density of homes and scattered land ownership provide opportunity for successful collaboration/partnership for risk reduction projects across communities. Town officials are committed to working closely with residents to identify and support risk reduction activities, protecting life and property and enhancing life safety in Castle Rock. Wildfire preparedness and hazardous fuels reduction activities are a shared responsibility across the study area.

How to Use This Document

It is important to note many of the recommendations for home ignition zone and landscape scale fuels modifications are generalized by design. All specific reduction prescriptions should be developed with the consultation of a representative of the Castle Rock Fire and Rescue Department, a qualified fire mitigation specialist and a forester or landscape architect, depending on vegetation.

General defensible space recommendations are included but will likely be modified based on a structure's topographic location, surrounding vegetation and predicted fire behavior. It should also be acknowledged that areas with small lot sizes and a high density of single and multi-family homes exist in the study area. These areas present a unique challenge to creating adequate defensible space. Where cooperation between adjacent property owners is not possible, adequate

defensible space may not be created. Cooperation between property owners, HOAs and the Town of Castle Rock will be a critical component of any fuels reduction project in these neighborhoods.

Areas of significant residential development have been divided into hazard zones in this CWPP and have been rated for overall hazard and risk. This rating alone, however, may not capture the mitigation needs of the hazard zone. At a minimum it is necessary to review the individual narrative for each hazard zone, as well as the accompanying graphics, to understand some of the specific information that went towards forming the rating.

Disclaimer

Recommendations in this document are not prescriptive but are intended to assist in the identification of possible solutions or actions to reduce the impact of wildfire on Values at Risk. The views and conclusions in this document are those of Anchor Point and the project stakeholders and should not be interpreted as representing the policies of any governmental entity, fire agency or signatory entity. The methodology used is proprietary and as such may not match other existing hazard and risk ratings. In the event the language in this document conflicts with any regulatory documents, policies or local laws, this document does not supersede those documents.

Introduction

This CWPP was developed by the Town of Castle Rock (Castle Rock) with guidance and support from the Castle Rock Fire and Rescue Department (CRFD), Douglas County and the Colorado State Forest Service (CSFS). It has been prepared in response to the CRFD 2017 Strategic Plan. Information in this CWPP will be provided at the level of specificity determined by The Town of Castle Rock and the appropriate agencies.

The process of developing a CWPP can help a community clarify and refine its priorities for the protection of life, property, and critical infrastructure in the WUI. It can also lead community members through valuable discussions regarding management options and implications for the surrounding watershed.

The assessment portion of this document estimates the hazards and risks associated with wildland fire in proximity to WUI areas. This information, in conjunction with identification of the Values at Risk defines hazard zones for the purposes of this document and allows prioritization of mitigation efforts. From the analysis of this data, solutions and mitigation recommendations are offered that will aid homeowners, land managers, local government, CRFD and other interested parties in developing short-term and long-term mitigation efforts.

For the purposes of this report the following definitions apply:

Risk is considered to be the likelihood of an ignition occurrence. This is primarily determined by the fire history of the area.

Hazard is the combination of the Wildfire Hazard Rating System (WHR^3) ratings of the Wildland Urban Interface (WUI) hazard zones and the analysis of the fire behavior potential. Hazard attempts to quantify the severity of undesirable outcomes to the Values at Risk.

Values at Risk are the intrinsic values identified by citizens as being important to their way of life in the study area (e.g., life safety, property conservation, access to recreation, cultural sites and wildlife habitat.)

A **Hazard Zone** is an area of significant, primarily residential, development that is geographically contiguous and represents similar risks for and hazards resulting from a moderately advancing wildfire.

Purpose

Generally, the purpose of a CWPP is to refine the priorities for the protection of life, property and critical infrastructure in the WUI. Specifically, for the Town of Castle Rock this plan:

1. Provides a scientifically based analysis of wildfire related hazards and risks in the WUI areas within the Town of Castle Rock municipal boundaries.

2. Performs a relative ranking of hazard areas and identifies and prioritizes risk reduction activities to protect life and property and first responders from wildland fire.
3. Supports the continuation and potential expansion of wildfire mitigation efforts currently underway and encourage the continued maintenance of completed projects.
4. Creates a CWPP document that conforms to the standards established by HFRA and CSFS.

The National Fire Plan and the Healthy Forest Restoration Act

In 2000 more than 8,000,000 acres burned across the United States, marking one of the most devastating wildfire seasons in American history. One high-profile incident, the Cerro Grande fire at Los Alamos, N.M., destroyed more than 235 structures and threatened the U.S. Department of Energy's nuclear research facility.

Two reports addressing federal wildfire management were initiated after the 2000 fire season. The first report, prepared by a federal interagency group, was titled "Review and Update of the 1995 Federal Wildland Fire Management Policy" (2001). This report concluded among other points, that the condition of America's forests had continued to deteriorate.

The second report, titled "Managing the Impacts of Wildfire on Communities and the Environment: A Report to the President in Response to the Wildfires of 2000," was issued by the U.S. Bureau of Land Management (BLM) and the U.S. Department of Agriculture's Forest Service (USFS). It became known as the National Fire Plan (NFP). This report, and the ensuing Congressional appropriations, ultimately required actions to:

- Respond to severe fires
- Reduce the impacts of fire on rural communities and the environment
- Ensure sufficient firefighting resources

Congress increased its specific appropriations to accomplish these goals. In 2002 there was another severe wildfire season with more than 7,000,000 acres burned and 1,200 homes destroyed. In response to public pressure, Congress and the Bush administration continued to designate funds specifically for actionable items such as preparedness and suppression. That same year the Bush administration announced the Healthy Forests Initiative, which enhanced measures to restore forest and rangeland health and reduce the risk of catastrophic wildfires. In 2003 the Healthy Forests Restoration Act (HFRA) was signed into law.

Through this piece of legislation Congress continues to appropriate specific funding to address five main categories: preparedness, suppression, reduction of hazardous fuels, burned-area rehabilitation and state and local assistance to firefighters. The general concepts of the NFP blend well with the established need for community wildfire protection in the study area. The spirit of HFRA and the NFP is reflected in the Castle Rock CWPP.

This CWPP meets the requirements of HFRA by:

1. Identifying and prioritizing fuels reduction opportunities across the landscape
2. Addressing structural ignitability
3. Addressing community fire-suppression capabilities
4. Collaborating with stakeholders

This plan has been prepared in accordance with the objectives of the National Cohesive Wildfire Management Strategy. The National Cohesive Wildland Fire Management Strategy is a collaborative process with active involvement of all levels of government and non-governmental organizations, as well as the public, to seek national, all-lands solutions to wildland fire management issues.

Collaboration: Community and Agencies

Organizations involved in the development of the Castle Rock CWPP are listed below with their roles and responsibilities.

Town of Castle Rock Fire and Rescue Department

Collaboration and coordination of the CWPP, community values and hazard and risk assessment, development of community protection priorities and establishment of fuels treatment project areas and methods.

Colorado State Forest Service

Provides assistance in the planning process and approval of the CWPP process and minimum standards. Provides input and expertise on forestry, fire, fuels, and Firewise concepts. Provides information support for hazard assessment and defensible space.

Douglas County

Provides input and expertise on county lands, forestry, fire and fuels. Provides information and expertise related to existing to CWPPs and fire mitigation efforts in the county.

Goals and Objectives

Goal 1: Enhance life safety of residents, visitors, and responders.

- Establish an approximate level of risk (the likelihood of a significant wildfire event in the study area).
- Provide a scientific analysis of the fire behavior potential of the study area.

Goal 2: Mitigate undesirable fire effects to property and infrastructure.

- Group densely populated areas into "hazard zones" that represent relatively similar hazard factors.
- Identify and quantify factors that limit (mitigate) undesirable fire effects to the Values at Risk.

Goal 3: Mitigate undesirable fire effects to natural areas.

- Manage common areas and open spaces with respect for the natural characteristics and protecting habitat features.

Goal 4: Maintain and enhance existing mitigation efforts.

- Evaluate existing mitigation efforts for viability and effectiveness.
- Review current and future funding sources.
- Identify potential improvements in escape routes, safety zones, and evacuation plans.

Goal 5: Promote collaborative efforts for outreach and education to the public.

- Wildland fire preparedness workshops
- Community Events
- Firewise events and workshops
- "Ready, Set, Go" and "what does red flag mean to you"

Other desired outcomes include:

1. Promote community awareness: Quantifying the study area's hazards and risk from wildfire will facilitate public awareness and assist in creating public action to mitigate the defined hazards.
2. Improve wildfire prevention through education: Community awareness through education will help reduce the risk of unplanned human-caused ignitions. Education can limit injury, property loss and even unnecessary death.

3. Facilitate and prioritize appropriate hazardous fuel removal projects: Organizing and prioritizing fuel management actions will provide stakeholders with the tools and knowledge to ensure projects are valuable and viable for the local community.
4. Promote improved levels of response: The identification of specific community planning areas and their associated hazard and risk rating will improve the focus and accuracy of pre-planning and facilitate the implementation of cross-boundary, multi-jurisdictional projects.

Study Area Overview

The Town of Castle Rock is a home rule municipality and the seat of Douglas County Colorado. The Town of Castle Rock's Development Services Department maintains an annual estimate of the resident population for the 34 square miles of the Town of Castle Rock. As of December 2021, the population within town limits is 80,379. The population density for the Town is 2,364/mile^2, is considered an urban population density, and this makes it the most populous municipality in the county. Development Services also reports that there 23,428 residential housing units within the town as of December 2021. The town is named for the prominent castle shaped butte near the center of town. Castle Rock is a dynamic area with considerable existing and planned development. The population boom and economic expansion are expected to continue for the foreseeable future.

The current town boundary encompasses 34.1 square miles. [4] Elevations within the town limits, including a ½ mile buffer, range from 5,928 to 6,949 feet MSL with a mean elevation of 6,385 for the study area. Castle Rock resides within the Colorado Foothills Life Zone. Vegetative fuels include large areas of native grasses, Gambel oak (also known as oak brush or scrub oak) and ponderosa pine woodlands. Scattered pinyon pines and juniper are also found in the area. Local mammals include the American badger, American black bear, bobcat, coyote, Colorado chipmunk, gray fox, mountain cottontail rabbit, mountain lion, mule deer, pocket gopher, porcupine, and skunk. Birds found in the area include the golden eagle, peregrine falcon, sharp-shinned hawk, black-billed magpie, red-tailed hawk, pinyon jay and western tanager.[5] The area also provides habitat for the endangered Preble's meadow jumping mouse.

Residential Hazard Zones

For the purposes of this CWPP areas of residential density inside the town boundary were divided based on wildfire propagation and impacts. The driving factors in these divisions are similarity in risk (the likelihood of an ignition resulting in a damaging fire) and hazard (the severity of fire impacts to life and homes) rather than existing political or HOA neighborhood boundaries. Many of the locally recognized neighborhood and HOA boundaries include undeveloped land and significant areas of natural fuels. These areas are dealt with in the fire behavior analysis. The purpose of dividing the residential areas of the town into hazard zones is to perform a structural ignitability analysis in order to sort residential areas into hazard categories

for prioritization of recommendations. This is accomplished by the use of the Wildfire Hazard Rating (WHR) tool, which is intended to analyze WUI development and does not have any applicability to undeveloped land. For a further discussion of this methodology see the *Structural Ignitibility Analysis and Recommendations* section of this report.

There are 19 residential hazard zones in the study area. Hazard ratings have been assigned based on five categories: low, moderate, high, very high and extreme. Two zones were rated as moderate, 12 as high and 5 as very high. The residential hazard zones are shown graphically in Figure 1**.** For a complete discussion of each of these zones please see the *Structural Ignitibility Analysis and Recommendations* section of this report.

Areas of Special Interest

In addition to the residential hazard zones the developed areas of Castle Rock also contain areas of special interest (ASIs). The ASIs include Commercial Zones A through D, Dawson's Ridge, Douglas County Fairgrounds and Open Space parks. Please see the *Areas of Special Interest* section of this report following the *Structural Ignitibility Analysis* section for a discussion of these areas.

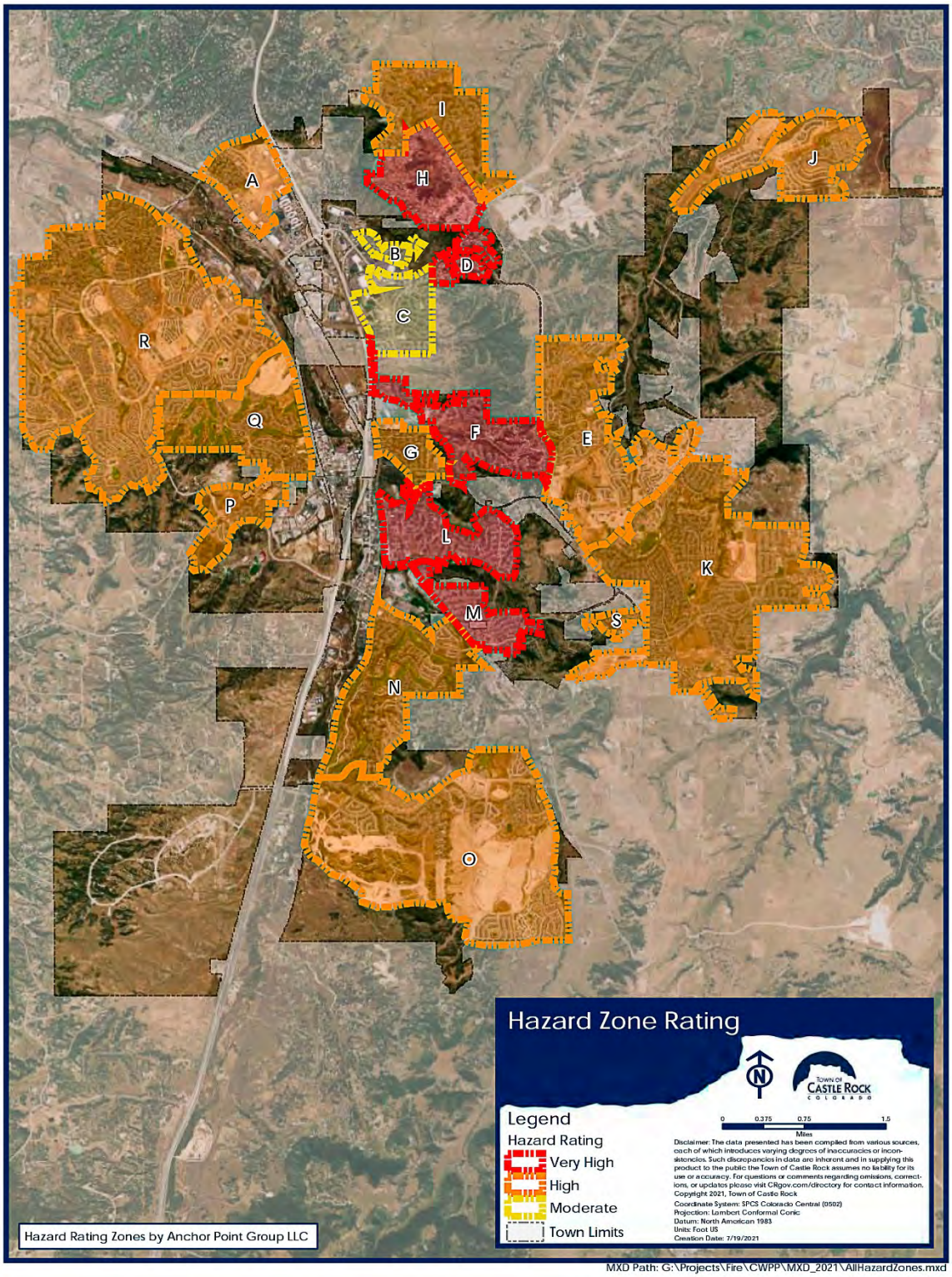

Figure 1 Hazard Zone Ratings

Values at Risk

Life Safety and Homes

The Town of Castle Rock's Development Services Department maintains an annual estimate of the resident population for the 34 square miles of the Town of Castle Rock. As of December 2021, the population within town limits is 80,379. The population density for the Town is 2,364/mile^2 and is considered an urban population density. Development Services reports 23,428 residential housing units in the town as of December 2021. By comparison, the 2010 Census reported there were 17,626 housing units in Castle Rock at that time with a population density of 1,526 people per square mile.[6] The town's website projects Castle Rock will grow to somewhere between 130,000 to 150,000 residents in the future.[7]

Commerce, Recreation and the Environment

Castle Rock is situated almost midway between Denver and Colorado Springs. Like most of the front range of Colorado, this area has experienced steady growth in the last decade. The median household income in Castle Rock grew to $109,700 in 2019. This represents an annual increase of 4.83% from 2018. [8] Employment growth in 2019 was 5.22% over 2018. The median property value also increased by 7.93% to $422,100. As mentioned above, the town government projects continued growth and is planning for aggressive development.[9]

Castle Rock maintains slightly under 6,000 acres of open space and 95 miles of trails.[10] The popularity of parks and open spaces such as Philip S. Miller Park, Rock Park, Memmen Ridge Open Space and The Bowl speak to the high value residents place on an active outdoor lifestyle. Castlewood Canyon State Park (2,600 acres) is also a short drive from Castle Rock.

Residents and the town government place a high value on a sustainable environment. As previously mentioned, the town lands provide habitat for the endangered Preble's meadow jumping mouse. Development planning that considers sensitive areas and wildlife habitat are a part of the concern for the environment shown by residents.

Critical Infrastructure

Although most Castle Rock neighborhoods are serviced by underground utilities there are still many power lines traveling through areas of native vegetation. (Figure 2) During periods of extreme burning conditions fire damage to overhead lines could result in significant power outages.

Castle Rock has numerous assets associated with water treatment and delivery, as well as wastewater collection.

The total quantity of water system assets associated with source water extraction, treatment, storage, pressure regulation, and pumping exceed several hundred, and include over 50 structures.

The wastewater collections system cannot operate on gravity alone due to the topography of the Town. The system requires numerous lift stations to collect and deliver municipal sewage to Plum Creek Water Reclamation Authority for treatment.

Most of these structures noted above are of at least partially ignition resistant construction, on concrete pads and have been cleared of nearby fuels. There are, however, some structures with fuels impinging them that could render them dangerous or impossible to access during fires (Figure 3). These assets are considered at risk due, not only, to the inherent value of water delivery and wastewater transport, but because of their reliance on electric power. For more information, see the water supply discussion in the *Water Supply* section of this report.

Interstate 25 and US Hwy 85 run through the study area north to south. Although it's unlikely the highway would experience damage from direct flame impingement, smoke and ember cast could render it unsafe to use.

Burlington Northern Santa Fe (BNSF) and Union Pacific both use rail lines through Castle Rock running roughly parallel with I-25. Damage to the rail lines from fire could be possible during fires with extreme fire behavior. Trains are also a potential ignition source, which is concerning as railroads travel close to homes in some parts of Castle Rock.

Other values may be considered critical infrastructure by the Castle Rock community including but not limited to:

- power transmission and substations
- cell/communication towers
- government owned properties
- natural gas supply, pipelines
- hospitals
- schools

We recommend stakeholders collaborate to generate a list of other critical infrastructure values and evaluate them for hazards related to wildfire.

Figure 2 Power lines

Figure 3 Natural Fuels Impinging a Pump Station

Current Risk Situation

The characteristics of Castle Rock that draw people to the town are also characteristics that put Castle Rock at risk for wildfire. Dense residential population and un-mitigated wildland fuels put many residences across the study area at risk. The Town of Castle Rock is listed in the Federal Register as a community at high risk from wildfire.[11] Castle Rock is shown on the Douglas County wildfire hazard assessment ignition risk map to be an area of moderate to high ignition risk.[12]

The portion of the front range where Castle Rock is located has an active fire history. Fires larger than 1,000 acres occurring in this part of the state from 2000 to 2019 include, High Meadow (2000), Schoonover and Hayman (2002), Cherokee Ranch (2003), Burning Tree (2011), Lower North Fork, Springer and Waldo Canyon (2012) and Black Forest (2013). The Hayman fire was one of the largest fires in Colorado history with 146,899 acres burned. The Black Forest Fire was one of the most destructive with over 500 structures destroyed.

Suppression resources in Castle Rock and their mutual aid partners across Douglas County have been successful in suppressing wildland fire starts before resources are overwhelmed, however residents and leaders must remember that recent data shows that only 3% of wildland fires in the continental United States make up 97% of the burned area[13].

CRFD responded to 27 in-district and 14 out-of-district wildland ignitions in 2020, 14 in-district and 7 out-of-district in 2019, 17 in-district and 22 out-of-district in 2018 and 25 in-district and 16 out-of-district in 2017. There was an annual average of 21 wildland responses within the Castle Rock Fire Protection District (CRFPD) boundary and 15 out-of-district responses over the last four years compared to an average of 18 in-district and 13 out-of-district wildland fire responses per year from 2014 -2017. The rise in wildland ignition responses indicates an increasing risk for ignitions in the study area. Ignition points and large fire perimeters (over 1,000 acres) for Castle Rock and the surrounding area are shown in Figure 4.

Front Range ecosystems have evolved with fire. Typically, a mixed severity fire regime in Ponderosa pine has areas of high intensity burning and areas of lower and moderate severity at 30-to-50-year intervals. The expected return interval for wildfire is shown in Figure 5. Return interval is the amount of time predicted between serious fire events for a given area; however, fires can and do occur at irregular intervals, sometimes much sooner than the return interval forecast as this prediction is based on long term history. Most of Castle Rock and the surrounding area shows short return intervals. In the entire area shown in Figure 5 the longest return interval is 60 years. In significant portions of Castle Rock, the return interval is less than 20 years, indicating fires in this area are expected frequently. Years of fire suppression have provided for fuel buildups, including Gambel oak. Gambel oak across the study area and beyond is overgrown, much is dead and decadent as a result of both early and late frost events. The

density, continuity, and presence of Gambel oak adjacent to residences puts life and property at risk from wildfire.

Based on an examination of existing assessments, a review of fire history and the expected fire return interval, the study area should be considered at high risk for continued ignitions.

Research continues to show wildland fire can exist without having a wildfire disaster, and fire risk can be modified by density and flammability of homes in the WUI[14]. Through post fire assessment research, the “WUI problem” as Jack Cohen calls it, continues to present/reveal itself as a structure ignition problem. If structures cannot be penetrated by embers and do not meet the parameters for ignition and combustion, they will not burn during a wildland fire.

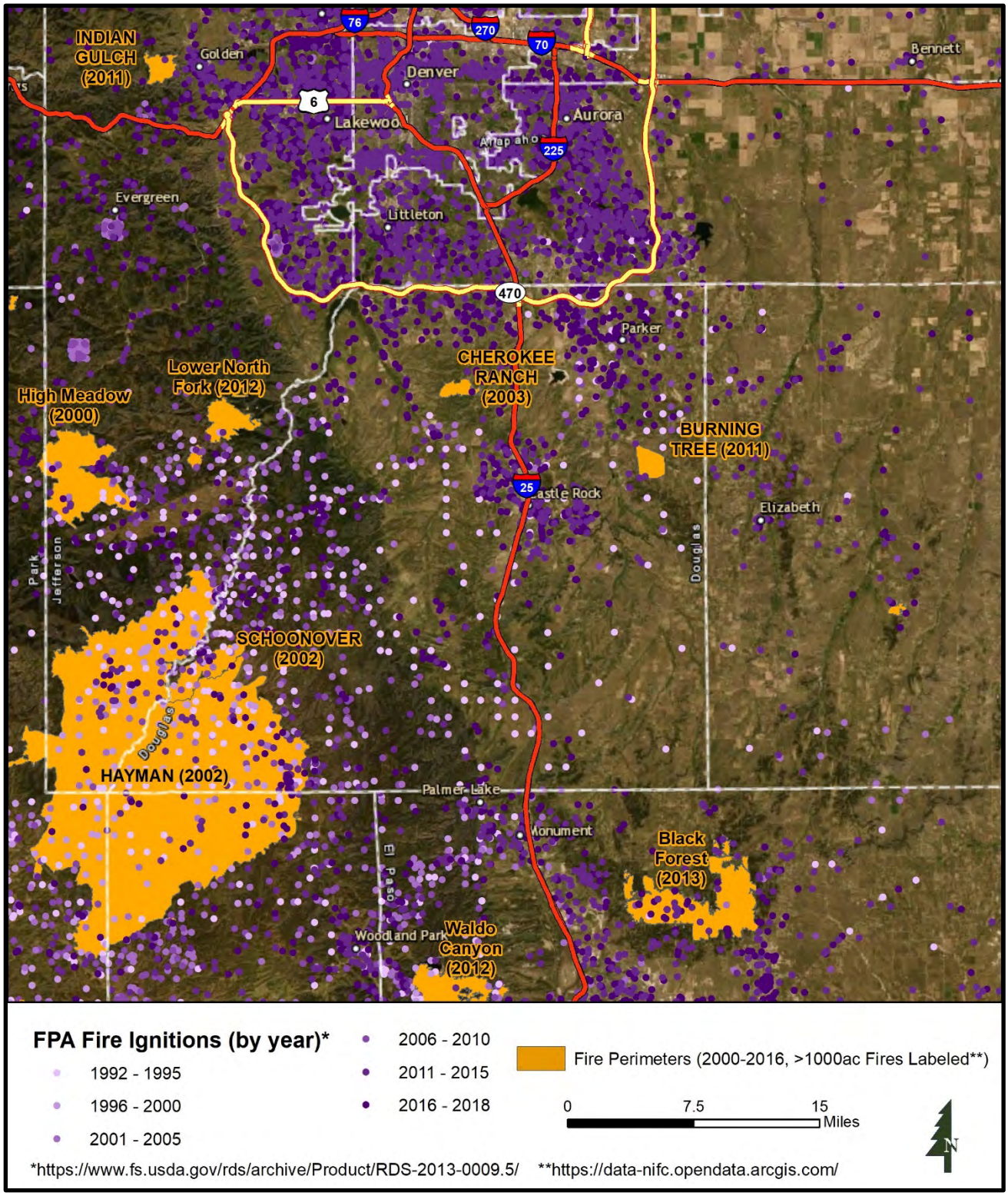

Figure 4 Wildland Fire Ignition Points with Large Fire Perimeters

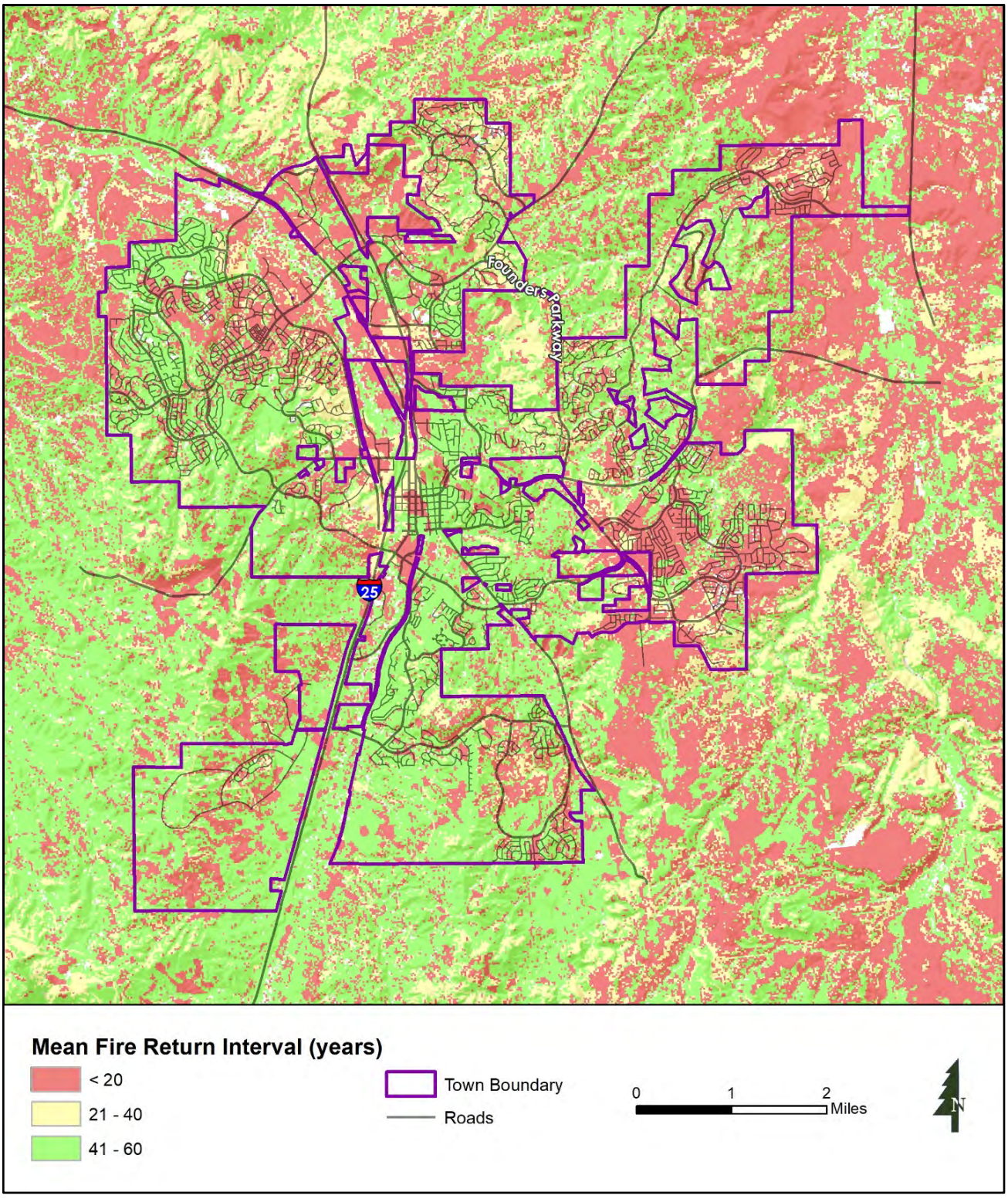

Figure 5 Return Interval

Firefighting Capabilities and Local Preparedness

The Castle Rock Fire and Rescue Department is responsible for the protection of a 66 square mile area including the Town of Castle Rock and the Castle Rock Fire Protection District in Douglas County. The department has 78 career members who staff five stations 24/7. Headquarters and administrative offices are combined with Station 151. 24 CRFD members are assigned to the Wildland Team. This is a nationally deployable team with certifications shown in Table 1**.**

The department handled a total call volume of 5,392 calls in 2020 and 5,876 calls in 2019. The average annual call volume from 2017-2020 was 5,626. The Department has an ISO (Insurance Services Office) Public Protection Classification (PPC) rating of 2.[15]

CRFD receives mutual aid from other fire suppression agencies within Douglas and Arapahoe Counties including South Metro Fire Rescue, Franktown Fire, Larkspur Fire, West Douglas and Jackson 105.

Fire Station 151 and Headquarters
300 Perry Street
Station 151 is paired with Fire Headquarters. Station staffing consists of at least six wildland-trained firefighters; one battalion chief, one lieutenant, one engineer, and three to four firefighters (either EMT or Paramedic). Apparatus includes one Quint (ladder truck) and one Type 3 brush truck with a 500-gallon tank (1,750 GPM pump).

The station is primarily responsible for protecting Baldwin Park, Castle North, Douglas County High School, I-25, the northern portion of Plum Creek, Rock Park, Phillip S Miller Park, several schools, Wilcox Square, the Woodlands, and the entire Downtown business and residential corridor.

Fire Station 152
435 Crystal Valley Parkway
Station 152 is located in the Crystal Valley area. The station is staffed by at least three wildland-trained firefighters. Apparatus includes one Type 1 or 2 engine and one Type 6 brush truck with a 300-gallon tank (110 GPM pump).

The station is primarily responsible for protecting Crystal Valley Ranch, Bell Mountain Ranch, the southern portion of Plum Creek, Sellers Creek Ranch, Stone Cañon Ranch, and a large area of agricultural and ranch land south of Castle Rock along Lake Gulch Road.

Fire Station 153
5463 E. Sovereign Street
Station 153 is located in the Founders neighborhood. The station is staffed by at least five wildland-trained firefighters; one lieutenant, one engineer, and three to four firefighters (either EMT or Paramedic). Apparatus includes one Type 1 or 2 engine with a 500-gallon tank (1,500 GPM pump), one Type 6 brush truck with a 300-gallon tank (110 GPM pump) and the HazMat unit.

The station is primarily responsible for protecting Founders Village, Castle Oaks, Castlewood Ranch, and the southern portion of Terrain.

Fire Station 154
3801 Prairie Hawk Drive
Station 154 is located on the front side of The Meadows neighborhood. The station is staffed by at least five wildland-trained firefighters; one lieutenant, one engineer, and three to four firefighters (either EMT or Paramedic). Apparatus includes one Type 1 or 2 engine with a 500-gallon tank (1,500 GPM pump) and one Type 6 brush truck with a 300-gallon tank (110 GPM pump).

The station is primarily responsible for protecting The Meadows, several schools, I-25, the Douglas County Courts and Justice Center, Highlands Vista, Red Hawk, a large industrial area, the Outlets at Castle Rock, and the Promenade.

Fire Station 155
3833 N. Crowfoot Road
Station 155 is located on Crowfoot Valley Road at the entrance to the Sapphire Point neighborhood. The station is staffed by at least three wildland-trained firefighters; one lieutenant, one engineer, and one to two firefighters (either EMT or Paramedic). Apparatus includes a Quint (ladder truck) and a Type-3 brush truck with a 500-gallon tank (1,750 GPM pump).

The station is primarily responsible for protecting Sapphire Point, Diamond Ridge, Metzler Ranch, the Founders commercial corridor, Crowfoot Valley Road, the northern portion of Terrain, the Canyons, Cobblestone Ranch, and Silver Heights.

Training and Accreditation

Castle Rock Fire and Rescue Department (CRFD) is one of 290 internationally accredited agencies through the Commission on Fire Accreditation International (CFAI).[16]

CRFD is committed to a continuous improvement process that encompasses a comprehensive self-assessment and evaluation model that examines past, current and future levels of service and performance, then compares them to industry best practices.

Each year, CRFD reviews and reports on its performance against established baselines and benchmarks (a measured improvement in performance, or goal), as well as progress toward strategic goals adopted by a team of department members.

International accreditation through the CFAI requires comprehensive self-evaluation of a fire and emergency service agency at every level.

At the center of the accreditation model is a continuous improvement philosophy that drives the Fire Department to 1) examine every part if its service delivery and 2) strive to improve, using industry best practices as a goal.

Table 1 CRFD Wildland Team, NWCG qualifications

NWCG Qualification	**Members Qualified**
Firefighter Type 2 (FFT2)	12
Firefighter Type 1 (FFT1)	7
Engine Boss (ENGB)	4
Task Force Leader (TFLD)	12
Division Supervisor Type 3 (DIVS)	1

Recommendations

Training

- Continue to require S130/190 for all firefighters.
- Require or continue to require the annual refresher and arduous pack test for all firefighters as per the *2021 CRFD RT-130 Training Plan*.
- Work with the town government and law enforcement agencies to provide minimum wildland fire training and Personal Protective Equipment (PPE) for law enforcement officers and any other personnel who will be involved in evacuations.
- Maintain training opportunities sponsored, or funded, by state and federal resources.
- Seek agreements that allow for cooperative training between local firefighters and county, state, and federal responders.
- Continue to encourage personnel to take additional wildland fire training courses including S-215 *Fire Operations in the Urban Interface*, S-290 *Intermediate Fire Behavior*, S230 *Crew Boss*, S-231 *Engine Boss*, and S-330 *Task Force/Strike Team Leader* as described in the *CRFD Wildland Goal 5K Plan for Department Members*. L-380 *Fireline Leadership* as well as ICS-200 through ICS-400 *Incident Command System* would also be desirable depending on rank.
- Encourage personnel to seek higher qualifications and participate in out-of-district assignments to develop skills and expertise.
- Build the capacity for a prescribed fire program within the Castle Rock town limits.

Equipment

- Ensure all firefighters have adequate wildland PPE including radios and new generation fire shelters and stockpile enough additional PPE on hand to outfit new recruits.
- Consider the purchase of a water tender to support suppression resources.
- Work with the town GIS department to provide a full set of tactical maps of hazardous areas within the CRFD response area. Emphasis should be placed on terrain and other hazards not easily discernable on maps commonly available to fire responders.
- Pursue grants and other funding opportunities to purchase additional wildland PPE and apparatus, such as the FEMA Assistance to Firefighters Grant Program.[17]

Public Education and Outreach

- Partner with the town planning department to encourage ignition resistant construction and defensible space when planning for new development.
- Consider the creation of a wildfire communication plan to coordinate notification and information dissemination to the public. This plan should include designating and training a fire event specific public information officer (PIO).
- Evaluate the current Code Red program for efficiency in promoting public participation.

- Evaluate the current reverse 911 program for efficiency and effective coverage.
- Collaborate with the town government to build awareness and use of mobile apps such as PulsePoint that will provide public access to incident and pre-incident notifications designed to promote public safety and awareness.

Structural Ignitability Analysis

Purpose

The purpose of dividing the residential areas of the town into hazard zones is to perform a structural ignitability analysis to sort residential areas into hazard categories for prioritization of recommendations. This is accomplished by the use of the Wildfire Hazard Rating (WHR) tool, which is intended to analyze WUI development.

Methodology

WHR was developed specifically to evaluate communities within the WUI for their relative wildfire hazard. The WHR model combines physical infrastructure such as structure density and roads, and fire behavior components such as fuels and topography, with the field experience and knowledge of wildland fire experts. It has been proven and refined by use in rating thousands of neighborhoods throughout the United States. Much of National Fire Protection Association Standard 1144 “Standard for Reducing Structure Ignition Hazards from Wildland Fire” (NFPA 1144) has been integrated into this methodology to ensure compatibility with national standards. Additionally, aspects of NFPA 1142 regarding water supply for rural and suburban firefighting are included in the assessments by looking at proximity and capacity of the water supply.

The model was developed from the perspective of performing structural triage on a threatened community in the path of an advancing wildfire with moderate fire behavior. The WHR survey and fuel model ground-truthing are accomplished by field surveyors with WUI fire experience. The rating system assigns a hazard rating based on categories such as topographic position, fuels and fire behavior, construction and infrastructure, suppression factors, and other factors including frequent lightning, railroads, campfires, etc. The rankings are also related to what’s customary for the area. For example, a high-hazard area on the plains of Kansas may not look like a high-hazard area in the Sierra Nevada. The system creates a relative ranking of community hazards in relation to the other communities in the study area.

Introduction

There are 19 residential hazard zones in the study area (see Figure 6) Hazard ratings have been assigned based on five categories: low, moderate, high, very high and extreme. Two zones are rated as moderate, 12 as high and five as very high.

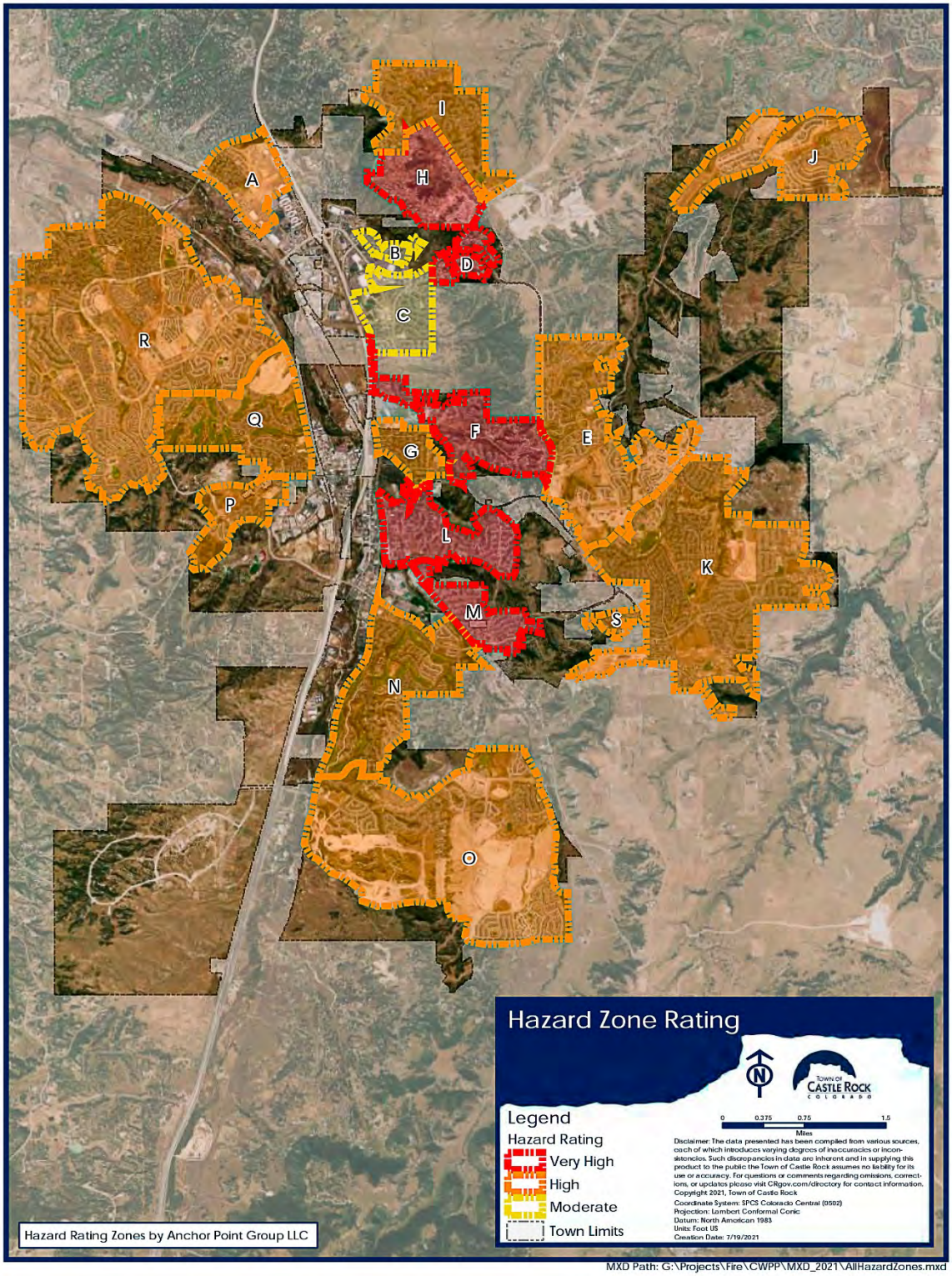

Figure 6 Hazard Zone Ratings

Zone A encompasses residential development in the Promenade and Outlets neighborhoods. Zone B includes part of Metzler Ranch. Zone C includes the rest of Metzler Ranch. Zone D includes Timber Canyon and Pinon Soleil. Zone E includes the Castle Oaks and Terrain neighborhoods. Zone F includes The Woodlands and Escavera. Zone G includes Castle North and the northern residential portion of downtown. Zone H includes Diamond Ridge. Zone I includes Maher Ranch (Sapphire Point). Zone J includes Cobblestone Ranch. Zone K includes the Founders Village and Castlewood Ranch neighborhoods. Zone L includes the eastern residential portion of downtown. Zone M includes Young American, Baldwin Park, part of the Memmen Young neighborhood within the city limits and some of the southern residential portion of downtown. Zone N includes the Plum Creek neighborhood. Zone O includes the portions of Crystal Valley Ranch, Heckendorf Ranch and The Lanterns that are within the city limits. Zone P includes Castle Highlands. Zone Q includes Red Hawk. Zone R includes The Meadows and Town Center. Zone S includes the part of Ridge Oaks inside the city limits. A summary of the hazard ratings is shown in Table 2**.**

Table 2 Structural ignitability hazard ratings by zone

Zone Name	Hazard Rating and WHR Score
Hazard Zone A	High - 77
Hazard Zone B	Moderate - 72
Hazard Zone C	Moderate - 54
Hazard Zone D	Very High - 112
Hazard Zone E	High - 93
Hazard Zone F	Very High - 114
Hazard Zone G	High - 108
Hazard Zone H	Very High - 117
Hazard Zone I	High - 96
Hazard Zone J	High - 102
Hazard Zone K	High - 108
Hazard Zone L	Very High - 125
Hazard Zone M	Very High - 120
Hazard Zone N	High - 91
Hazard Zone O	High - 99
Hazard Zone P	High - 92
Hazard Zone Q	High - 87
Hazard Zone R	High - 94
Hazard Zone S	High - 100
WHR Rating Categories: Low < 40; Moderate 41-74; High 75-110; V High 110-140, Ext >140	

Structural Ignitability Discussion – Hazard Zone A

Figure 7 Hazard Zone A

Hazard Rating:	**High**
Utilities Above or Below Ground:	Below ground
General Construction:	Primarily combustible siding with asphalt shingle roofs
Average Lot Size:	< 1 acre
Dual Access Roads:	Yes
Road Widths, Slope and Surface:	Good
Water Supply:	Hydrants
Proximity to Fire Station:	Station 154, mean distance 1.86 miles
Terrain:	Flat to moderate slope, Primary aspect, SW

Hazards:

- Flammable decks, projections, and fences
- Flammable ornamental plantings too close to structures
- Close proximity of buildings could result in house-to-house transmission

Operational Factors:

- Recent development has created large areas without fuels

Zone Characteristics and Additional Information

Zone A encompasses residential development in the Promenade and Outlets neighborhoods. Multi-family homes including apartments and condos are the dominant structures. This is a high-density area and buildings are close together. Most are newer construction and development is ongoing. This area is bordered by the City of Castle Pines which has larger homes with larger lots and heavier loads of primarily conifer fuels. Ignitions in this part of Castle Pines could spread to homes in this zone through ember cast.

Figure 8 Hazard Zone A, Aerial View

Structural Ignitability Discussion – Hazard Zone B

Figure 9 Hazard Zone B

Hazard Rating:	**Moderate**
Utilities Above or Below Ground:	Below ground
General Construction:	Primarily combustible siding with asphalt shingle roofs
Average Lot Size:	< 1 acre
Dual Access Roads:	Yes
Road Widths, Slope and Surface:	Generally good. Some steep grades
Water Supply:	Hydrants
Proximity to Fire Station:	Station 155, mean distance 1.7 miles
Terrain:	Some steep slopes, various aspects predominately SW

Hazards:

- Flammable decks projections and fences
- Heavy pockets of oak brush and grass is stringers & islands in open space
- Moderate to heavy loads of shrub fuels to the NE

Operational Factors:

- Cul-de-sacs and dead ends

Zone Characteristics and Additional Information

Zone B includes part of Metzler Ranch. Homes in this zone are primarily multi-family structures, condos and townhouses. Although there are some structures with stucco or brick near the ground, most are built with combustible siding and asphalt roofs. Native fuels are primarily oak brush with grass understory, but there are also scattered conifers.

Figure 10 Hazard Zone B, Aerial View

Structural Ignitability Discussion – Hazard Zone C

Figure 11 Hazard Zone C

Hazard Rating:	**Moderate**
Utilities Above or Below Ground:	Below ground
General Construction:	Primarily combustible siding with asphalt shingle roofs
Average Lot Size:	< 1 acre
Dual Access Roads:	Yes
Road Widths, Slope and Surface:	Good
Water Supply:	Hydrants
Proximity to Fire Station:	Station 155, mean distance 1.7 miles
Terrain:	Flat to gently sloping. Primary aspect West

Hazards:

- Close proximity of buildings could result in house-to-house transmission
- Flammable ornamental plantings close to structures

Operational Factors:

- No defensible space

Zone Characteristics and Additional Information

Zone C includes the residential portions of Metzler Ranch not in Zone B. Predominantly small to mid-sized homes on small lots. The dominant construction type is combustible siding with an asphalt roof, but some homes have partial brick or stone veneer near the ground. Most of the homes are typical of late 20th Century construction. Fuels inside this area consist of mostly ornamental plantings. Most homes have small, irrigated lawns. Natural fuels border this area and include grasses and shrubs occurring in stringers and patches.

Figure 12 Hazard Zone C, Aerial View

Structural Ignitability Discussion – Hazard Zone D

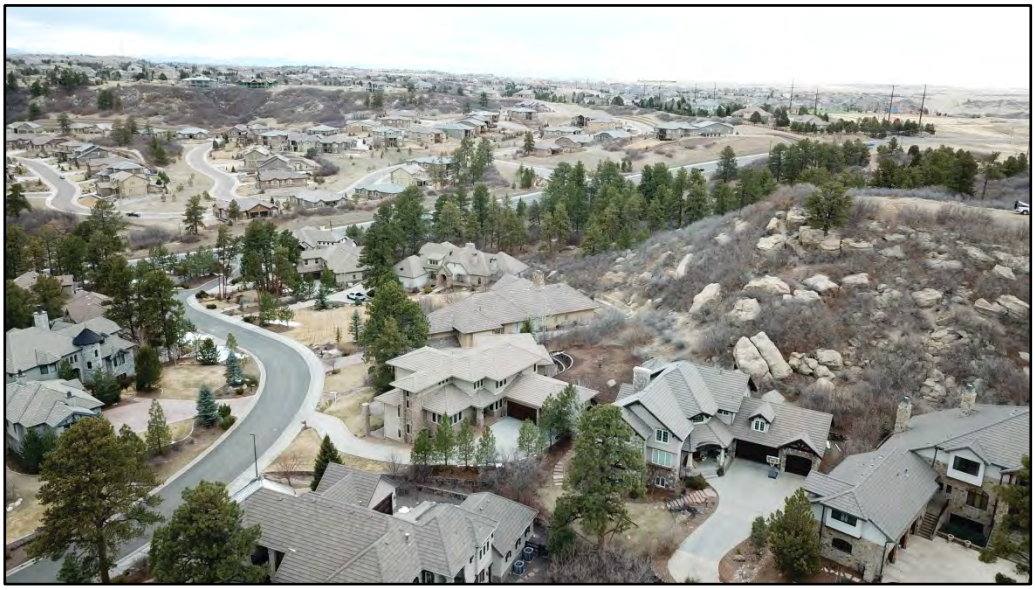

Figure 13 Hazard Zone D

Hazard Rating:	**Very High**
Utilities Above or Below Ground:	Below ground
General Construction:	Mix of Ignition Resistant and combustible siding with asphalt shingle or tile roof
Average Lot Size:	Approximately 1 acre
Dual Access Roads:	No
Road Widths, Slope and Surface:	Paved. Some steep grades, mid-slope roads
Water Supply:	Hydrants
Proximity to Fire Station:	Station 155, mean distance 0.8 miles
Terrain:	Steep slopes, ravines. Primary aspect, West

Hazards:

- Flammable outbuildings, decks, projections, and fences
- Natural and ornamental vegetation close to structures
- Homes mid-slope and at the top of ravines
- Decadent timber stands

Operational Factors:

- No defensible space
- Cul-de-sacs and dead ends

Zone Characteristics and Additional Information

Zone D includes Timber Canyon and Pinon Soleil. Large, upscale homes on small to medium size lots. Most are newer construction. This area is still being built out. Construction types are a mix of ignition resistant and combustible siding with an asphalt or tile roof. Mostly conifer with grass and/or shrub understory. Some pockets of shrubs are dense.

Figure 14 Hazard Zone D, Aerial View

Structural Ignitability Discussion – Hazard Zone E

Figure 15 Hazard Zone E

Hazard Rating:	**High**
Utilities Above or Below Ground:	Below ground, but some transmission lines
General Construction:	Combustible siding with asphalt shingle roof
Average Lot Size:	< 1 acre
Multi Access Roads:	Yes
Road Widths, Slope and Surface:	Good
Water Supply:	Hydrants
Proximity to Fire Station:	Station 155, mean distance 2.3 miles
Terrain:	Rolling hills, mixed aspects

Hazards:

- Flammable decks, projections, and fences
- Homes built mid-slope and at the top of hills
- Significant islands of oak brush in open space corridors

Operational Factors:

- No defensible space

Zone Characteristics and Additional Information

Zone E includes the Castle Oaks and Terrain neighborhoods. Homes in this zone are small to moderate size on small lots, built close together in clusters. The dominant construction type is wood siding with asphalt roofs. Fuels are mostly grass with islands of oak brush. Some areas have oak brush stringers running between the homes. Fires occurring on a windy day could spread across islands of oak brush through ember cast.

Figure 16 Hazard Zone E, Aerial View

Structural Ignitability Discussion – Hazard Zone F

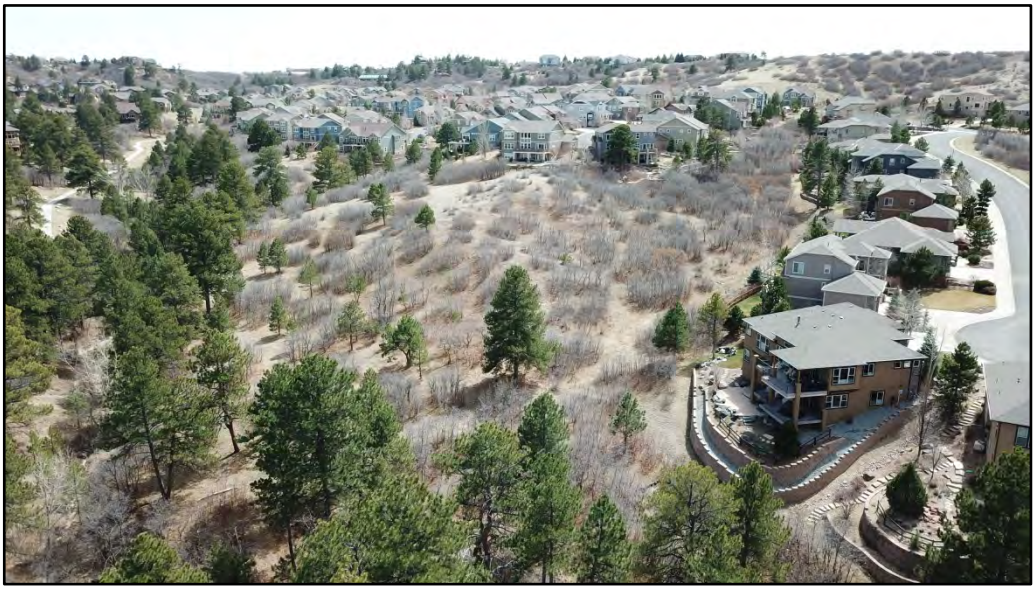

Figure 17 Hazard Zone F

Hazard Rating:	**Very High**
Utilities Above or Below Ground:	Below ground
General Construction:	Mix of ignition resistant and combustible siding with asphalt shingle or tile roof
Average Lot Size:	< 1 acre
Multi Access Roads:	Yes
Road Widths, Slope and Surface:	Generally good, but some steep grades
Water Supply:	Hydrants
Proximity to Fire Station:	Station 151, mean distance 1.9 miles
Terrain:	Steep slopes and ravines. Mixed aspects

Hazards:

- Flammable eaves, trim, decks, projections, and fences. Wood shake architectural features
- Homes built mid-slope and on ridge tops
- Flammable ornamentals near structures including tall grasses and conifers
- "The Bowl" open space has heavy loads of oak brush.

Operational Factors:

- No defensible space

Zone Characteristics and Additional Information

Zone F includes The Woodlands and Escavera. Homes in this zone are generally larger homes of newer construction. Many have ignition resistant siding (stucco or brick), but still have flammable features. Wood siding construction becomes dominant on the NW side where homes and lots tend to be smaller. Homes are built close together. There are pockets of timber and shrub fuels throughout this zone.

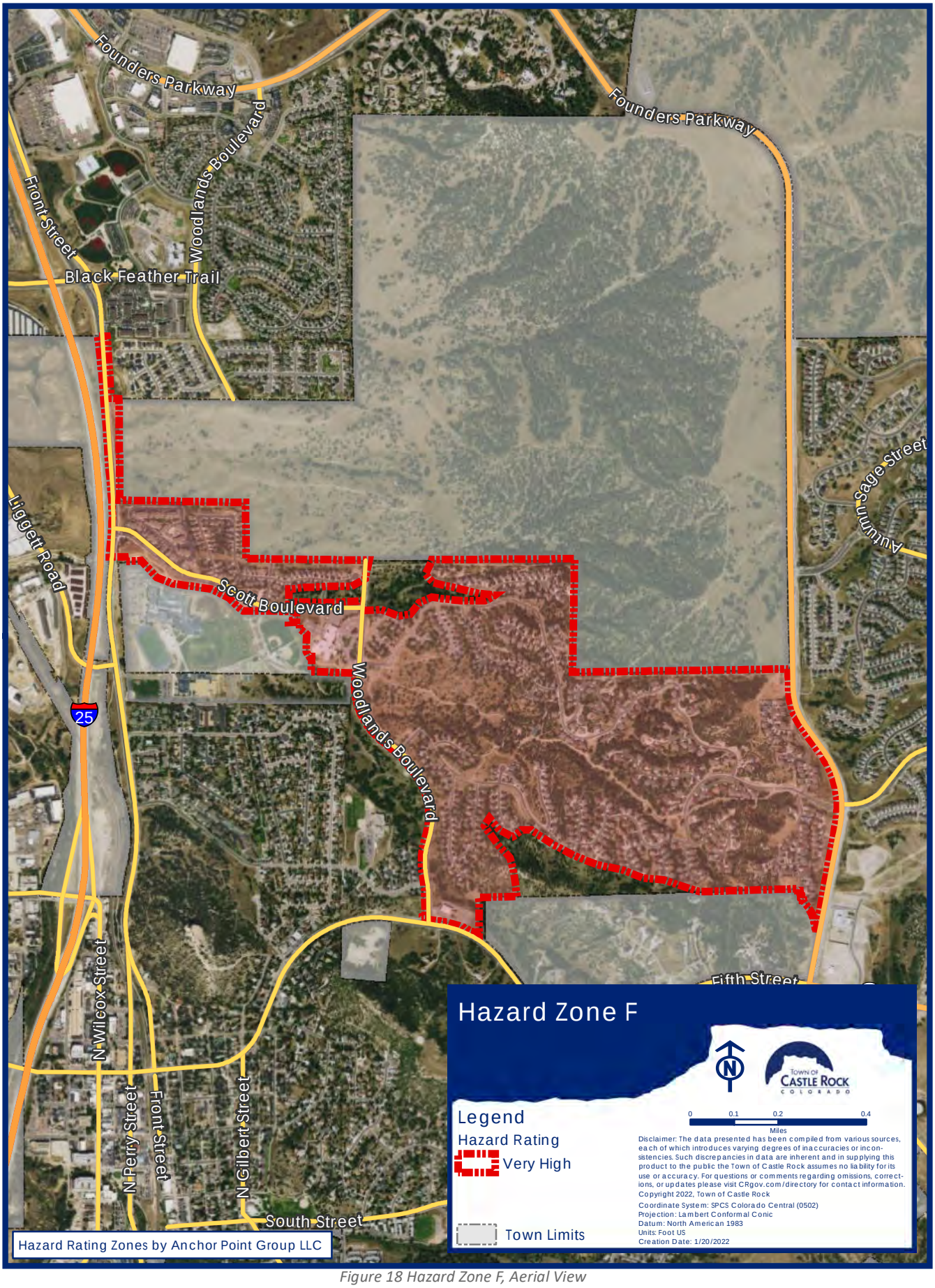

Figure 18 Hazard Zone F, Aerial View

Structural Ignitability Discussion – Hazard Zone G

Figure 19 Hazard Zone G

Hazard Rating:	**High**
Utilities Above or Below Ground:	Below ground
General Construction:	Combustible siding with asphalt shingle roof
Average Lot Size:	< 1 acre
Multi Access Roads:	Yes
Road Widths, Slope and Surface:	Generally good, but some steep grades
Water Supply:	Hydrants
Proximity to Fire Station:	Station 151, mean distance 1.1 miles
Terrain:	Moderately steep slopes & ravines. Primary aspect, West

Hazards:

- Combustible decks, projections, and fences
- Ornamental plantings close to many structures
- Rock Park open space to the southwest has heavy oak brush and trails that are potential ignition sources
- Moderate to heavy loads of shrubs and grasses in islands and stringers

Operational Factors:

- No defensible space

Zone Characteristics and Additional Information

Zone G includes Castle North and the northern residential portion of downtown. This zone is characterized by small to moderate size homes on small lots. The dominant construction is older single-family homes with wood siding and asphalt roofs. Homes are close together. Many homes have small, irrigated lawns.

Figure 20 Hazard Zone G, Aerial View

Structural Ignitability Discussion – Hazard Zone H

Figure 21 Hazard Zone H

Hazard Rating:	**Very High**
Utilities Above or Below Ground:	Below ground
General Construction:	Mix of ignition resistant and combustible siding with asphalt shingle or tile roof
Average Lot Size:	1 -5 acres
Multi Access Roads:	Yes, but secondary access winding & slow
Road Widths, Slope and Surface:	Generally good, but some steep grades
Water Supply:	Hydrants
Proximity to Fire Station:	Station 155, mean distance 0.8 miles
Terrain:	Steep slopes & ravines. Primary aspect, SE

Hazards:

- Flammable decks, projections, architectural details, and fences
- Homes located on ridge tops backed up to steep slopes with ravines and chimneys
- Flammable ornamental plantings & native fuels close to the structures. Large islands of native fuels
- "The Bowl" open space has heavy loads of oak brush.

Operational Factors:

- No defensible space
- Cul-de-sacs and dead ends

Zone Characteristics and Additional Information

Zone H includes Diamond Ridge and Timber Pines. Large to moderate size homes on moderate size lots. Newer construction with continuing development. There is a mix of ignition resistant and combustible siding. Most homes have stucco or brick near the ground, but many have flammable features. Homes are on larger lots. Many have some irrigated lawn. The entire area is surrounded by moderate to heavy loads of shrubs and timber.

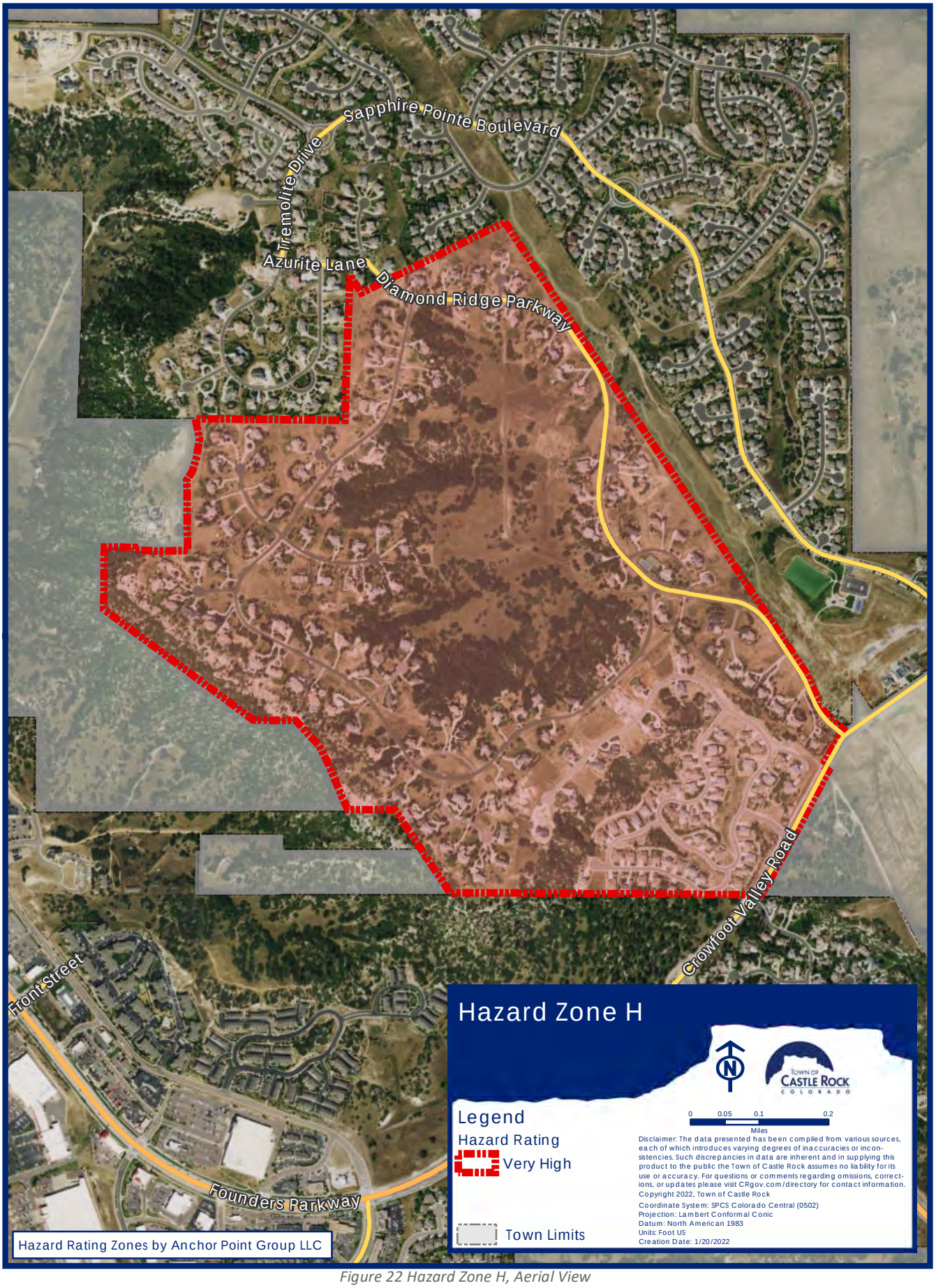

Figure 22 Hazard Zone H, Aerial View

Structural Ignitability Discussion – Hazard Zone I

Figure 23 Hazard Zone I

Hazard Rating:	**High**
Utilities Above or Below Ground:	Below ground except for some powerlines
General Construction:	Combustible siding with asphalt shingle roof
Average Lot Size:	<1 acre
Multi Access Roads:	Yes
Road Widths, Slope and Surface:	Generally good, but some steep grades
Water Supply:	Hydrants
Proximity to Fire Station:	Station 155, mean distance 1.4 miles
Terrain:	Mod to steep slopes, ravines. Mixed aspects

Hazards:

- Flammable decks, projections, and fences
- Homes backed up to native fuels
- Flammable ornamental plantings & native fuels close to the structures. Fuel islands.

Operational Factors:

- No defensible space
- Cul-de-sacs and dead ends

Zone Characteristics and Additional Information

Zone I includes Sapphire Point. Large to moderate size homes on small lots. Newer construction with continuing development. Higher density and smaller lot sizes than Zone H. Some homes with stucco or brick near the ground, but most built with combustible siding and asphalt roofs. Many homes have small, irrigated lawns. Fuels are generally light to moderate coverings of grass, but oak brush exists in stringers and patches. Heavier loads of shrub and timber exist on slopes and in ravines to the west, which is a concern for ember cast into this zone.

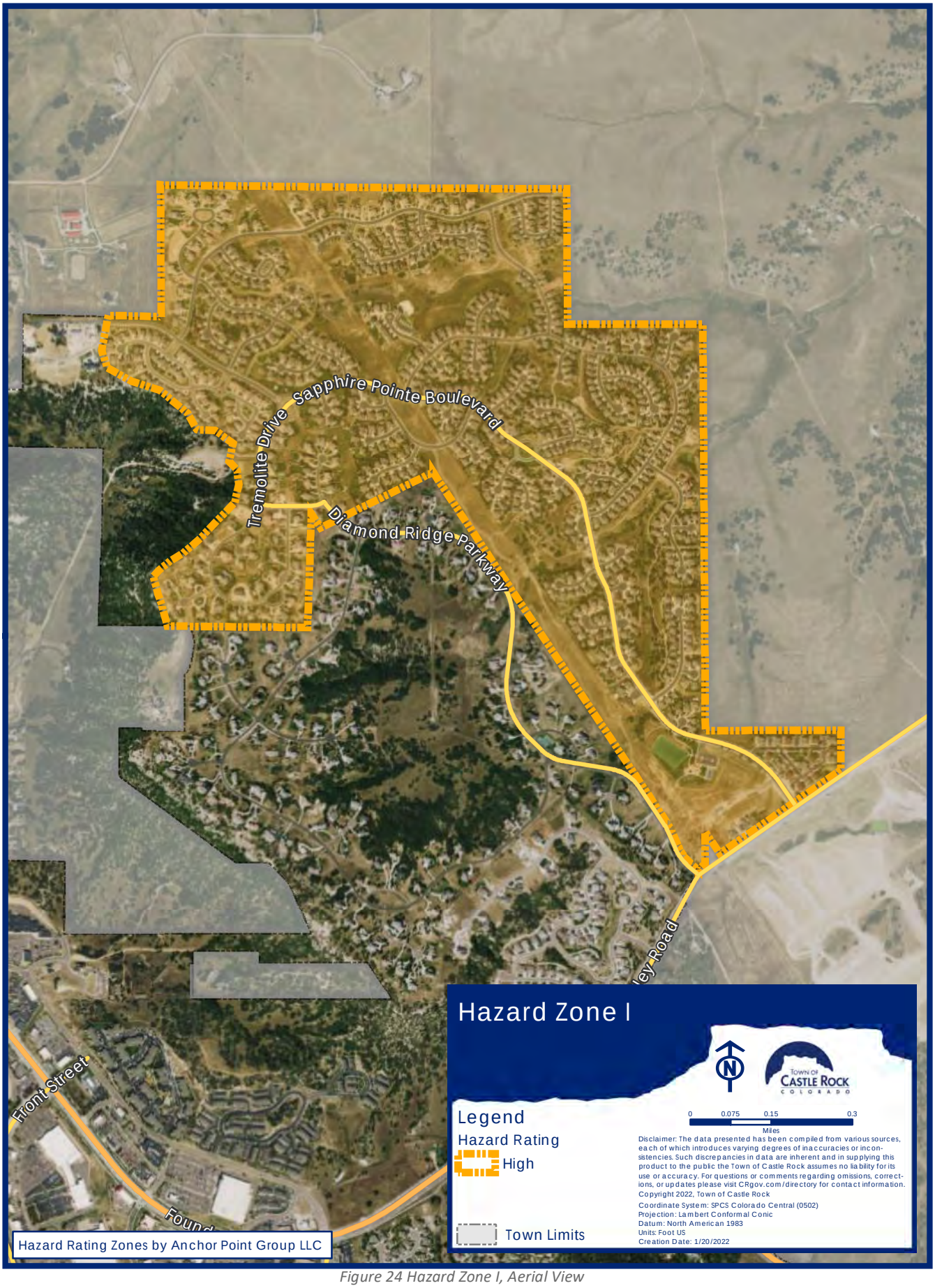

Figure 24 Hazard Zone I, Aerial View

Structural Ignitability Discussion – Hazard Zone J

Figure 25 Hazard Zone J

Hazard Rating:	**High**
Utilities Above or Below Ground:	Below ground
General Construction:	Combustible siding with asphalt shingle roof
Average Lot Size:	<1 acre
Multi Access Roads:	Yes
Road Widths, Slope and Surface:	Generally good, but some tight loops
Water Supply:	Hydrants
Proximity to Fire Station:	Station 155, mean distance 2.9 miles
Terrain:	Low to moderate slopes. Mixed aspects

Hazards:

- Flammable decks, projections, and fences
- Flammable ornamental plantings & fuel beds of native grasses close to structures

Operational Factors:

- No defensible space
- High density and tight turns could complicate evacuation
- Long response time

Zone Characteristics and Additional Information

Zone J includes Cobblestone Ranch. Moderate size homes on small lots very close together. This area is still being built out. Newer construction, primarily wood siding and asphalt roofs. Some homes have masonry veneer near the ground, but most do not. Some homes have small, irrigated lawns. Fuels near the homes are mostly grasses. Heavier loads of shrubs and timber exist in the more complex topography to the west and south, which is a concern for ember cast in this zone. An ignition in any of these large fuel beds could spread quickly through the grasses surrounding homes in this zone.

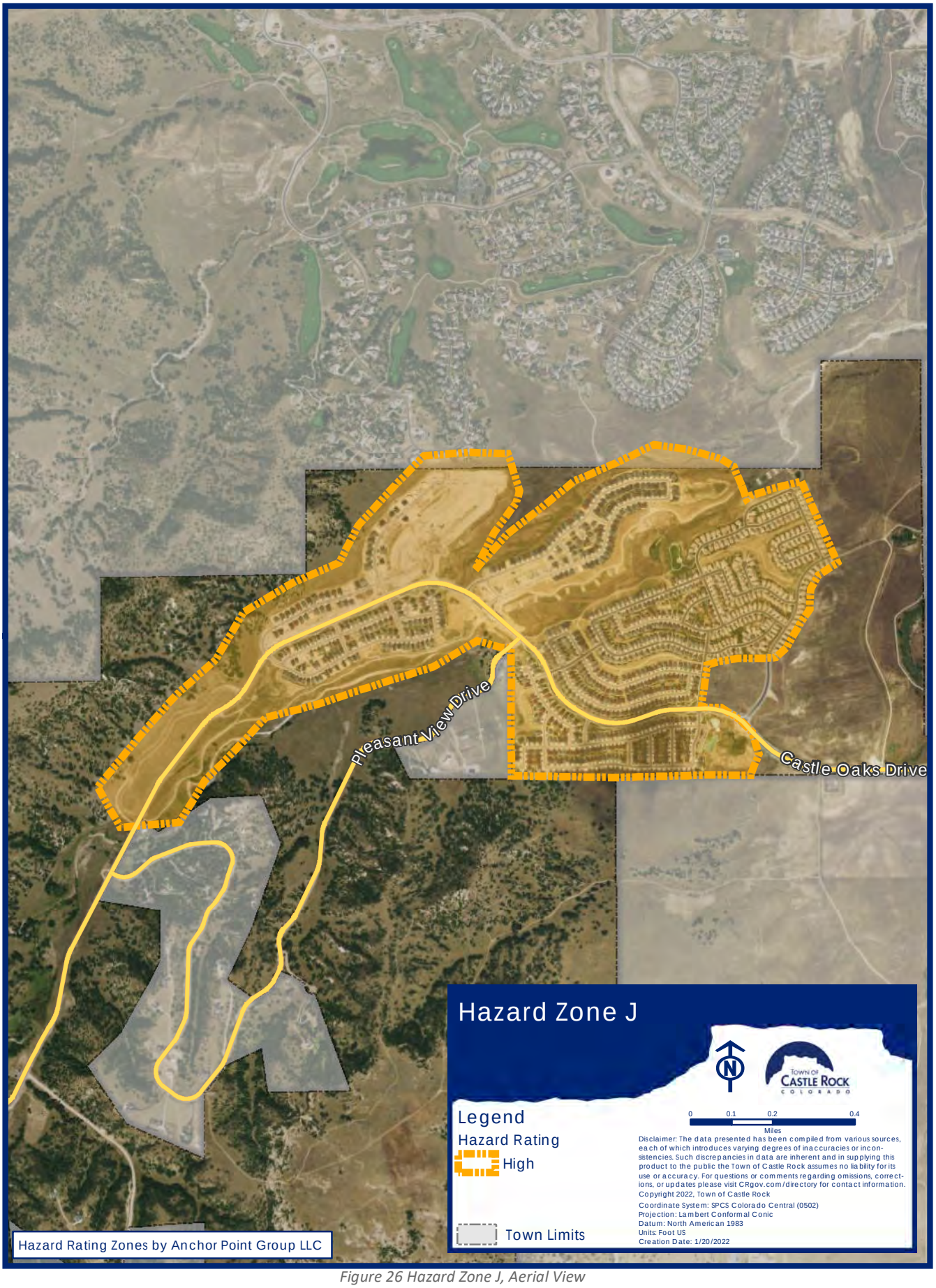

Figure 26 Hazard Zone J, Aerial View

Structural Ignitability Discussion – Hazard Zone K

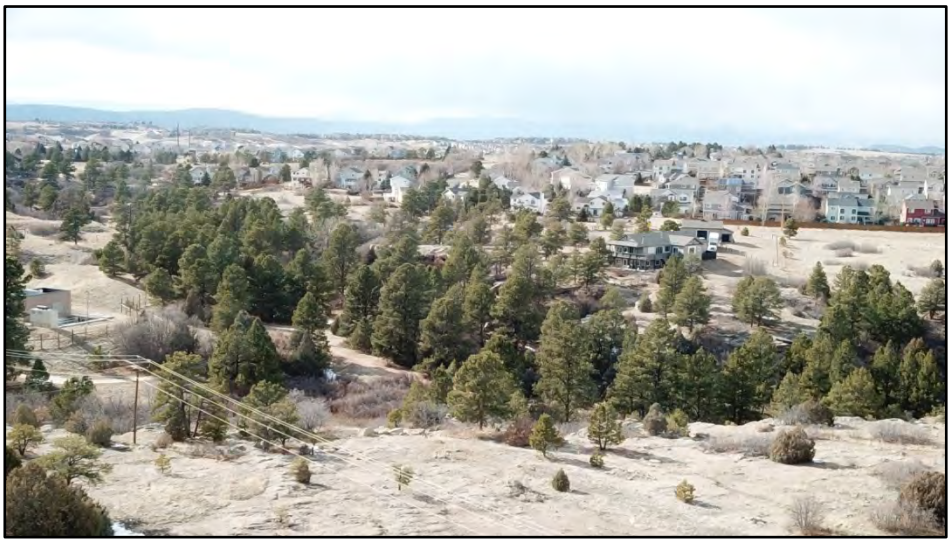

Figure 27 Hazard Zone K

Hazard Rating:	**High**
Utilities Above or Below Ground:	Below ground except for some powerlines
General Construction:	Combustible siding with asphalt shingle roof
Average Lot Size:	<1 acre
Multi Access Roads:	Yes
Road Widths, Slope and Surface:	Generally good, but some steep grades
Water Supply:	Hydrants
Proximity to Fire Station:	Station 153, mean distance 1.2 miles
Terrain:	Low to moderate slopes except near ravines

Hazards:

- Flammable decks, projections, and fences
- Flammable ornamental plantings and native fuels close to structures
- Mitchell Gulch has steep ravines with heavier fuel loads
- Heavy oak brush in islands and stringers
- Homes located mid-slope and on hill tops

Operational Factors:

- No defensible space

Zone Characteristics and Additional Information

Zone K includes the Founders Village and Castlewood Ranch neighborhoods. Moderate to small homes on small lots, very close together in most parts of this zone. Mix of new and older construction, primarily wood siding and asphalt roofs. Some homes have masonry veneer near the ground, but most do not. Fuels are moderate to heavy loads of grasses and shrubs. Steeper slopes with heavier timber and shrub fuels exist along the entire east side of this zone, which is a concern for ember cast.

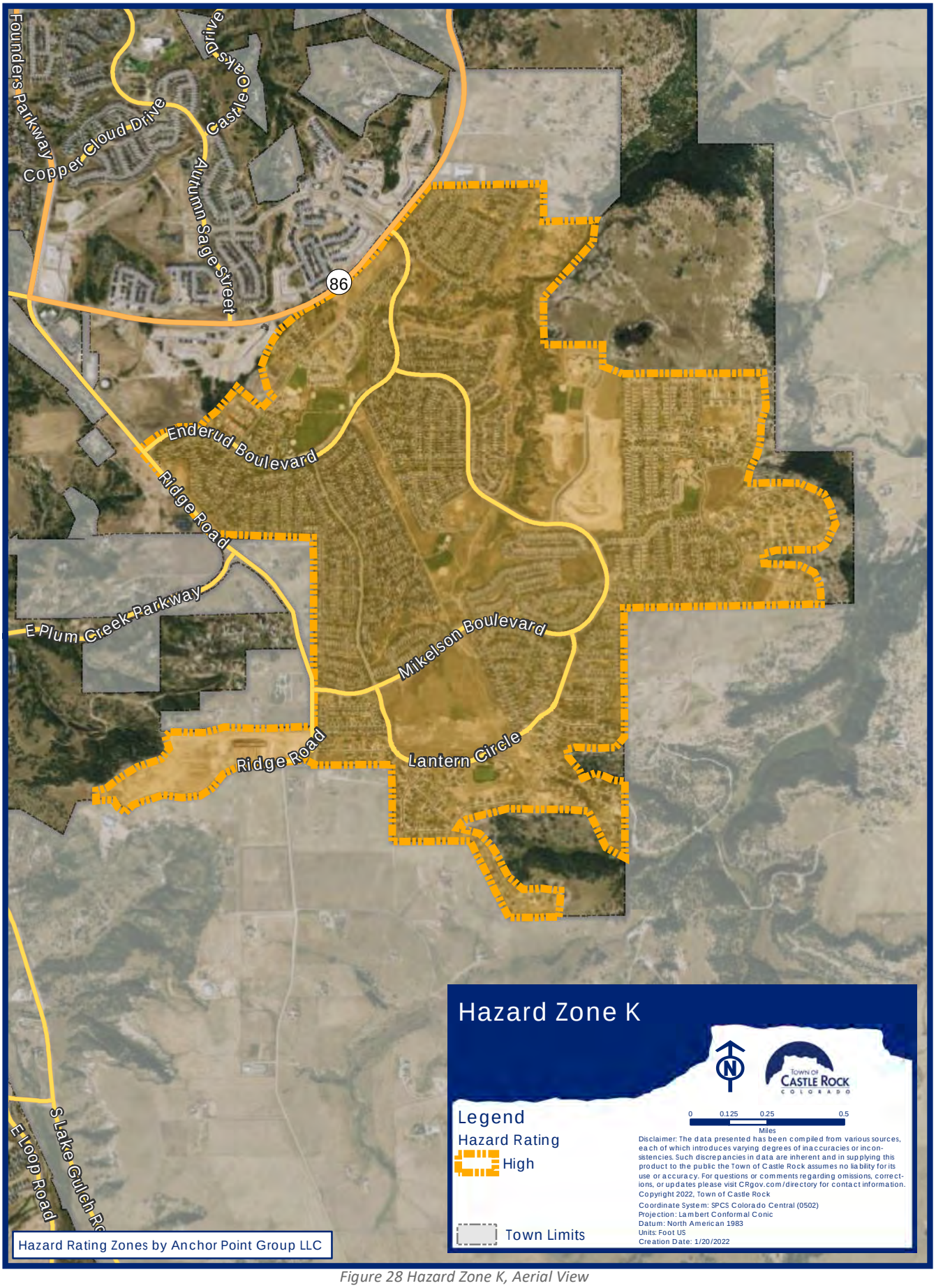

Figure 28 Hazard Zone K, Aerial View

Structural Ignitability Discussion – Hazard Zone L

Figure 29 Hazard Zone L

Hazard Rating:	**Very High**
Utilities Above or Below Ground:	Below ground except for some powerlines
General Construction:	Combustible siding with asphalt shingle roof
Average Lot Size:	<1 acre
Multi Access Roads:	Yes
Road Widths, Slope and Surface:	Generally good, but some steep grades
Water Supply:	Hydrants
Proximity to Fire Station:	Station 151, mean distance 0.8 miles
Terrain:	Steep slopes. Primary aspect, SW

Hazards:

- Flammable decks, projections, and fences
- Native fuels and flammable ornamental plantings close to structures
- Memmen Ridge Open Space has heavy fuels.
- Homes located mid-slope on steep to moderately steep hillsides

Operational Factors:

- No defensible space

Zone Characteristics and Additional Information

Zone L includes the eastern residential portion of downtown. Moderate to small homes on small lots, the dominant construction of which is combustible siding. Most homes are older construction. There are heavy, continuous fuel beds of Ponderosa pine and oak brush adjacent to this zone. A fire in Memmen Ridge Open Space could be especially threatening to this area.

Figure 30 Hazard Zone L, Aerial View

Structural Ignitability Discussion – Hazard Zone M

Figure 31 Hazard Zone M

Hazard Rating:	**Very High**
Utilities Above or Below Ground:	Below ground except for some powerlines
General Construction:	Combustible siding with asphalt shingle roof
Average Lot Size:	<1 acre
Multi Access Roads:	Yes
Road Widths, Slope and Surface:	Generally good, but some steep grades
Water Supply:	Hydrants
Proximity to Fire Station:	Station 151, mean distance 1.5 miles
Terrain:	Steep slopes, deep ravines. Primary aspect, SW

Hazards:

- Flammable decks, projections, and fences. Many in poor condition
- Memmen Ridge Open Space has heavy fuels
- Native fuels, flammable ornamental plantings close to structures. Oak brush fuel islands
- Homes located mid-slope

Operational Factors:

- No defensible space
- Dead ends and cul-de-sacs

Zone Characteristics and Additional Information

Zone M includes Young American, Baldwin Park, Glovers, part of Memmen Young and some of the residential portion of downtown. Mix of single and multi-family homes. Single family homes are small to moderate size on small lots. High density. Older construction of primarily wood siding with asphalt roofs. Memmen Ridge open space is between this zone and Zone L.

Figure 32 Hazard Zone M, Aerial View

Structural Ignitability Discussion – Hazard Zone N

Figure 33 Hazard Zone N

Hazard Rating:	**High**
Utilities Above or Below Ground:	Below ground
General Construction:	Mix of ignition resistant and combustible siding with asphalt shingle or tile roof
Average Lot Size:	<1 acre
Multi Access Roads:	Yes
Road Widths, Slope and Surface:	Generally good, but some steep grades
Water Supply:	Hydrants
Proximity to Fire Station:	Stations 151 & 152, mean distance 1.4 miles
Terrain:	Steep slopes, ravines. Primary aspect, West

Hazards:

- Flammable decks, projections, and fences
- Homes located mid-slope and on ridge tops
- Heavy jackpots of oak brush in stringers and islands (see Additional Information)

Operational Factors:

- No defensible space
- Golf course provides some fuel break (see below)

Zone Characteristics and Additional Information

Zone N includes the Plum Creek neighborhood. Mix of single and multi-family homes with most of the multi-family units on the north side. Moderate to large single-family homes of mostly newer construction on small lots. A golf course provides a fuel break between homes and the railroad line to the east; however, there are significant islands and stringers of oak brush in and around the fairways. Fires occurring on a windy day could easily spread across fairways through ember cast.

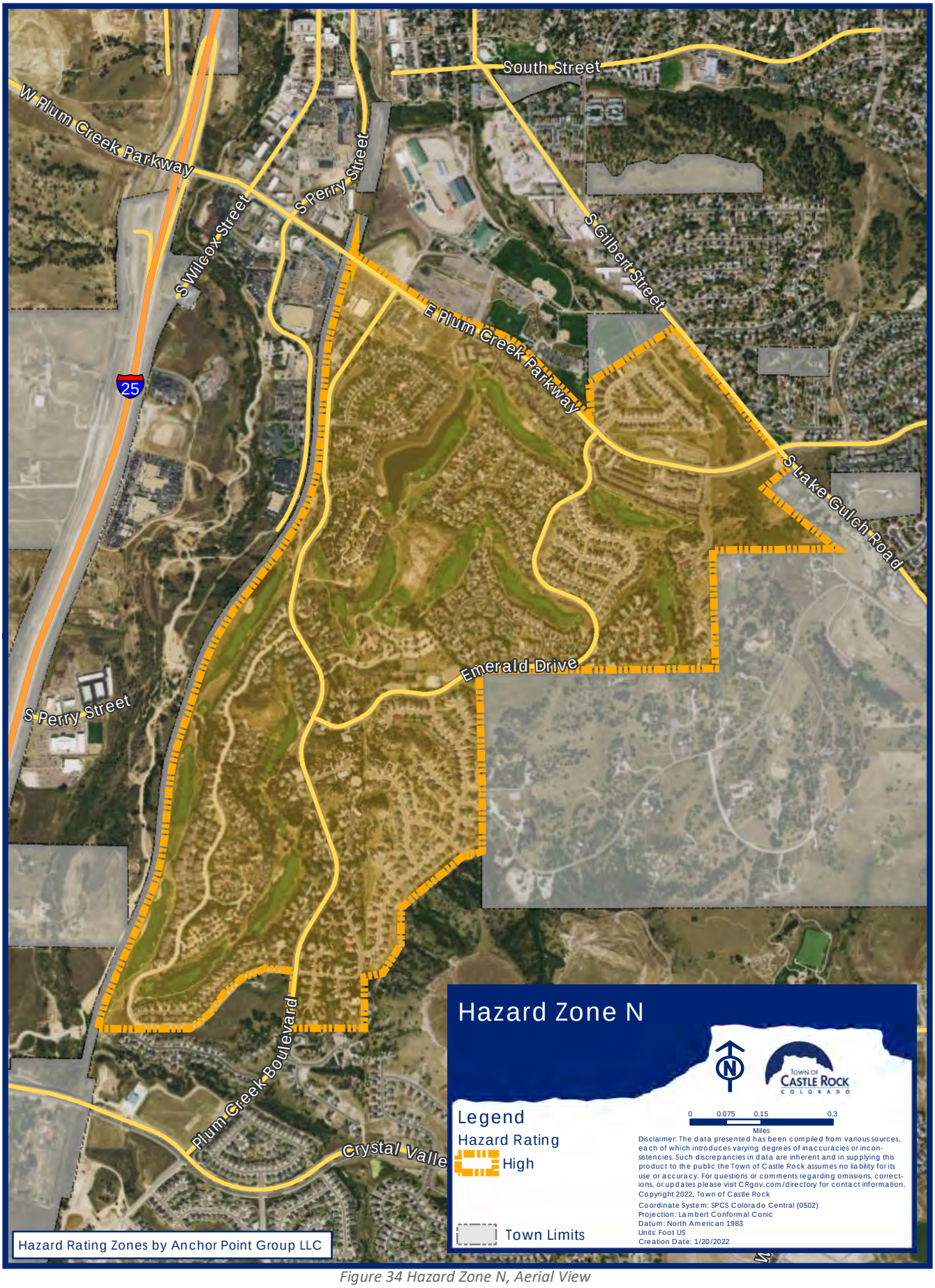

Figure 34 Hazard Zone N, Aerial View

Structural Ignitability Discussion – Hazard Zone O

Figure 35 Hazard Zone O

Hazard Rating:	**High**
Utilities Above or Below Ground:	Below ground
General Construction:	Mix of ignition resistant and combustible siding with asphalt shingle or tile roof
Average Lot Size:	<1 acre
Multi Access Roads:	Yes
Road Widths, Slope and Surface:	Some tight turns & steep grades, dead ends
Water Supply:	Hydrants
Proximity to Fire Station:	Station 152, mean distance 1.9 miles
Terrain:	Rolling and hilly. Mixed aspects

Hazards:

- Flammable decks, projections, and fences
- Homes located mid-slope and on ridge tops
- Islands and stringers of oak brush
- Natural fuels close to structures (but generally light loads of grasses)

Operational Factors:

- No defensible space, but recent development has created some large areas without fuels

Zone Characteristics and Additional Information

Zone O includes the portions of Crystal Valley Ranch, Heckendorf Ranch and The Lanterns that are within the city limits. Moderate to large homes on small lots. Newer construction. This area is still being built out. There are some homes with ignition resistant siding, but most have combustible siding with an asphalt roof. There is a large open space in and bordering this zone adjacent to railroad tracks. Natural fuels consist mostly of grasses and shrubs.

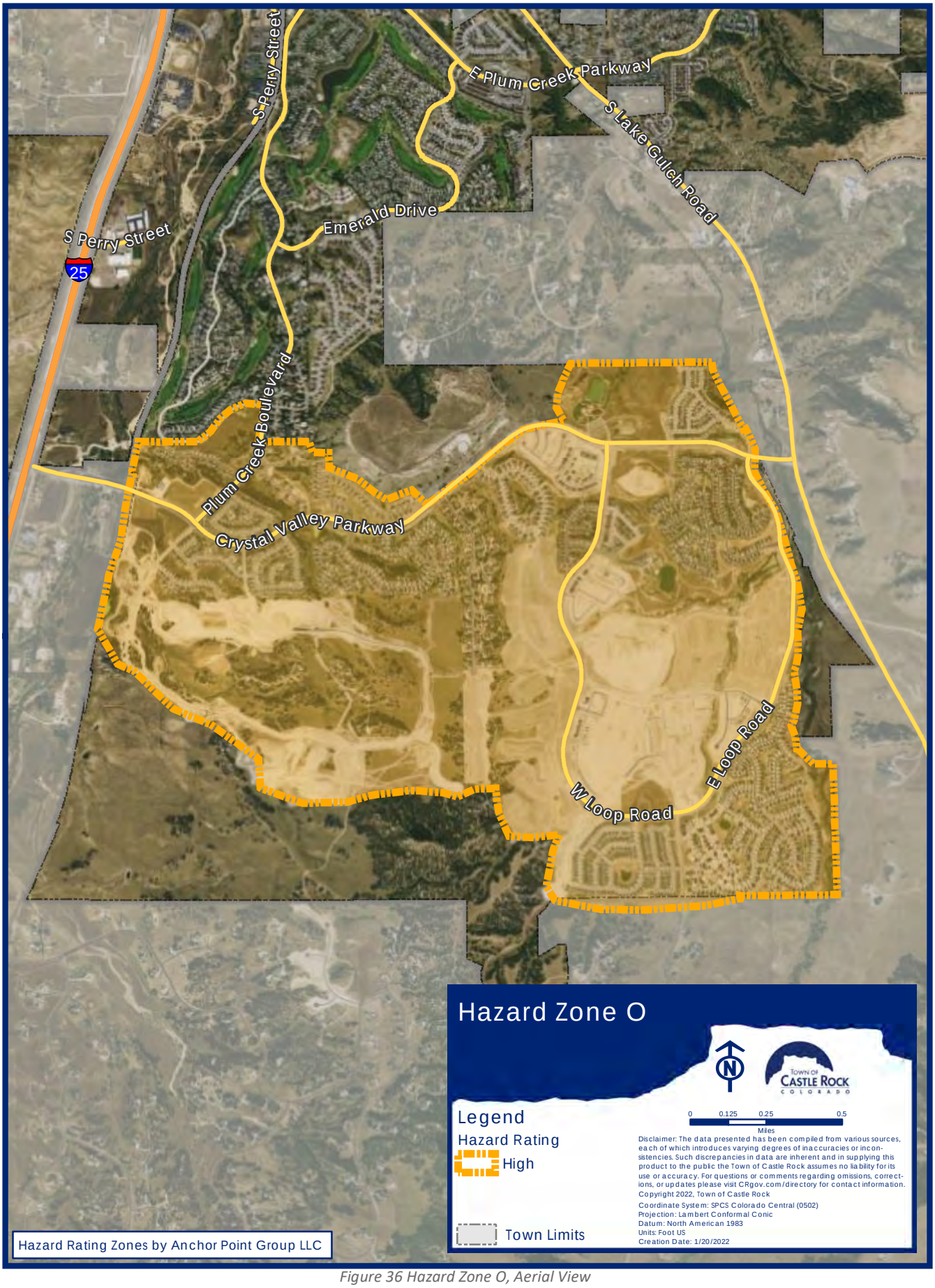

Figure 36 Hazard Zone O, Aerial View

Structural Ignitability Discussion – Hazard Zone P

Figure 37 Hazard Zone P

Hazard Rating:	**High**
Utilities Above or Below Ground:	Below ground
General Construction:	Mix of ignition resistant and combustible siding with asphalt shingle or tile roof
Average Lot Size:	<1 acre
Multi Access Roads:	Yes
Road Widths, Slope and Surface:	Good
Water Supply:	Hydrants
Proximity to Fire Station:	Station 154, mean distance 1.9 miles
Terrain:	Moderate slopes. Primary aspect, NE

Hazards:

- Flammable decks, projections, and fences
- Flammable ornamental plantings close to structures
- Heavy loads of shrub fuels in islands in Castle Highlands Park; center of this zone
- Homes located mid-slope, but most slopes not more than 15%.

Operational Factors:

- No defensible space

Zone Characteristics and Additional Information

Zone P includes Castle Highlands. Mix of multi-family and moderate size single family homes on small lots. High density, homes are close together. Homes are recent, and this area is still being built out. Most buildings have combustible siding with masonry trim near the ground. Natural fuels near the homes are mostly grass with some oak brush. Heavy loads of shrub fuels and steeper, more complex topography borders homes on the south side, which is a concern for ember cast. These fuel beds are continuous to Philip S. Miller Park.

Figure 38 Hazard Zone P, Aerial View

Structural Ignitability Discussion – Hazard Zone Q

Figure 39 Hazard Zone Q

Hazard Rating: **High**
Utilities Above or Below Ground: Below ground
General Construction: Combustible siding with asphalt shingle roof
Average Lot Size: <1 acre
Multi Access Roads: No. Red Hawk Drive is the only access
Road Widths, Slope and Surface: Good
Water Supply: Hydrants
Proximity to Fire Station: Station 154, mean distance 1.3 miles
Terrain: Hilly, steep slopes. Primary aspect, East
Hazards:

- Flammable decks, projections, and fences
- Homes located mid-slope and on hill tops
- Heavy jackpots of oak brush in stringers and islands (see Additional Information)

Operational Factors:

- No defensible space
- Dead ends and cul-de-sacs
- Golf course provides some fuel break (see below)

Zone Characteristics and Additional Information

Zone Q includes Red Hawk. Mix of multi-family and moderate size, single family homes on small lots. Most multi-family dwellings are on the southeast side. A golf course provides some fuel break between homes and moderate to heavy loads of shrub and grass fuels to the south; however, there are significant islands and stringers of oak brush in and around the fairways. Fires occurring on a windy day could easily spread across fairways through ember cast.

Figure 40 Hazard Zone Q, Aerial View

Structural Ignitability Discussion – Hazard Zone R

Figure 41 Hazard Zone R

Hazard Rating:	**High**
Utilities Above or Below Ground:	Below ground
General Construction:	Combustible siding with asphalt shingle roof
Average Lot Size:	<1 acre
Multi Access Roads:	Yes
Road Widths, Slope and Surface:	Generally good, but some narrow streets
Water Supply:	Hydrants
Proximity to Fire Station:	Station 154, mean distance 1.6 miles
Terrain:	Flat to rolling. Mixed aspects

Hazards:

- Flammable decks, projections, and fences
- Flammable ornamental plantings too close to structures
- Close proximity of buildings could result in house-to-house transmission

Operational Factors:

- No defensible space
- Some streets with 16’ driving lanes

Zone Characteristics and Additional Information

Zone R includes The Meadows and Town Center. Mix of multi-family and single-family homes on small lots. The largest residential zone in Castle Rock. High density, many multi-family units near Town Center, mostly single-family homes toward the edges. Some homes are as little as six feet apart. This zone has significant islands of natural fuels between clusters of homes; however, most of these fuels are grasses and are in general more maintained than in most other zones. Some areas, especially on the south side of this zone, have pockets of heavier shrub fuels near homes that could be a concern for ember cast.

Figure 42 Hazard Zone R, Aerial View

Structural Ignitability Discussion – Hazard Zone S

Figure 43 Hazard Zone S

Hazard Rating:	**High**
Utilities Above or Below Ground:	Below ground
General Construction:	Combustible siding with asphalt shingle roof
Average Lot Size:	1-5 acres
Multi Access Roads:	No
Road Widths, Slope and Surface:	Some long narrow drives w/ inadequate turnarounds. Some dirt driveways.
Water Supply:	Hydrants
Proximity to Fire Station:	Station 153, mean distance 2.3 miles
Terrain:	Hilly, steeper slopes & ravines to the West, Primary aspect, North

Hazards:

- Flammable decks, projections, and fences
- Few homes with defensible space
- Native fuels, flammable ornamental plantings close to structures. Oak brush fuel islands

Operational Factors:

- Few homes with defensible space

Zone Characteristics and Additional Information

Zone S includes the part of Ridge Oaks inside the city limits. Moderate to large single-family homes on moderate size lots. Although many of these homes have some masonry trim, the dominant construction type is combustible siding with an asphalt roof. Fuels are a mix of grass, shrubs, and shrubs with grass understory.

Figure 44 Hazard Zone S, Aerial View

Areas of Special Interest

In addition to the residential hazard zones the developed areas of Castle Rock also contain five areas of special interest (ASIs). These ASIs are shown graphically in Figure 47.

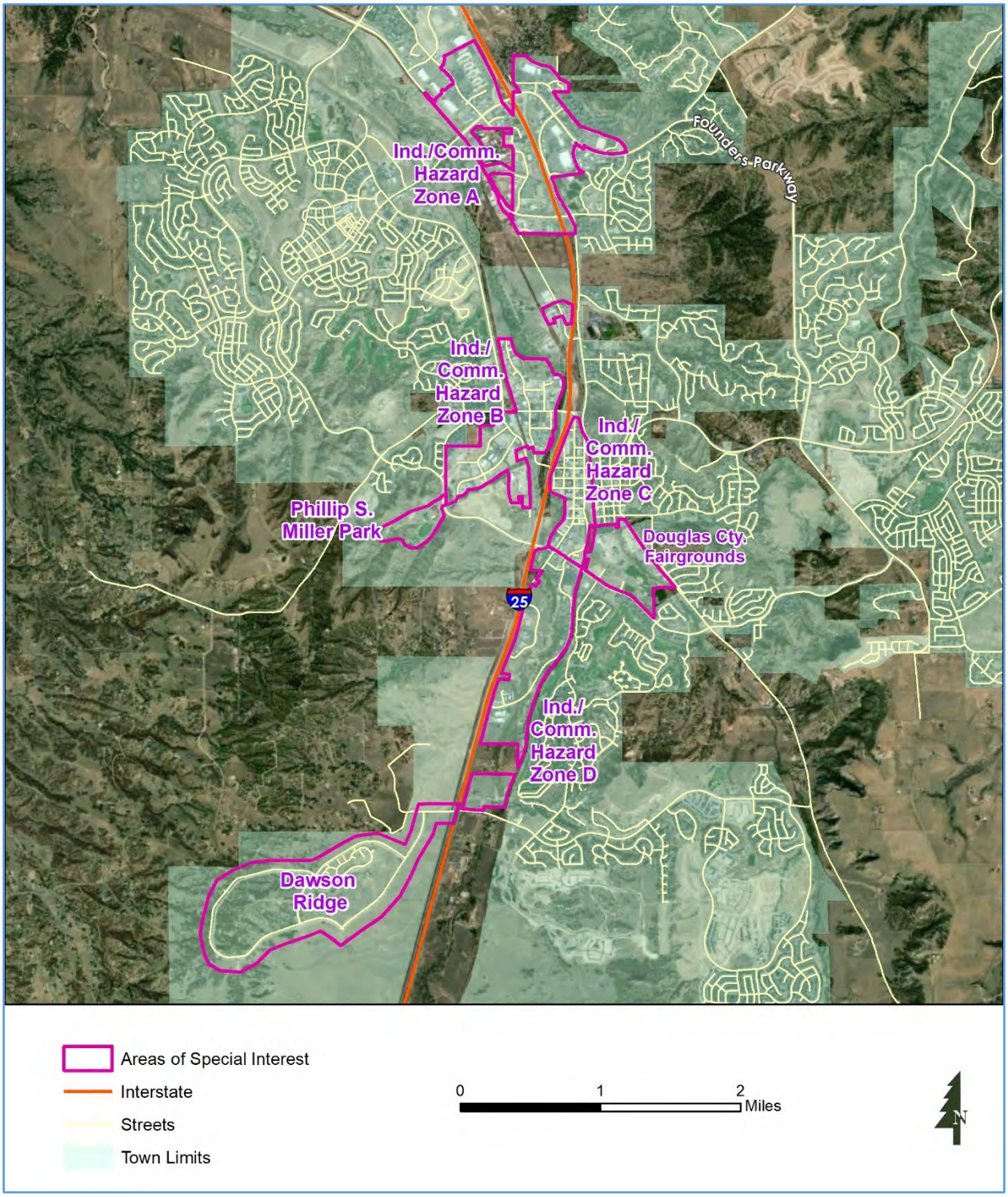

Figure 45 Areas of Special Interest

The commercial zones are dominated by large ignition resistant buildings and parking lots. In general, most native fuels have been removed and hazards to life and property from wildfire are low.

Commercial Zone A (CZ-A)

This zone is an area of primarily retail development and includes the Factory Shops and Promenade. This ASI runs between I-25 and US 85 south of residential Hazard Zone A. There is a railroad line to the west. There are moderately heavy loads of riparian vegetation along Plum Creek, however, fuels located near structures consist of isolated plantings of ornamentals and maintained lawns. The greatest hazard during a wildfire event would be the potential for gridlock during an evacuation.

Recommendations

No recommendations for this zone.

Commercial Zone B (CZ-B)

This zone is bordered on its west side by residential hazard zones Q and P and Philip S. Miller Park. This is a more industrial area, but like CZ-A, natural fuels are sparse except for along Plum Creek, where moderate loads of riparian vegetation exist, and along this zone's southern border where there are stringers of timber. Like CZ -A, buildings tend to be ignition resistant with large parking lots. The greatest threat to this area would be from ember cast produced by a fire in the heavier native fuels to the southwest. In general, however, this is an area where wildfire hazards are low.

Recommendations

Evaluate properties adjacent to East Plum Creek Open Space for adequate defensible space. Develop and maintain and emergency plan for schools in this zone that considers shelter in place as an alternative to evacuation. Evaluate properties backed up to stringers of timber along the southern border of this zone for adequate defensible space and fuels management.

Commercial Zone C (CZ-C)

This zone includes the downtown area which is a high-density area of retail, office, and government buildings. This area is bordered by I-25 on the west and a railroad line on the east. Although fuels in most of this zone are limited to scattered ornamental plantings, there are some significant loads of riparian vegetation along Plum Creek and Sellars Gulch that could carry fire through this zone under the right conditions. Except for these areas, fuels are so light and discontinuous that the major hazard during a wildfire would be the potential for gridlock during and evacuation.

Recommendations

No recommendations for this zone.

Commercial Zone D (CZ-D)

This zone runs between I-25 and the railroad line to the east from Plum Creek Parkway to the southern town limits. Like the other commercial zones, the buildings tend to be larger, ignition resistant structures with large parking lots. Structure density is lower here and there are some significant natural fuel beds between properties. With the exception of some moderate loads of riparian vegetation along some sections of Plum Creek, fuels tend to be grass with scattered clusters and stringers of shrubs and timber. Although the potential for ignition growth is greater in this zone, threats to life and property from wildfire are still low due to ignition resistant buildings, low density, large parking lots and other clearings and generally flat topography.

Recommendations

No recommendations for this zone.

Dawson Ridge

About thirty years ago Dawson Ridge was planned for development. Some infrastructure was built including a loop access road. This area was abandoned before any homes were built and it is currently gated and closed to the public. The neglected infrastructure would need to be rebuilt before any future development could begin. This area is a mean distance of 4.2 miles from the nearest fire station with some portions as much as 5.4 miles away. Territorial Road, a county-maintained dirt road is currently the only access to this area. Gentle terrain and grass fuels near I-25 transition quickly to steeper terrain with heavier loads of shrubs and timber.

Recommendations

Before any development is done a wildfire preplan should be prepared for this area. Fuels reduction and maintenance on slopes below the figure-eight access loop should be planned for at least 150 feet below the road grade to protect homes and access. A second point of access should be required. Lots of at least one acre or larger should be planned with Zone 1 and 2 defensible space required. Ignition resistant construction for homes in this area is highly recommended due to its isolated location in complex terrain surrounded by continuous natural fuel beds. Although the new Station 152, located on Crystal Valley Parkway is closer than any of the previously constructed CRFD stations, a new fire station should be considered for construction in this area before homes are sold and occupied. A revised and tested hydrant network or other reliable water source for fire suppression should be a requirement for development.

Other Areas for Future Investigation

In addition to the geographic areas of special interest discussed above, other non-residential values of special interest to the Castle Rock community should be identified and assessed for wildfire mitigation needs. These areas may include, but are not limited to:

- Schools
- Hospitals and clinics
- HOA Natural Spaces (see Figure 46)
- Town Owned lands/Open Space areas

Please also see the *Values at Risk – Critical Infrastructure* section of this report for a discussion of critical infrastructure values.

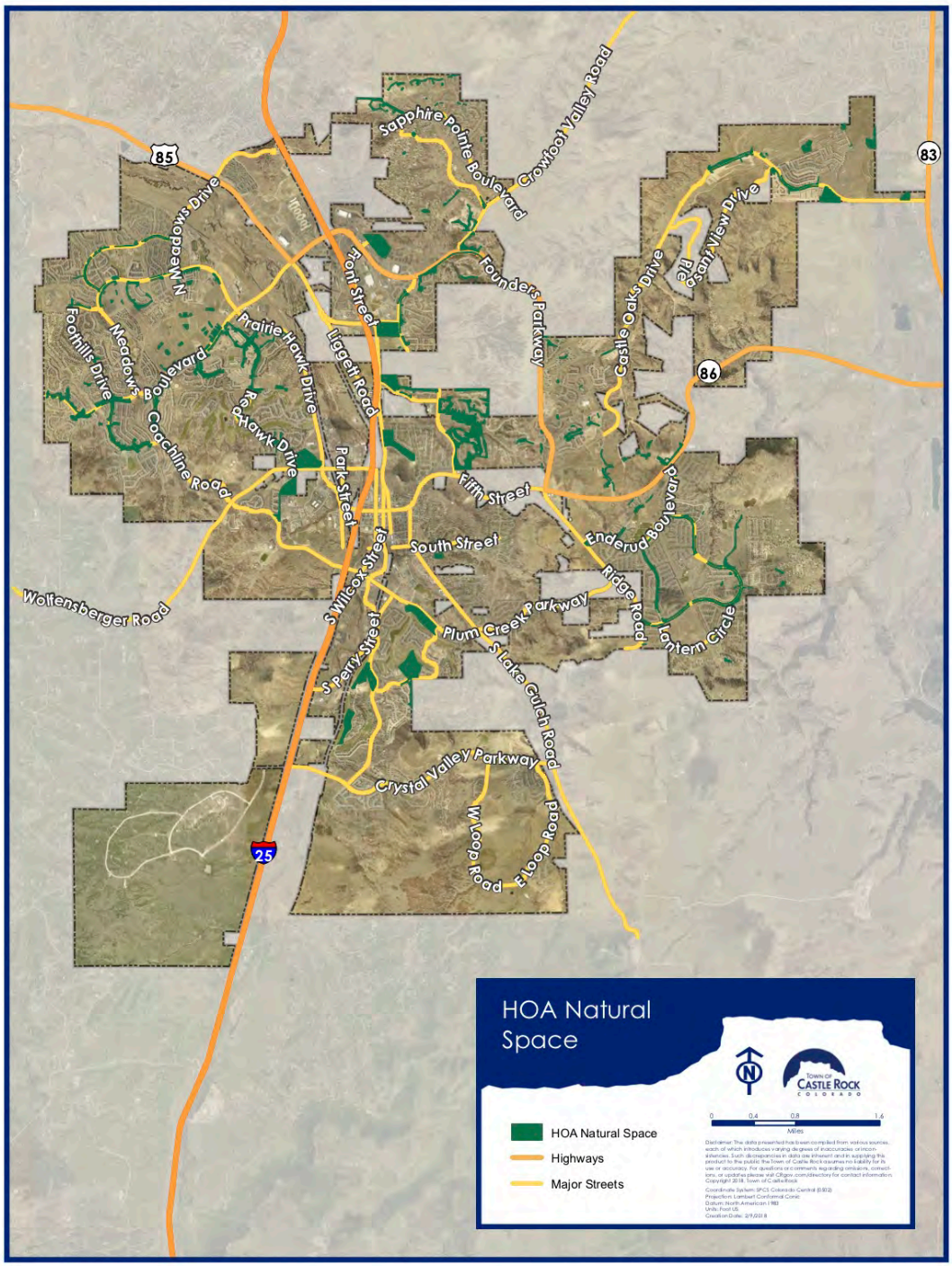

Figure 46 HOA Natural Spaces

Recommendations

General Recommendations

The following general measures listed below should be practiced throughout the study area. Some of these recommendations may already be in place in some areas.

1. Clean roofs and gutters at least twice a year. It is vital to remove pine needles and other flammable litter from the roof.
2. Don't store firewood or other combustibles under decks, stairs, or wooden projections.
3. Maintain an irrigated greenbelt or other non-combustible ground cover around buildings.
4. Maintain and clean spark arresters on any chimneys.
5. Connect and have available a minimum of 50 feet of garden hose near all buildings to extinguish small fires before they spread. For large buildings, two or more hoses may be required to provide adequate coverage.
6. Trees, large shrubs, and other vegetation along driveways should be pruned as necessary to maintain a minimum of 15 feet of vertical clearance for emergency vehicle access. This recommendation is for both conifers and deciduous trees.
7. Install illuminated, or reflective, house numbers so that they are clearly visible from the main road. Illuminated or reflective numbers should also be visible on the structure itself.
8. For driveways longer than 150 feet, a cleared turnaround for fire apparatus should be provided. Turnarounds may consist of a 96-foot circle, 60-foot "Y", or 120-foot "Hammerhead" described in the 2018 International Fire Code.[18] Driveways should be at least 20 feet wide where possible.
9. Maintain the defensible space around buildings by:
    a. Mowing grass and weeds to a height of four inches or less
    b. Removing any branches overhanging roofs or chimneys.
    c. Removing all trash, debris, and cuttings from the defensible space. Debris and cuttings should be removed entirely from the area and never dumped into adjacent wildlands or vacant lots.

It is essential to remember that fire mitigation is not a one-time job. Defensible space should be maintained year-round, and reducing structural ignitibility is an ongoing process. Detailed information for achieving these goals can be found in the *Home Ignition Zone Recommendations* section below and on the Colorado State Forest Service website.
https://csfs.colostate.edu/wildfire-mitigation/protect-your-home-property-from-wildfire/

Home Ignition Zone Recommendations

The two most important recommendations in this report are:

1) For existing structures to implement defensible space techniques and be fire hardened to the greatest extent practical.
2) For ignition resistant construction and defensible landscaping to be incorporated into future development.

One of the greatest challenges to limiting the potential damage from interface fires in the Town of Castle Rock is the lack of defensible space. Development in this area has emphasized density and as a result there are many neighborhoods with homes too close together to create individual defensible spaces. In some cases, homes are less than six feet apart. It is important to note that throughout Castle Rock land, adjacent to homes is of varied ownership and any fuels modifications extending beyond lot boundaries will require collaboration and perhaps special permission to implement. Homeowners need to be instructed they cannot cut and dump behind their property to create defensible space. It should also be noted that there are also some neighborhoods with larger lots that have good landscaping that mitigate the native fuels.

Structure hardening and ignition resistant planting will be discussed later, but first, we'll cover the basic practices involved in fuels management in the Home Ignition Zone. The defensible space concepts presented below can be applied to closely built groups of homes as well as individual homes built on larger lots with greater spacing. The authors and stakeholders of this report recognize the difficulty involved in coordinating large groups of homeowners and organizations such as HOAs; however, structure hardening and the creation of defensible spaces will produce the greatest benefits for the protection of life and the conservation of property from the effects of wildfire. For more information on broader community protection, please visit https://csfs.colostate.edu/wildfire-mitigation/ and https://fireadaptednetwork.org/ .

What is the Home Ignition Zone?

There are primarily two factors that determine a home's ability to survive wildfire, the ignitibility of the structure and the quality of the defensible space surrounding it. These two factors are combined in the Home Ignition Zone (HIZ) (See Figure 47), which takes into account both the structure itself and the space immediately surrounding it when designing actions to mitigate the effects of wildfire.

Under extreme conditions, wildland ignitions could quickly involve homes located on the edge of natural fuels and spread through neighborhoods by house-to-house transmission. This type of fire spread is similar to the 2012 Waldo Canyon fire near Colorado Springs that destroyed 486 homes and claimed two lives. It is clearly not possible to develop individual defensible space where homes are spaced very close together on small lots; however, it is possible to develop linked defensible space by building defensible perimeters around clusters of homes and replacing

native and flammable ornamental plantings near and between structures with ignition resistant plantings. (See Figure 48)

The following general information regarding creating defensible space has been adapted from information available on the Colorado State Forest Service (CSFS) website. The specific distances quoted below are guidelines, and depending on circumstances of fuels, topography, and ownership, these distances may need to be modified. For more information, please see the CSFS publication *Protecting Your Home from Wildfire: Fire 2020-1*.

Defensible space is defined as an area around a structure that has been modified to reduce fire hazards. Natural and manufactured fuels are treated, cleared, consolidated, or substituted with ignition-resistant landscaping to slow the spread and intensity of fire. The development of defensible space involves three zones in which different techniques are deployed. These zones should be developed for every structure on the property, including detached garages, storage sheds, barns, etc., as well as the home. The specific design depends on many factors, including, but not limited to, the size and shape of buildings, construction materials, topography, and vegetative type.

Zone 1 extends from zero to five feet from the structure. Zone 1 distance is measured from the outside edge of the eves, decks, or other attached projections.

- In general, nothing should be planted in the first five feet from the structure, and ground cover should be non-flammable such as gravel, cement, or flagstones.
- Any cuttings, mulch, or woody debris should be removed.
- Pine needles and any other flammable debris should be removed from any decks or projections and raked to a distance of five feet away from these. Raking this material more than five feet has not been shown to significantly reduce the likelihood of ignition and is not recommended.
- Any branches that overhang the roof or are within 10 feet of a chimney should be removed.

Zone 2 extends from five to 30 feet from the structure and is managed to reduce the intensity of approaching fire. Fuels management in this Zone consists of the following:

- Remove any stressed, diseased, dead, or dying trees or shrubs.
- Create at least 10 feet of crown spacing between an individual or small groups of trees. Groups of two or three trees may be left in some areas, but a spacing of 30 feet is recommended between such groupings.
- Remove ladder fuels and prune branches from tree trunks up to a height of 6-10 feet or 1/3 of the tree height, whichever is less. Limbs should be cut no less than ¼ inch from the trunk to preserve tree health.
- Keep shrubs at least 10 feet away from tree branches and leave a minimum distance of 2 ½ times the mature height between groups of shrubs.

- Clumps of shrubs should be reduced in diameter to no more than twice the mature height.
- Mow grasses to a maximum height of four inches. This is especially important in the fall when grasses have dried out.
- Avoid heavy accumulations (known as jackpots) of fuels on the ground, including logs, slash, or mulch piles.

The distances given here are minimums and should be increased for slopes and dangerous terrain features. We strongly recommend a fire or forestry professional be consulted when planning defensible space in steep or complicated topography.

Zone 3 is designed to provide a gradual transition between Zone 2 and the natural vegetation condition of the surrounding lands. This zone extends from 30-100 feet from structures and is managed to promote vegetative health and limit fire behavior. Healthy forests usually contain various ages, heights, and species; however, reducing ladder fuels and maintaining or creating crown spacing should be primary concerns. Contacting the local CSFS office for guidance with Zone 3 management is highly recommended.

Remember creating defensible space is not a one-time job. Instead, defensible space must be maintained on an annual basis. A handy checklist of defensible space maintenance tasks is available from the CSFS website.

Figure 47 The Home Ignition Zone

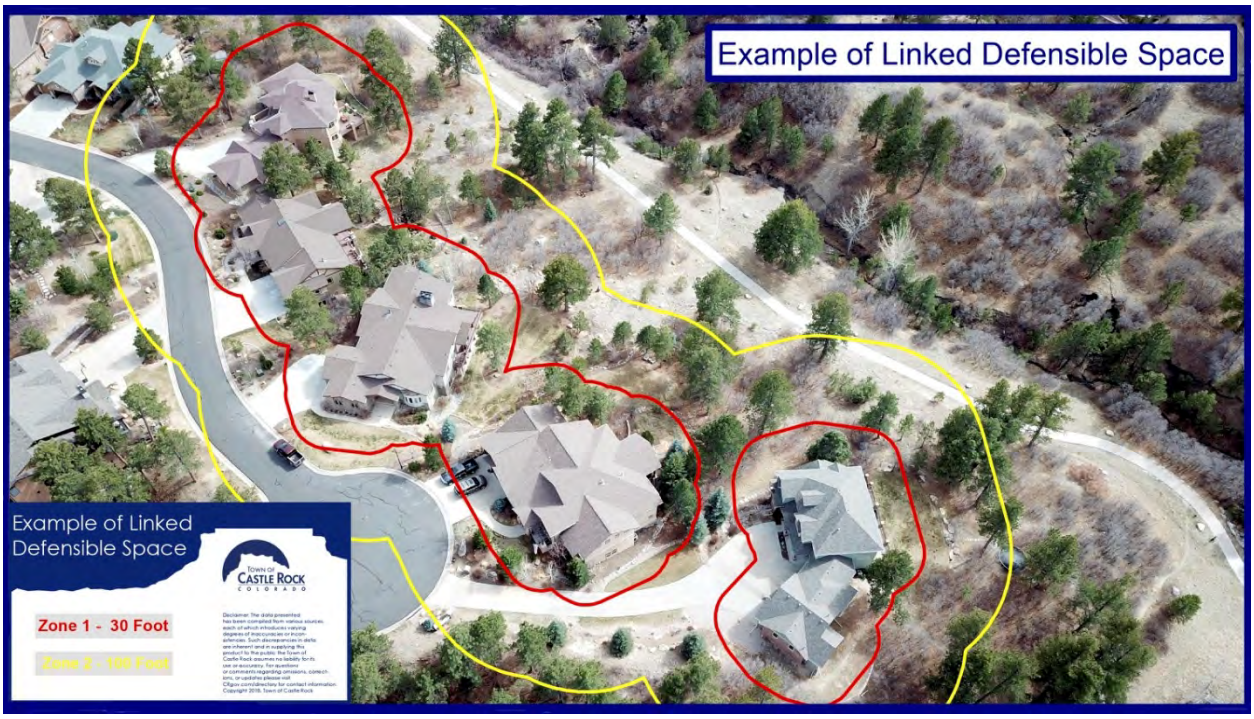

Figure 48 Linked Defensible Space Example

Ignition-Resistant Landscaping and Native Fuels Management

Ignition-resistant landscaping generally includes widely spaced trees, low-fuel volume shrubs, and herbaceous groundcover. Ignition-resistant, native re-vegetation should be considered at least as far as the 30-foot perimeter of Zone 2. In areas where it is practical and desirable, replanting with fire-wise species and implementing proper planting practices will provide the following benefits:

- Reduce the fire risk by limiting the ability of invasive and flammable species to return.
- Protect bare soils from erosion.
- Promote natural beauty and ecological stability without sacrificing adequate wildland fire protection.

Examples of fire-wise planting practices would be to space trees widely to interrupt the continuity of aerial fuels, plant low-fuel volume shrubs (usually no greater than 18 inches in height) and integrate decorative rocks and non-combustible natural features into the landscape architecture design. Deep watering trees through the summer and fall and during dry winters will keep trees alive and deter insects. Healthy, well-irrigated plants are less flammable, and irrigation systems can reduce the intensity and spread of surface fires.

Drought-resistant plants and irrigation systems should be utilized in newly planted areas. Existing native plants that are fire-adapted do not have to be replaced to reduce the fire risk; however, flammable species such as juniper and Gambel oak should be avoided. Any retained natural vegetation needs to be maintained at a conservative fuel level and arrangement.

The primary natural fuels of concern in Castle Rock consist of grass, grass/shrub, shrub, and timber-understory models. In the case of native grasses removal in defensible space Zone 1 and mowing to a height of four inches or less in Zone 2 are the only treatments necessary. The fuels of most concern occurring near homes are moderate to heavy loads of dry climate shrubs, principally Gambel oak and low to moderate loads of timber with a shrub understory. Timber stands are dominated by ponderosa pines often with dense accumulations of Gambel oak understory. In many of these stands trees are stressed and underdeveloped and the oak understory is decadent, thick and contiguous. During a wildfire the oak would act as a ladder fuel bringing fire from the surface to tree crowns.

There is a popular perception that Gambel oak is not a particularly dangerous fuel due to it only being receptive to fire in the fall and early spring when the shrub is dormant and dries out, or during periods of drought. In spite of this general perception, oak brush, especially decadent stands common in the Castle Rock area, should be treated as potentially highly dangerous. Spring frosts that kill foliage can result in Gambel oak exhibiting extreme fire behavior through summer as dead leaves remain on the shrub. 14 firefighters died in Gambel oak fuels on Storm King Mountain near Glenwood Springs in July of 1994. This incident was the largest single loss of firefighter lives in a Colorado wildfire.

We recommend any Gambel oak occurring within 30 feet of homes should be removed and replaced with landscaping conforming to the defensible space recommendations for Zone 1 and Zone 2 described earlier in this report. Where Gambel stands occur from 30 to 100 feet from homes the best tactic would be to replace these stands with fire resistive plantings. This generally includes widely spaced trees, low-fuel volume shrubs (typically no greater than 18 inches in height) and herbaceous groundcover. Decorative rocks should be integrated into the design. Rock will help anchor and stabilize soil, create fuel breaks and provide a natural look to the landscape. Emphasis should be placed on the use of drought-resistant plant material. A list of Firewise plants recommended by the CSFS can be found in Firewise Plant Materials – http://extension.colostate.edu/topic-areas/natural-resources/Firewise-plant-materials-6-305/

In areas within 100 feet of homes where it is not desirable or practical to replace Gambel oak with fire resistive species oak stands should be maintained by the removal of dead material and trimming decadent plants to promote new, more vigorous growth. Oak shrubs should be clumped so that the maximum diameter of the clumps is no more than two times the height of the shrubs and spacing between clumps is at least two and one-half times the height of the vegetation. Figures 49 and 50 show before and after examples of successful fuels reduction in Gambel oak.

Figure 49 Gambel Oak Untreated

Figure 50 Gambel Oak after treatment

Careful planting of a Firewise landscape can provide open space and common areas with natural beauty and ecological stability without sacrificing adequate wildland fire protection.

To retain the health and vigor required to be fire-resistive, plants require maintenance. Maintenance of plant material is a critical factor in safeguarding these species' ignition-resistant qualities and continuing resistance to undesirable fire effects. On-going maintenance should include removing of dead material, weed control, cutting grasses to four inches or less, pruning trees and shrubs as necessary to prevent the buildup of ladder fuels, and removing surface fuel jackpots. Ladder fuels and fuel jackpots contribute to crown fire development and spotting during fires. General recommendations regarding fuels treatment are given earlier in this report, however, all significant concentrations of native fuels near homes should be evaluated annually at the beginning of the fire season for treatment needs.

The Importance of Reducing Structural Ignitability and Individual Parcel Assessments

In their 2013 publication *How Risk Management Can Prevent Future Wildfire Disasters in the Wildland-Urban Interface* David E. Calkin, Jack D. Cohen, Mark A. Finney, and Matthew P. Thompson come to the following conclusion:

"The demonstrated inability to suppress wildfires under extreme weather conditions and the fact that many homes are not destroyed when exposed to these wildfires indicates that reducing home ignition potential is key to effectively reducing home destruction. Because home ignitions are primarily determined by conditions on private property, the principal authority, and thus, primary responsibility for preventing WUI home destruction lies with homeowners rather than public land managers."[19]

As mentioned earlier, the Home Ignition Zone (HIZ) is comprised of the structure itself and the area within the first 100 feet. Individual home hazard assessments can provide a road map for homeowners to reduce the ignition potential of the Home Ignition Zone (HIZ), however, individual assessments rely heavily on the evaluation of conditions existing from the structure to a minimum of 100 feet out. As such they are most effective when lot sizes are 1 acre or greater. Homes in a few of the residential hazard zones identified in this report, such as Zone D and Zone S, could benefit from parcel level hazard assessments; however, in most of the residential areas of Castle Rock homes are too close together and lots too small for individual parcel assessments to yield much actionable information. For that reason, **we recommend** individual parcel assessments only for neighborhoods where the average lot size is one acre or greater. For the other residential areas of Castle Rock, **we recommend** focusing on reducing HIZ ignition potential through linked defensible space and structure hardening tactics which are discussed in this section and the previous one. In the neighborhoods where lots are large enough to benefit from parcel level assessments the data gathered should be integrated with data in the CWPP (such as fire behavior data) to establish a framework for future damage assessment responsibilities and recovery efforts.

Figure 51 The Home Ignition Zone

Structure Hardening Recommendations

NEW DEVELOPMENT

The best time to reduce the ignitibility of a home is before it's built. **We recommend** during the planning stage questions such as these be addressed:

- Are there multiple access points and would access be safe for responders and evacuees during fire conditions?
- Can the adjacent fuels be modified to create adequate defensible space for homes considering the fuel type and topography?
- What are the potential fire behavior and ember cast from fires approaching the development during typical fire and extreme weather conditions?
- Will complex forms or flammable materials in the architectural design trap heat and embers?
- Does the design of homes and neighborhoods include adequate turnarounds and access for apparatus and sufficient water for fire suppression?
- Are streets and home addresses visibly marked with consistent, reflective signage?

EXISTING COMMUNITIES

Although some of the factors impacting the survivability of structures are best addressed before the home is built, there are still steps that should be taken to improve the survivability of existing homes.

The role of embers in structure losses cannot be overstated. Embers are generated by burning materials and lofted by wind and/or convective heat ahead of the main fire front. Structures are vulnerable to ember penetration in numerous ways. Some of the more common areas are outlined below.

ROOF: Castle Rock is fortunate in that flammable wood roofs are a rarity in and near the town limits. The roof of a home has a significant impact on its ignitability as well as the likelihood of house-to-house spread. Class A roofing materials such as the asphalt shingles, metal and tile roofs found in the study area are all considered ignition resistant. Although there are few wood shingle roofs, there are some homes in Castle Rock using wood shakes as architectural features. We recommend these be regulated and non-flammable materials should be strongly encouraged when these features are in need of repair or replacement.

DECKS: There are a number of homes with wooden decks and projections in Castle Rock. According to CSFS wooden decks are so combustible that, "when a wildfire approaches, the deck often ignites before the fire reaches the house."[20] The shape of decks and outdoor stairs makes them excellent traps for heat and embers. Nothing flammable should ever be stored under decks or projections because of this. **We recommend** that as the wooden decks and projections found throughout Castle Rock become in need of repair or replacement, non-flammable materials, such as plastic composites or aluminum decking, should be strongly encouraged. The quality and number of choices for wood substitute building materials has grown exponentially in the last decade and homeowners are no longer limited to materials with an inferior look and finish. In addition to reducing fire hazards these materials usually require much less maintenance than wood. In areas where fire behavior predictions call for low to moderate intensities it is helpful to isolate existing wooden decks from the energy of fires by building a non-combustible patio and wall below the deck to limit the heat trap effect. The best design is to enclose the deck completely to create a solid form.

WINDOWS quickly fail when exposed to the radiant heat of a wildfire. Once windows have failed, they provide a direct path for embers and heat to enter the home and ignite the inside. Although many of the residential portions of Castle Rock have newer, more heat resistive windows, such as low E Thermopane (double glazed), and tempered glass patio doors, some older homes are likely to have conventional single pane window glass, especially in historic neighborhoods like downtown. We recommend replacing single pane windows with modern double pane windows that will improve the resistance to breakage from heat exposure by as much as double the exposure time.[21] Homes near heavy fuels should consider installing heavy, non-flammable window coverings that will afford the home some additional protection from embers in the event windows break. Homes in these areas should also consider replacing large windows (2 feet or more wide or tall) with smaller panes that are more likely to stay in place even if fractured by heat.

VENTS are another location where embers can enter the structure. Vents, especially vents on the downhill side of the home, should have flammable vegetation removed as per Zone 1 defensible space standards and be protected by non-flammable landscaping features such as stone or brick that will block the heat path of the fire. Vents in eaves and soffits should be covered with a non-

combustible mesh with openings 1/8” or smaller. Any open eaves should be enclosed to prevent them from becoming a trap for heat and embers. When enclosing an open eave, a flat soffit is preferred over a sloping soffit to limit the heat trap effect.

PROPANE TANKS Any above-ground propane tank should be kept at least 30 feet from structures, and all flammable vegetation should be removed from within 10 feet of tanks, lines, and meters.

Historic fire events have proven that poor construction techniques and materials are linked directly to structure loss, reinforcing the message of the research quoted earlier. The Insurance Institute for Business and Home Safety (IBHS) wildfire research center has developed a video demonstrating how various home construction materials burn during an ember storm (https://www.youtube.com/watch?v=IvbNOPSYyss).

For more detailed information regarding structure hardening and construction method and material vulnerabilities, please see the CSFS publication *Firewise Construction: Site Design & Building Materials,* which can be downloaded from the CSFS website at https://csfs.colostate.edu/wildfire-mitigation/construction-design-materials/ and the following links:

- https://fireadapted.org/wp-content/uploads/2018/06/waldo-canyon-report.pdf (Lessons learned from the Waldo Canyon Fire)
- https://www.fema.gov/media-library-data/20130726-1652-20490-4085/fema_p_737.pdf (FEMA *Home Builder’s Guide to Construction in Wildfire Zones*)
- https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1141 National Fire Protection Association (NFPA) 1141, *Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural, and Suburban Areas*.
- https://www.youtube.com/watch?v=vL_syp1ZScM *Your Home Can Survive a Wildfire* NFPA video presentation.

Landscape Scale Fuels Modification

Figure 52 shows town owned park/open space boundaries in blue. As this figure graphically demonstrates, rather than being a contiguous land mass there are many inholdings throughout the area covered by the town limits. With the possible exception of the I-25 highway easement, there are no significant tracts of state or federal land adjacent to Castle Rock. Most of the adjacent land falls under the jurisdiction of Douglas County. In addition to these parcels the Town of Castle Rock maintains nearly 6,000 acres of parks and open space and 95 miles of trails within the town limits. Development plans have encouraged open space islands between clusters of homes where natural fuels have been retained. The riparian vegetation corridors in Plum Creek and Sellars Gulch are habitat for the endangered Preble's meadow jumping mouse and have therefore remained largely undeveloped. These are shown as Riparian Conservation Zones (RCZ) in Figure 53. These factors have created a patchwork of islands and stringers of natural fuels occurring throughout the town limits. This balkanized geography of natural fuels makes it difficult to recommend traditional fuel breaks and other landscape scale fuel modifications. Instead, **we recommend** treatments focus on defensible space, reducing structural ignitability and reducing hazardous vegetation between homes.

Riparian Corridors

As previously mentioned, the Plum Creek drainage and Sellars Gulch constitute the significant riparian corridors running through the Castle Rock town limits. There has been some concern these corridors of natural fuels could become a highway for fire and create ember cast in residential subdivisions that could lead to structure ignitions and fire spread. In general, riparian vegetation has a high moisture content and is not a good carrier of fire. Flame lengths tend to be moderate and rates of spread low in this fuel model. As a part of this study the fire behavior for the riparian corridors of Plum Creek and Sellars Gulch were modeled. In the riparian fuels along both corridors the model predicted flame lengths of less than four feet and rates of spread less than 30 chains per hour. Due to the relatively high live fuel moistures the probability of ignition is also low under most conditions. Fuel treatments along this corridor would be extremely difficult, if not impossible, due to the habitat conservation needed for Preble's meadow jumping mouse and would not likely result in increased safety for residents or property. For these reasons we do not recommend fuels modifications in these riparian corridors.

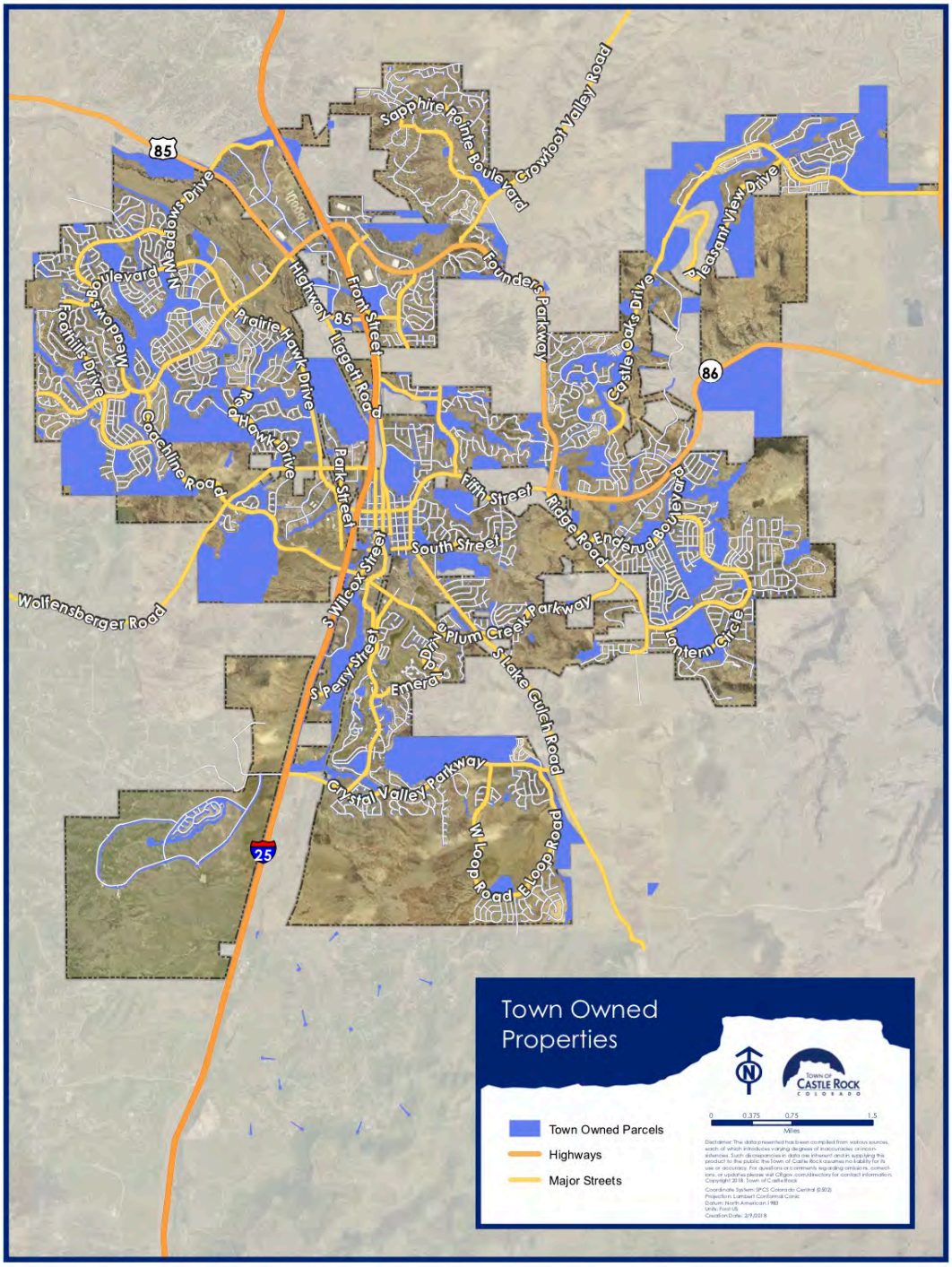

Figure 52 Town Owned Properties

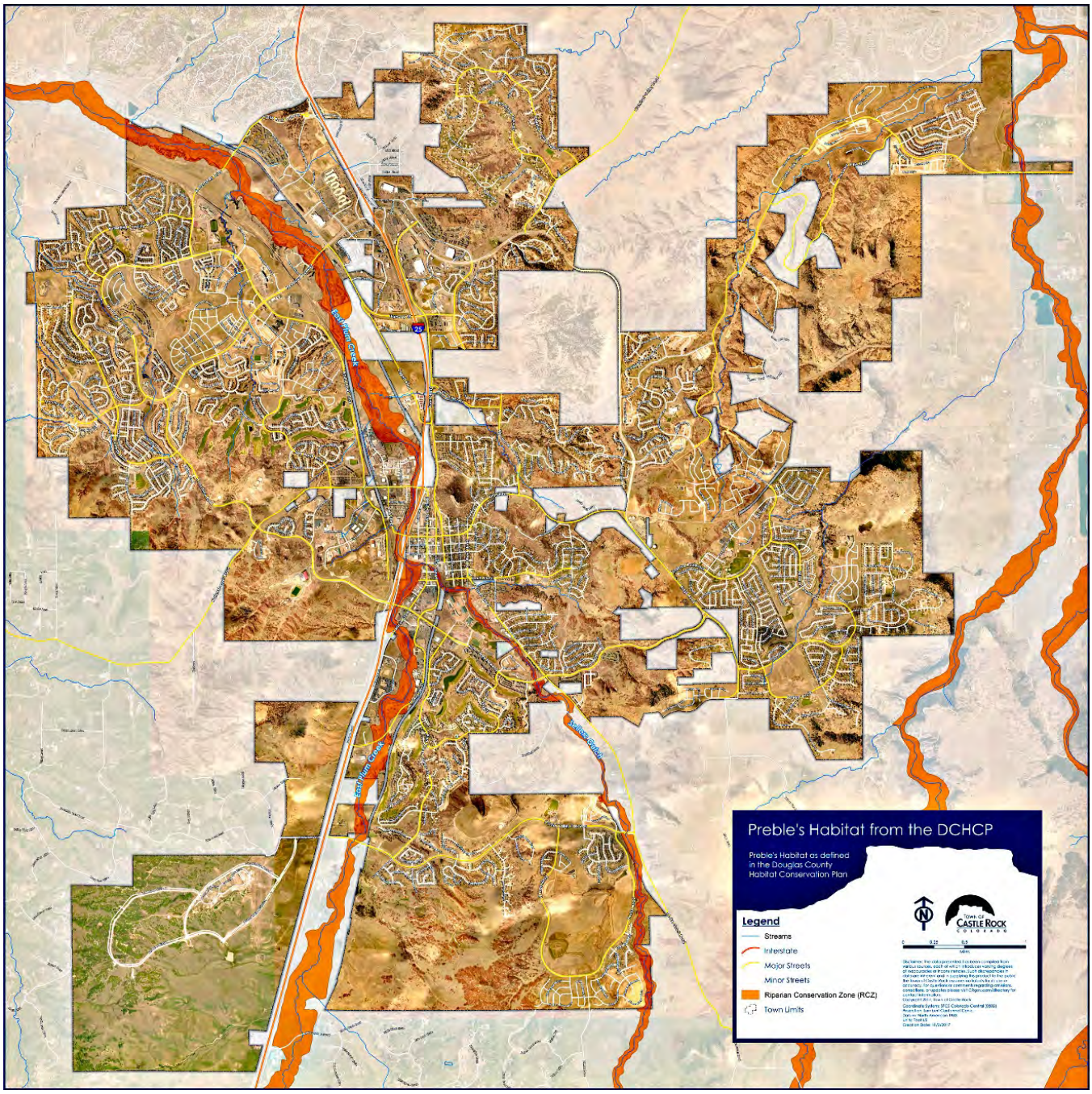

Figure 53 Preble's Mouse Habitat

Access/Egress Route Recommendations

With very few exceptions, access to homes in Castle Rock is on paved roads in good condition and of adequate width. Most streets inside the town limits maintain a 20-foot-wide drive lane for fire access. There are only a few areas in the Meadows community where the drive lane would be 16 feet or less if the roadway had parking along the entire length of the road. Although there are many homes built on cul-de-sacs most turnarounds are adequate for fire apparatus.

Streets are generally well marked with reflective signs of adequate size. Vegetation on town streets is well managed so that signs stay visible. Although mapping applications such as Google Map and Waze have made it easier for responders to locate specific structures, reflective addressing that is visible from the street is still highly desirable. Most applications relying on GPS technology have some difficulty pinpointing addresses from time to time and technology does sometimes fail. Addressing on homes throughout Castle Rock is mixed in type and position. Most homes have some address marker, but in many cases, markers are not reflective and are not consistently placed from house to house. **We recommend** CRFD, the town government, developers, homeowners and HOAs work together to create and implement a consistent system of reflective address markers. See Figure 54 below.

Figure 54 Modern Reflective Address Marker

The biggest difficulty with access and evacuation in Castle Rock is sheer population density. Most, but not all, neighborhoods in Castle Rock have been developed with high density urban style lots and structures. Successful evacuation relies on extensive pre-planning and coordination

between fire responders and law enforcement. **We recommend** evacuation plans be developed both comprehensively and at the neighborhood level. Castle Rock is experiencing a period of dynamic expansion. New homes and other structures are being added on a daily basis. Evacuation plans should be reevaluated annually to ensure they remain accurate and effective. Community level drills should be conducted on a regular basis (at least a couple of times a year) so that residents remain familiar with evacuation routes and staging areas.

Shelter-in-Place

Traditionally in the United States the preferred method of protecting the public from an advancing wildfire is evacuation and involves relocation of the threatened population to a safer area. Another possibility is to instruct people to remain inside ignition resistant buildings until the danger passes. This concept is controversial regarding wildfire in the United States, but not for hazardous materials incident response where time, hazards, and sheer logistics often make evacuation impossible. This concept is the dominant modality for public protection from wildfires in Australia where fast moving, non-persistent fires in light fuels make evacuation impractical. The success of this tactic depends on a detailed preplan that takes into account the construction type and materials of the building used, topography, depth and type of the fuel profile, as well as current and expected weather and fire behavior.

Shelter–in-place should only be considered when the structure is determined to be “stand alone” in structural triage terms. A combination of access, ignition resistant construction, and fuels reduction is necessary to create an environment safe for emergency service personnel and provide reasonable protection to structures from a wildfire. In order to be “stand alone”, buildings need to be of ignition resistant construction and have defensible space.

Ignition resistant construction is necessary for shelter-in-place tactics. Wooden roofs, shake architectural features and old structures with untreated wooden sidings are particularly hazardous and should not be considered. It is preferable to have ignition resistant roofs and ignition resistant siding such as stucco or concrete, especially close to the ground. Eves should be enclosed and any holes in the foundation, siding, or eves should be covered to prevent embers from entering. Buildings with large areas of non-burnable surfaces adjacent to them, such as paved parking lots and bare earth are desirable.

Although evacuation would be preferred under most conditions there may be some areas where high numbers of people attempting to evacuate on residential streets may create a more dangerous situation than pre-planning shelter-in-place safety zones for residents. Schools and other public buildings may work well for this purpose. **We recommend** CRFD, traffic engineering and law enforcement work together to identify neighborhoods where pre-planning shelter-in-place locations could be a desirable alternative to evacuation.

Water Supply

The Town of Castle Rock has a high-quality municipal distribution system, consisting of over 3,800 hydrants, capable of delivering flows of at least 1,000-1500 GPM. The approximate location of hydrants is shown in Figure 55. Hydrants are tested regularly and repaired as necessary by Castle Rock Water. CRFD should consider the purchase of a water tender. A water tender would provide a backup water supply for fire suppression and could be invaluable in CRFD response in the unlikely event of a pressure failure, and for areas outside the Town limits.

As mentioned earlier in this report, the numerous assets associated with water and wastewater service for the Town are of at least partially ignition resistant construction, on concrete pads and have been cleared of nearby fuels. There are, however, some assets with fuels impinging the structure that could be dangerous or impossible to access during fires. See Figure 56. All of these assets should be inspected on an annual basis for proper defensible space and access by CRFD. Any asset that does not have adequate defensible space and safe access should be mitigated, and any structure with flammable features adjacent to fuels should be evaluated for structure hardening.

Other Town facilities include Plum Creek Water Reclamation Authority, and a surface water diversion facility in the town of Sedalia. Although these facilities are not inside the town limits, and therefore outside the scope of this study, they are considered critical infrastructure and should be evaluated by CRFD for adequate defensible space and any potential threats from wildfire. Castle Rock Water should work with CRFD to develop a list of assets and a plan to ensure defensible space and any structure hardening that is desirable and practical in accordance with the recommendations given earlier in this report.

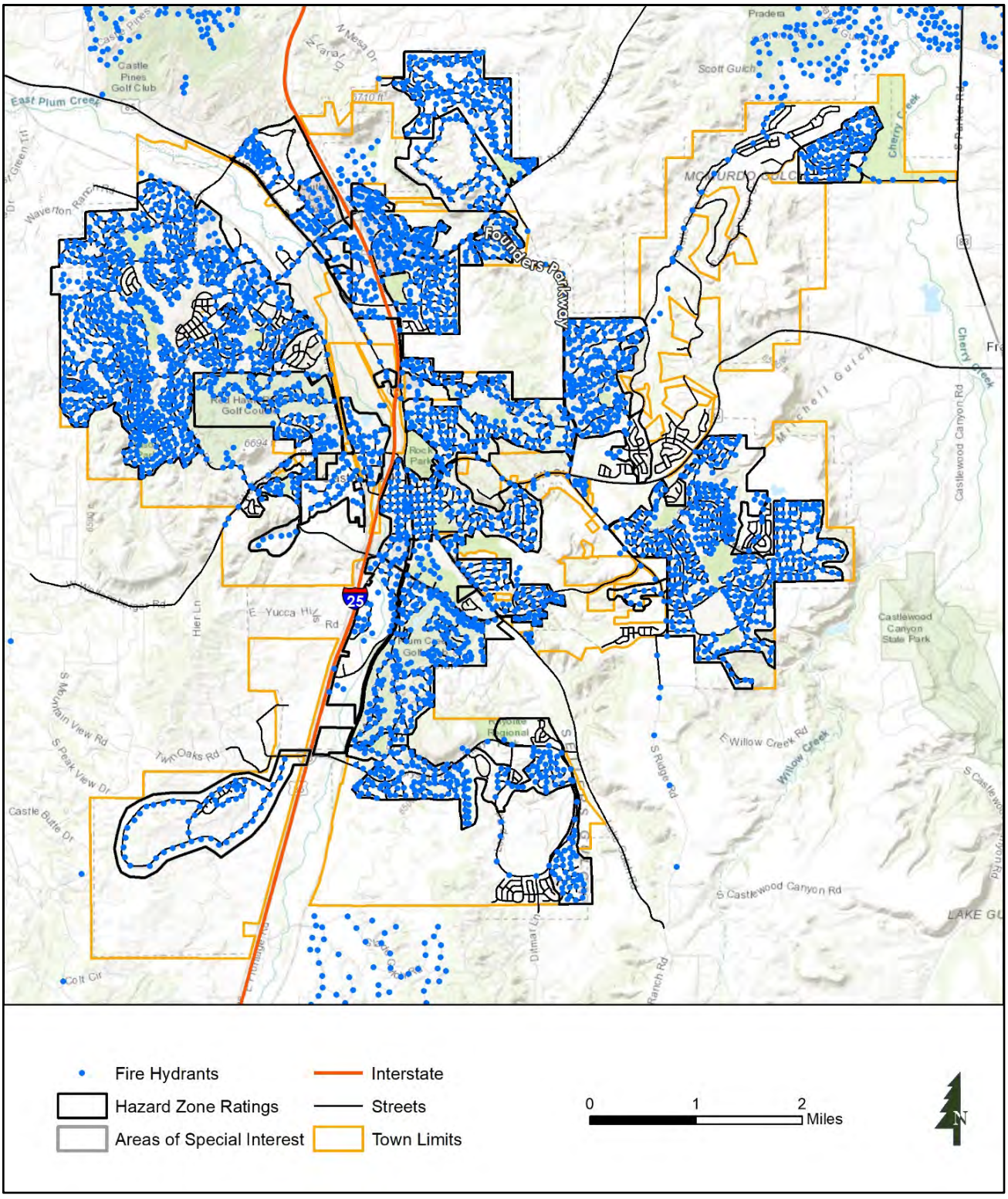

Figure 55 Castle Rock Hydrant Locations

Figure 56 Natural Fuels Surrounding a Pump Station

Development Planning

Throughout this report, the robust development of Castle Rock has been highlighted. Construction is on-going in many neighborhoods and large tracts are still being planned. Approved entitlements total 54,899 dwelling units and future development is being planned in most parts of town not already fully built out. Figure 57 shows areas of potential development and Figure 58 shows the future land use plan. As pointed out in the sections of this report related to defensible space and structure hardening, many factors that make interface homes safer are best addressed in the planning stage. This is a big job and CRFD cannot do it alone, however CRFD should be a referral agency for development reviews, open space development plans and any other town projects that change vegetation or land management. While the Town and CRFD have incorporated some guidance in the planning, zoning, and building codes as it relates to wildland fire, CRFD's assistance in these processes is critical to ensuring Firewise concepts are considered. National Fire Protection Association (NFPA) standards 1141 (Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural, and Suburban Areas) and 1144 (Standard for Reducing Structure Ignition Hazards from Wildland Fire) should also be referenced during development and land use planning. It is critical for town government, developers and CRFD to work together to be sure Firewise principles are part of every new development.

The first step in reducing the ignition potential of the Home Ignition Zone (HIZ) is to work with the town government to determine ownership of all the areas where unmitigated natural fuels exist both inside and adjacent to the town limits including open space owned by governmental

entities and private entities such as HOAs and development companies. This information should be integrated into GIS mapping that can be updated frequently. A dynamic and easily updated format for this information is necessary to keep up with the rapid rate of development in Castle Rock.

The Town has identified a goal of maintaining 30% of its land as open space. Fuels maintenance practices such as thinning, mastication, and prescribed burning should be evaluated for all town-owned properties and a comprehensive fuels management plan developed. A Firewise demonstration area with interpretive signs should be considered on one of the popular park lands such as Rock Park or Phillip S. Miller Park. Opportunities for fuel breaks should be considered in future trail design and along public land boundaries.

We recommend the integration of hazard mitigation practices; ignition resistant species selection and on-going maintenance be an integral part of all planning. The Town's Development Services, Parks, Recreation and Open Space, and Water Departments, along with CRFD, should work to adopt additional codes as it relates to planning, zoning, and building construction in the wildland urban interface to further address the wildland fire hazard. Integrating fire safety into these processes will ensure lives and homes in Castle Rock are safer while still providing the natural beauty and high quality of life Colorado is known for.

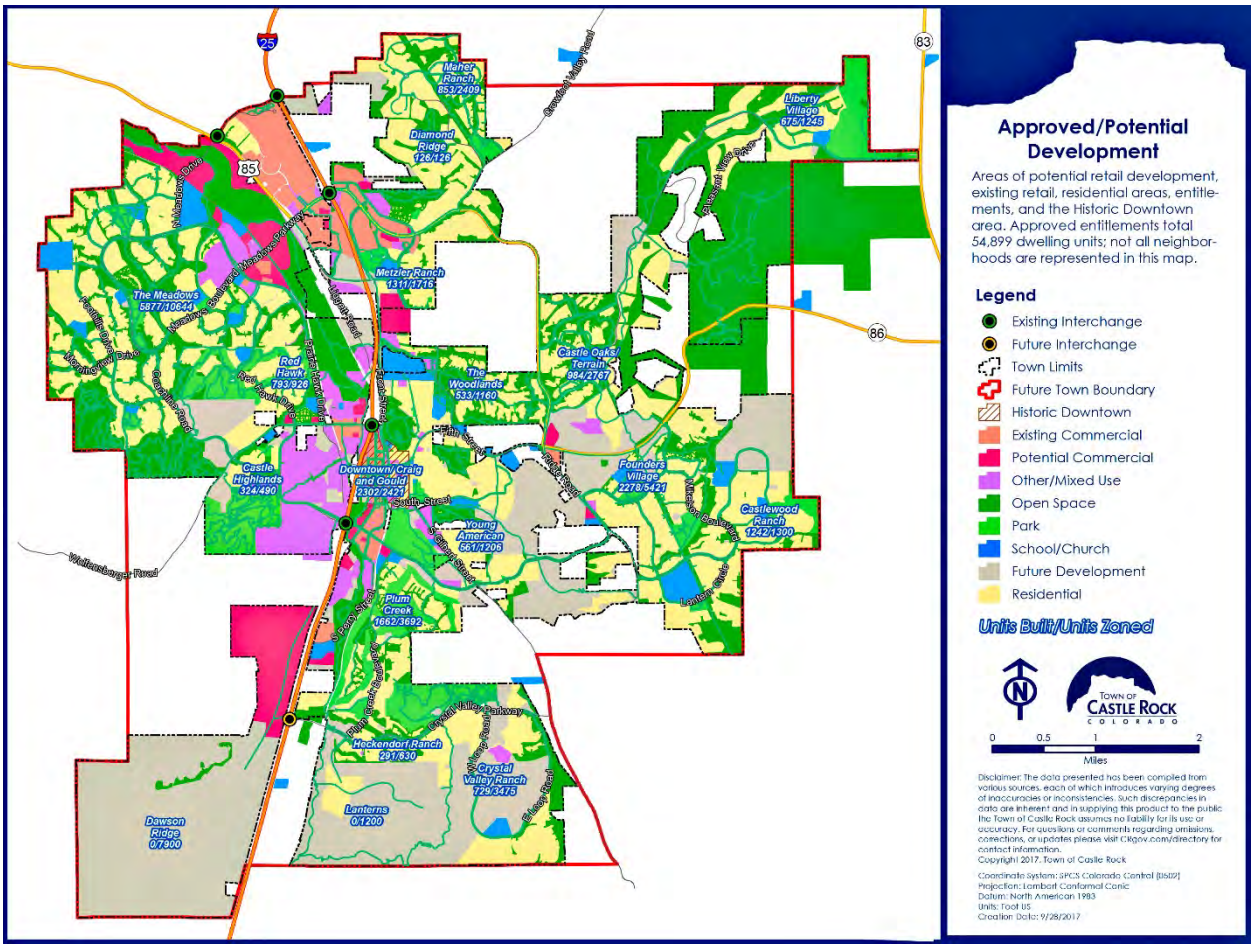

Figure 57 Potential Development

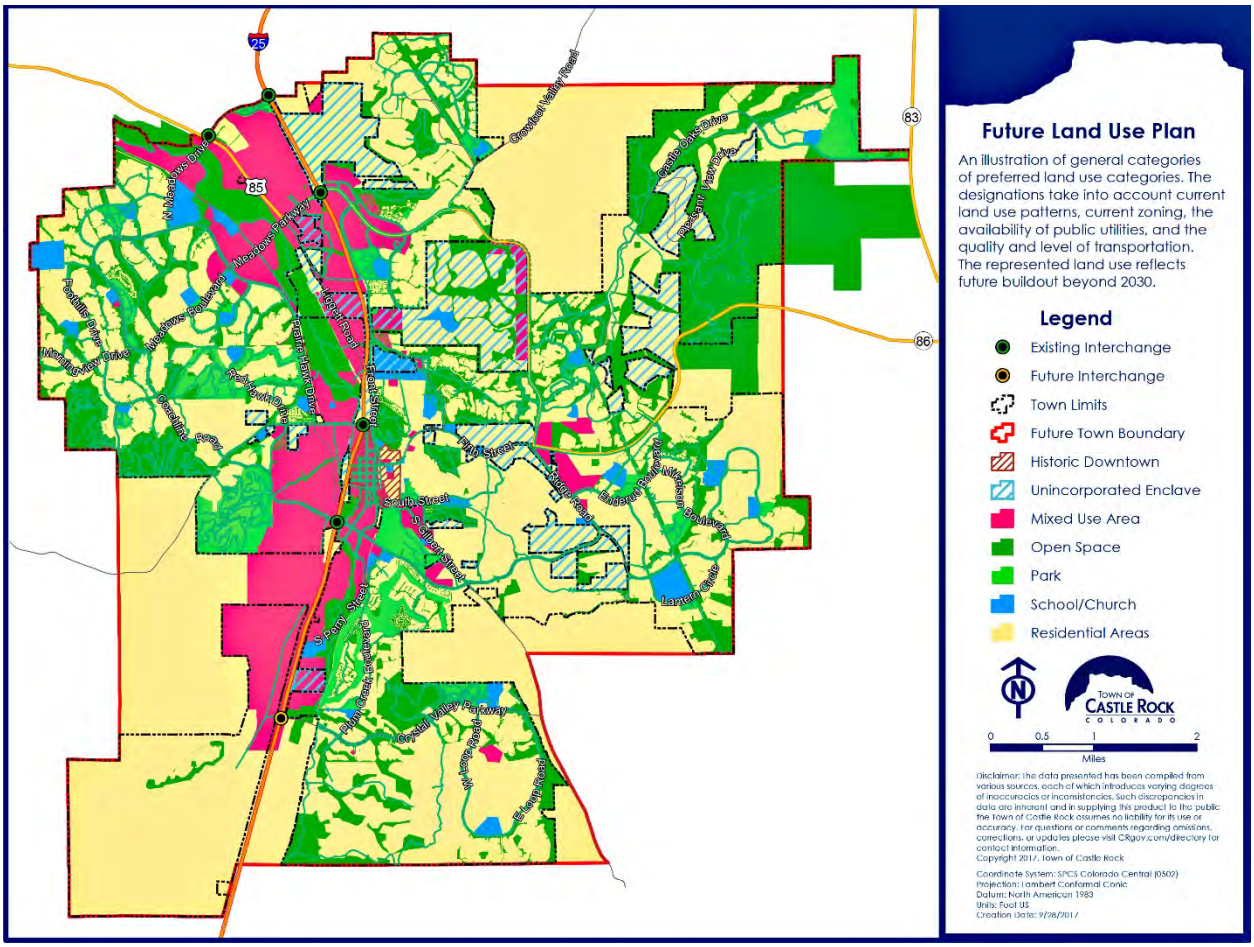

Figure 58 Future Land Use

Public Outreach and Education

Essential to raising awareness and changing behaviors surrounding wildfire is a strong outreach and education program. Adult learners must recognize/feel value in the potential action before they will take it. Castle Rock provides for many social and family-oriented activities that lend themselves to providing venues to raise awareness and move those who are aware to action. The *Town Talk* newsletter arrives in every household water bill each month and is an excellent opportunity to continue a vigilant message. Currently, Town staff addresses resident and HOA concerns on an ad hoc basis, provides a limited number of publications to residents on wildfire mitigation, and efforts are in place to address the wildland fire problem for any new planned developments. However, Town staff should assess their knowledge base, staffing levels and funding to be able to achieve a year-round campaign regarding wildfire. All residents must be educated in wildfire hazards, wildfire preparedness, evacuation, risk reductions methods to protect life and property including reducing hazardous fuels, creating defensible space, and home hardening methods. Residents must take responsibility and prepare themselves, their families and their households for an evacuation and the possibility of needing to rebuild their lives. This list of concepts is by no means inclusive of all aspects of wildfire

Many communities across the United States have become engaged in the Firewise USA program. There are over 1,400 Firewise sites across the US. Firewise USA teaches people how to adapt to living with wildfire and encourages neighbors to work together. The program focuses on actions homeowners can take to prevent loss of lives and property. For more information on Firewise visit: http://www.Firewise.org/ .

The Ready, Set, Go! (RSG) Program, managed by the International Association of Fire Chiefs (IAFC), seeks to develop and improve the dialogue between fire departments and the residents they serve. The program helps fire departments teach individuals who live in high-risk wildfire areas – and the wildland-urban interface – how to best prepare themselves and their properties against fire threats. For more information regarding the RSG Program visit: http://www.wildlandfirersg.org/.

Town and Community Property Projects

Land ownership in communities often provides opportunities for collaborative projects that can serve as a model for residents. Communities are often eager to create demonstration projects that assist in providing a greater understanding for residents and providing the motivation for residents to take action on their own properties. Often these projects are a catalyst for continued resident led community efforts. Town staff should identify Town owned property that would lend itself for a demonstration site. For best results strong community outreach is encouraged to make these projects as successful as possible. Staff should also target community properties strategically located and reach out to communities to foster collaborative projects in and across communities. Collaborative projects accompanied by strong outreach and education will often result in the most successful behavior and attitude changes towards risk reduction activities.

Grant and Other Resources

One of the biggest obstacles to overcome when trying to implement CWPP recommendations and wildfire mitigation projects is funding. A certified CWPP opens up a multitude of funding sources to complete work outlined in the plan. For many mitigation projects federal, state and county funds are available to begin treatments. The list below is not inclusive, but rather serves as a starting point for the most commonly available sources of funding and outreach.

Federal Emergency Management Agency (FEMA)

- **Assistance to Firefighters Grant Program**
  - **https://www.fema.gov/welcome-assistance-firefighters-grant-program**
- **SAFER: Staffing for Adequate Fire and Emergency Response**
  - **https://www.fema.gov/staffing-adequate-fire-emergency-response-grants**
- **Fire Prevention and Safety Grants (FP&S)**
  - **https://www.fema.gov/fire-prevention-safety-grants**
- **Hazard Mitigation Assistance Grant Program (HMA)**
  - **https://www.fema.gov/media-library-data/1441133724295-0933f57e7ad4618d89debd1ddc6562d3/FEMA_HMA_Grants_4pg_2015_508.pdf**
- **Pre-Disaster Mitigation Grant Program (PDM)**
  - **https://www.fema.gov/pre-disaster-mitigation-grant-program**

Colorado State Forest Service

- **https://csfs.colostate.edu/funding-assistance/**
- **https://csfs.colostate.edu/franktown/fr-forest-management-stewardship/**

Firewise Communities

- **http://www.Firewise.org**

National Volunteer Fire Council

- **http://www.nvfc.org/**

National Resources Conservation Service Emergency Watershed Protection Program

- **https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/ewp/**

USFS Cooperative Forestry Assistance

- **https://www.fs.fed.us/spf/coop/programs/loa/**

References

[1] https://legcounsel.house.gov/Comps/Healthy%20Forests%20Restoration%20Act%20Of%202003.pdf
[2] https://csfs.colostate.edu/franktown/fr-forest-management-stewardship/
[3] http://www.emnrd.state.nm.us/SFD/FireMgt/docs/wham.pdf
[4] Ibid
[5] https://en.wikipedia.org/wiki/Castle_Rock,_Colorado#cite_note-Census2010-5
[6] https://en.wikipedia.org/wiki/Castle_Rock,_Colorado#cite_note-Census2010-5
[7] https://www.crgov.com/1961/Community-Character
[8] https://datausa.io/profile/geo/castle-rock-co/#economy
[9] https://datausa.io/profile/geo/castle-rock-co/
[10] http://crgov.com/1985/Open-Space-and-Trails
[11] https://www.federalregister.gov/documents/2001/01/04/01-52/urban-wildland-interface-communities-within-the-vicinity-of-federal-lands-that-are-at-high-risk-from
[12] http://www.douglas.co.us/documents/appendix-a.pdf
[13] https://www.gollnerfire.com/wp-content/uploads/2012/07/REPORT-Pathways-for-Building-Fire-Spread-in-the-WUI-Final.pdf, pg. 20
[14] https://www.gollnerfire.com/wp-content/uploads/2012/07/REPORT-Pathways-for-Building-Fire-Spread-in-the-WUI-Final.pdf, pg. 65
[15] https://www.cpse.org/accreditation/accredited-agencies/
[16] ibid
[17] https://www.fema.gov/welcome-assistance-firefighters-grant-program
[18] https://codes.iccsafe.org/content/IFC2018/APPENDIX-D-FIRE-APPARATUS-ACCESS-ROADS
[19] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3896199/
[20] https://static.colostate.edu/client-files/csfs/pdfs/FIRE2012_1_DspaceQuickGuide.pdf, Page 4.
[21] https://www.coloradowildfirerisk.com/Help/FirewiseHome, Page 30.

APPENDIX A FIRE BEHAVIOR DISCUSSION

Fires are a natural ecosystem process and will continue to occur. The potential for damage to life, property and the environment is dependent on the intensity and rate of spread, which in turn dictates the effectiveness of suppression efforts.

Fuels

The fuels throughout the study area vary but are primarily in three groups.

The Grass group **(GR)** that is represented by short (Figure 59) or mid grasses (Figure 60) in parks, open space areas or HOA holdings. These are sometimes mowed and represent the least threat but are receptive to burning for more of the year. The ability to spread is dependent on the continuity of the fuel bed and if the grass is curing or green. These are considered flashy fuels because they can dry out quickly and usually have a high rate of spread. The wind will dictate how fast the fire spreads.

The Grass/Shrub group **(GS)** is represented by grass fields interspersed with Mountain Mahogany or Gamble oak (Figure 61). The shrubs grow in either small clumps or larger patches. This group has variability in fire behavior potential based on the season or drought conditions. The grass and fallen leaves may be dry but the shrubs will still have moisture and not burn readily. However, when the shrubs are cured, dormant or have low moisture they burn very intensely, due in part to volatile oils in the leaves. Wind is the critical factor in determining how intense the fires will be. Spotting will also occur from dry leaves lofting ahead of the fire front and landing in the dried grass.

The Timber litter group **(TL)** is represented by riparian areas that are mostly hardwood trees and pose a low threat (Figure 62) and ponderosa pine stands that usually have Gamble oak in the understory (Figure 63, Figure 64). This group also has variability in fire behavior potential based on the season or drought conditions. The riparian areas are usually low intensity fires, burning in leaf litter and only during the driest time of the year or in drought conditions. Hardwood trees do not readily ignite so crown fires are not a concern. However, they can be difficult to extinguish because of the amount of dead and down material accumulated over the years.

The pine stands are more of a concern and represent the highest threat. The pine stands have an abundance of ladder fuels, both from low hanging limbs and Gamble oak in the understory. Depending on the conditions, the oak may greatly increase the intensity and help transition the fire from the surface into the crowns. Wind is a major factor but the same can happen under dryer conditions without wind. The potential for spotting is also high. Embers are lofted from the tops of the trees and land either in grass or other pine stands. These fuels are the hardest to extinguish.

Figure 59 Fuel Model GR1

Figure 60 Fuel Model GR2

Figure 61 Fuel Model GS2

Figure 62 Fuel Model TL2

Figure 63 Fuel Model TL8

Figure 64 Fuel Model TL8

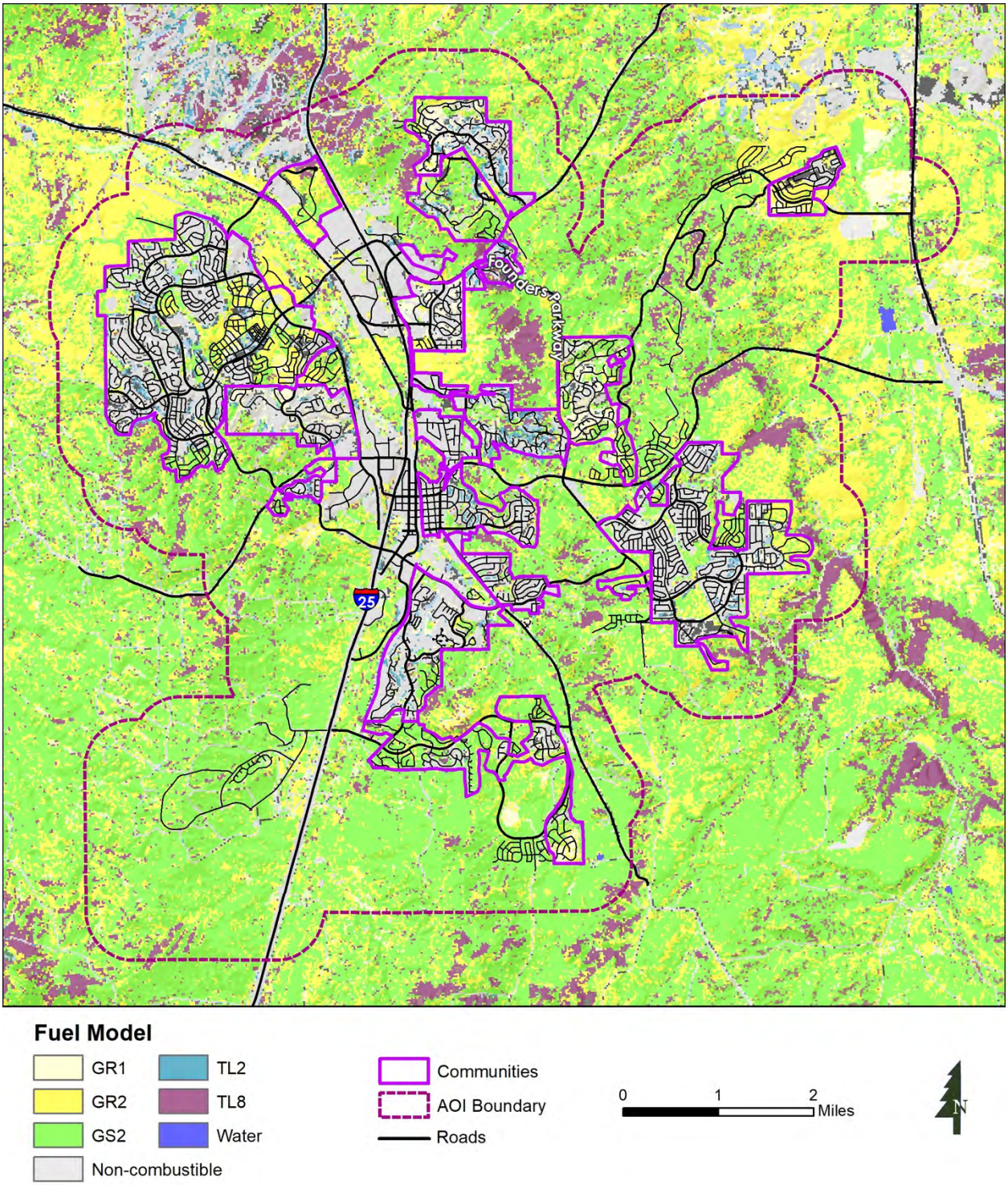

Figure 65 Fuels Map of the area

Weather

In Colorado, fire activity peaks from late spring through fall. However, on the front range, winter and early spring can also have fire activity. Since the grasses are cured and shrubs and trees dormant, they are readily ignitable if there is no snow. Strong winds are common most of the year due to the influence of the mountain ranges to the west and the Palmer Divide.

The most troublesome fire weather events are caused by strong winds either in summer (Red Flag days) or the Chinook winds that occur in the fall, but which are possible into the winter. These strong winds are warm and dry out the vegetation ahead of them. This can last through the night, which keeps temperatures high, relative humidity low and fires burning actively.

Even typical summer weather conditions can support large fire growth, with or without extreme winds. High daytime temperatures and low relative humidity levels are common beginning in May and typically lasting through October.

Topography

The elevation varies from approximately 5,928 to 6,949 feet within the study area. Much of the area is flat but with steep, narrow canyons and drainages on the perimeter. A fire will move faster as it goes up steeper slopes. Steep slopes also increase the potential for ignited material to roll, starting spot fires (new fires started outside of the main fire perimeter). Spot fires make fire suppression increasingly difficult and allow the main fire to expand at a faster rate. Slopes in the study area are as high as 70%. (Figure 66)

Narrow, steep chutes funnel the winds and further increase the rate of spread of a fire. There are several major north-south canyons within the vicinity of the study area. Homes and other structures that lie above or near the rim of these drainage areas and are at an increased risk.

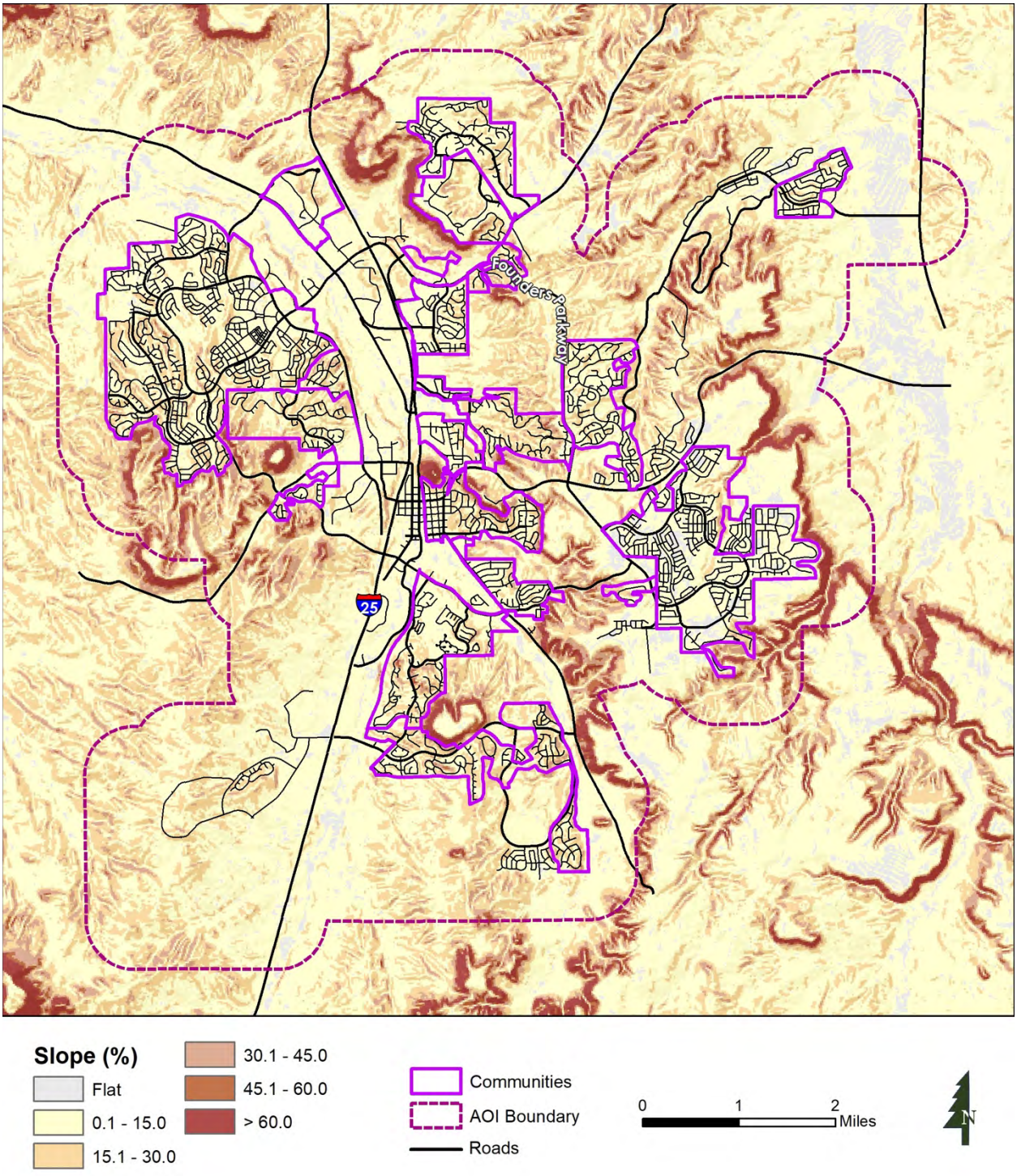

Figure 66 Slope map

Fire Behavior Outputs

There are numerous outputs that can be calculated from the fire behavior modeling, but the following are ones that are most useful to firefighters and for mitigation planning.

Rate of Spread

Most of the area would have very high to extreme rates of spread and even more so with the Chinook winds. It should be noted that a high rate of spread is not necessarily associated with severe fire effects. Fire will move very quickly across grass fields but will not burn very hot and does not cause major damage to the soil. The rate of spread is greater in open areas and less in pine stands where the fire is sheltered from the wind. This model does not account for spotting which will also make the fire move faster ahead of the main fire front. (Figure 67)

Flame Length

The flame lengths are primarily above 8 feet in all fuel types. It will be a challenge to extinguish without heavy equipment and aircraft. Steeper slopes will be very dangerous with flames well above 20 ft. (Figure 68)

The Fire Behavior Hauling Chart[1] display flame length in ranges meaningful to firefighters.

Flame Length	Interpretations
Less than 4 feet	Fires can generally be attacked at the head or flanks by firefighters using hand tools. Handline shonld hold fire.
4 to 8 feet	Fires are too intense for direct attack on the head with hand tools. Handline cannot be relied on to hold the fire. Dozers, tractor-plows, engines and retardant drops can be effective.
8 to 11 feet	Fire may present serions control problems: torching, crowning, and spotting. Control efforts at the head will probably be ineffective.
Over 11 feet	Crowning, spotting, and major fire runs are probable. Control efforts at the head of the fire are ineffective.

Table 3 Tactical Interpretation of Flame Length

Crown Fire

The pine stands are likely to have active crown fire under the modeled conditions, supporting crown to crown ignition. Active crown fires are very difficult to control and will have higher intensities and rates of spread than can be modeled. Under more moderate weather conditions, single and group tree torching would be expected because of the abundant ladder fuels. The model limits crown fire to Timber models but Gambel oak with predicted flame lengths 2.3 the height of the plant would also “crown” and create very intense fire conditions. (Figure 69)

[1] https://www.nwcg.gov/sites/default/files/publications/pms461.pdf pg 69

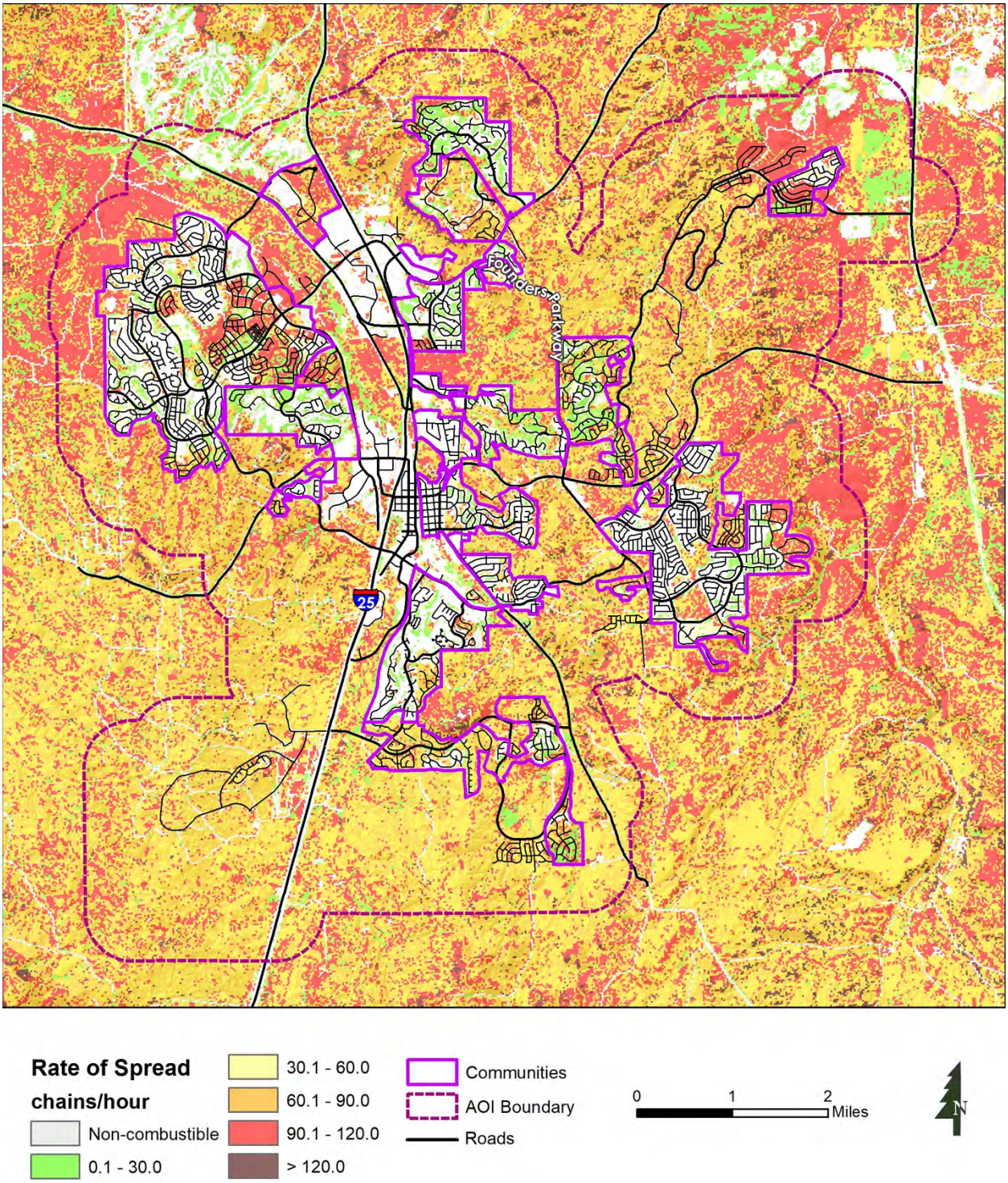

Figure 67 Rates of Spread, 90th percentile weather conditions[2]

[2] Spread rate values were classified into four categories: A chain is a logging measurement that is equal to 66 feet. 80 chains = 1 mile, 1 ch/hr = 1 foot/minute and 80 ch/hr = 1 mph.

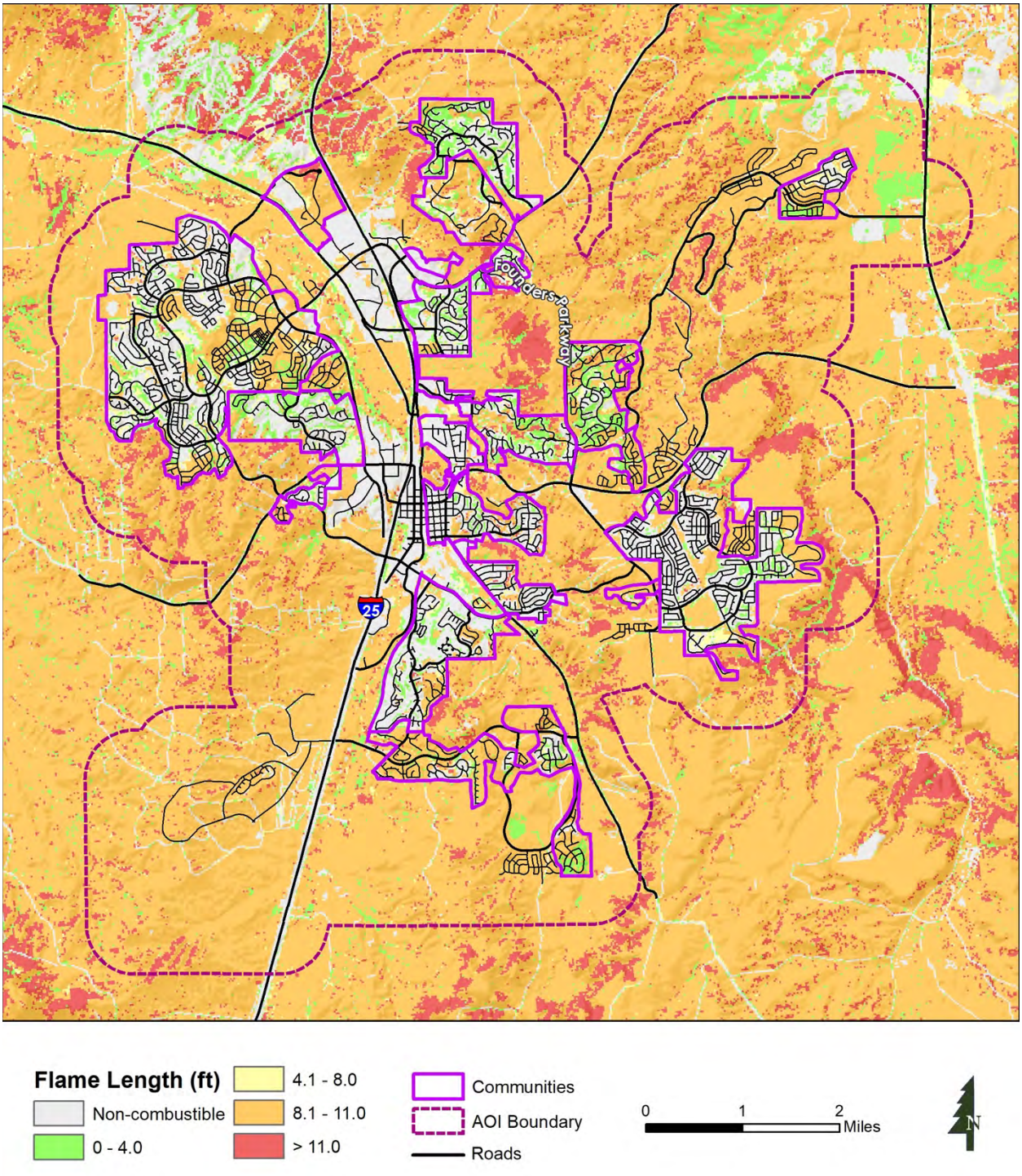

Figure 68 Flame Lengths, 90th percentile weather conditions

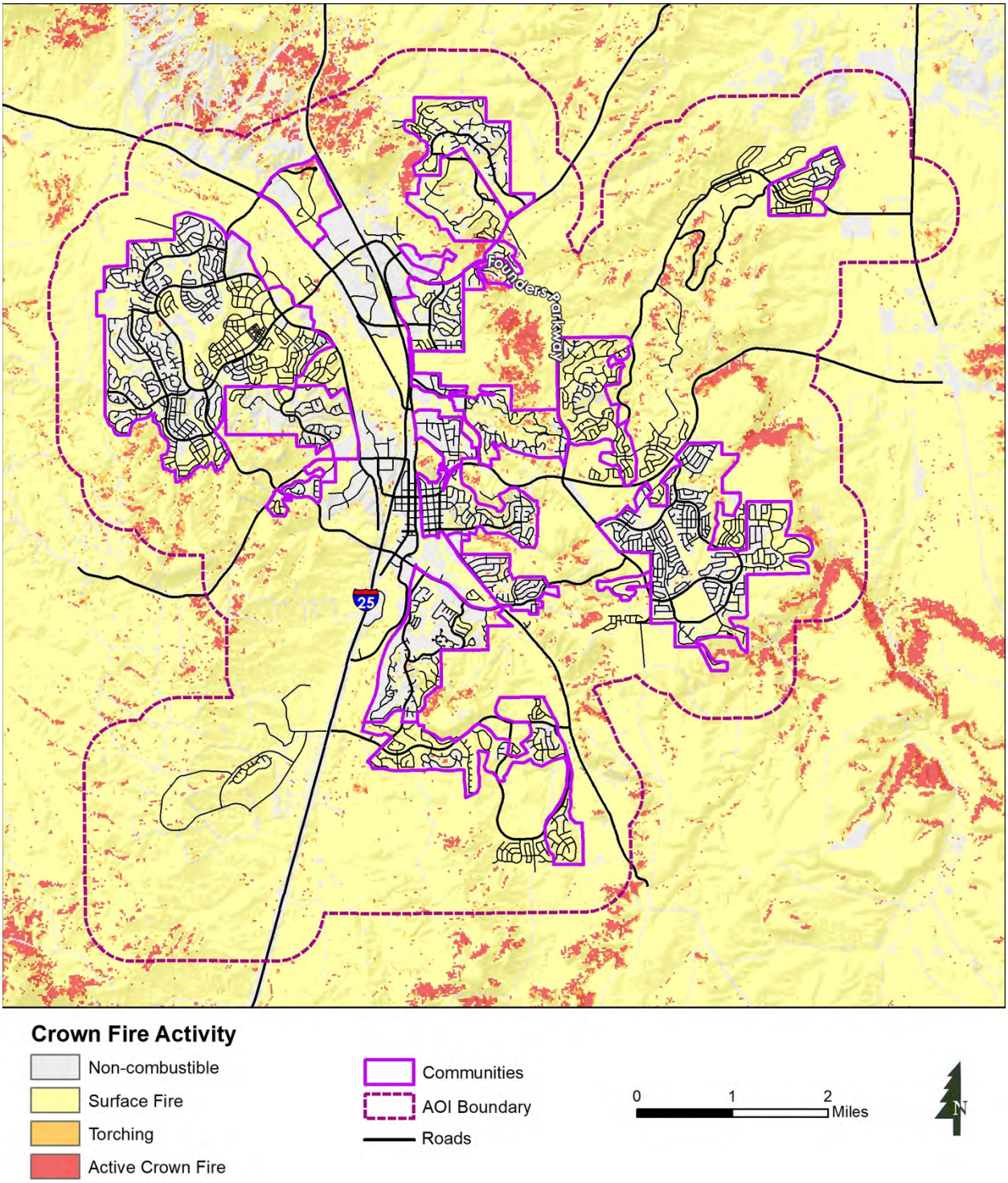

Figure 69 Crown Fire for the area

APPENDIX B FIRE MODELING TECHNICAL REFERENCE

Purpose

The purpose of this appendix is to describe the methodology used to evaluate the threat represented by physical hazards, such as fuels, weather and topography, to values-at-risk in the study area by modeling their effects on fire behavior potential.

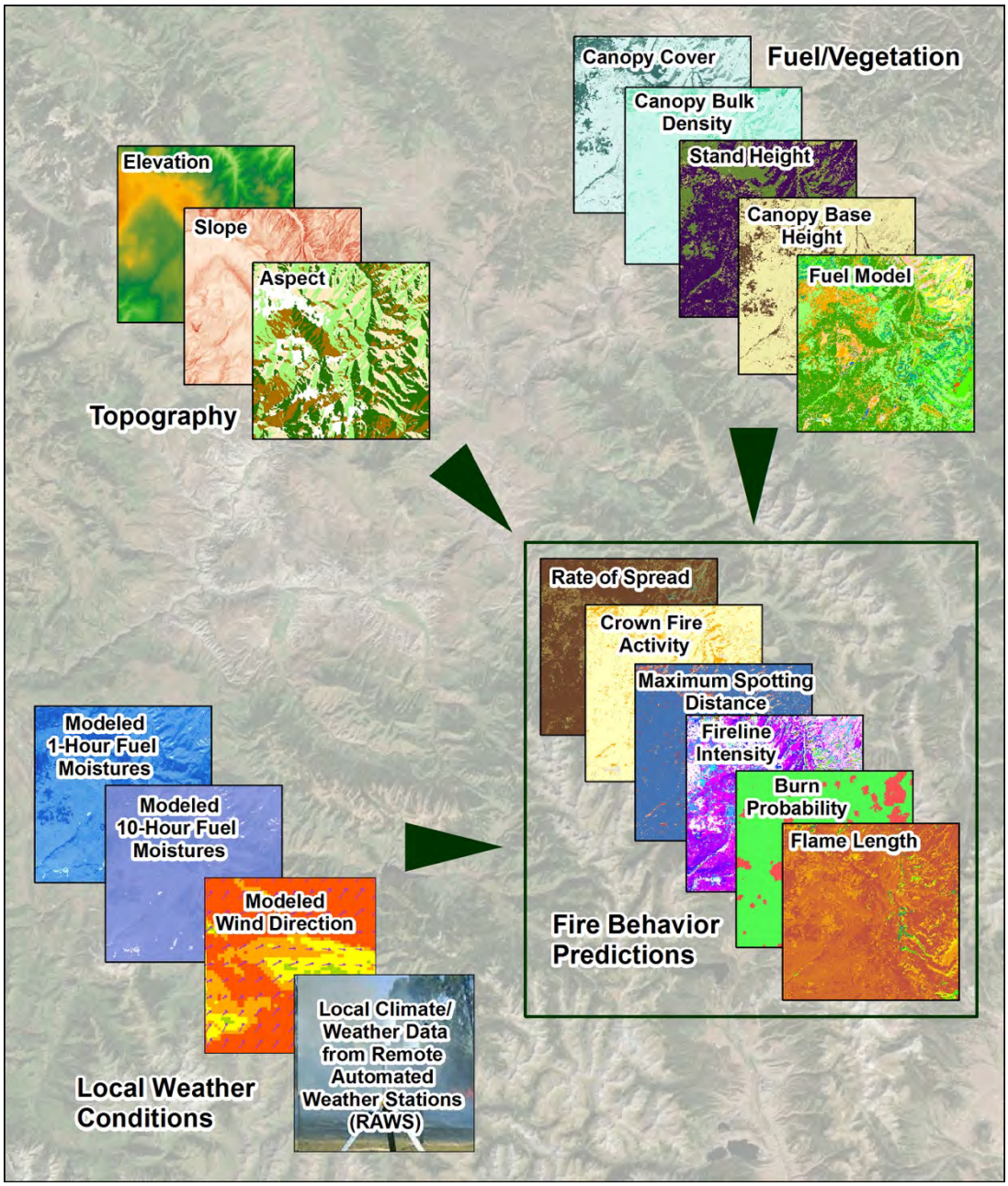

Figure 70 Fire Behavior Flow Chart[3]

Anchor Point used FlamMap[4] software (V 5.0 64 bit) to evaluate the potential fire conditions in the fire behavior study area. The study area encompasses 62.5 square miles (40,026 acres).

[3] This graphic shows input and output data sets that are not required for every analysis run and not all layers shown are used in all cases.

[4] Mark Finney, Stuart Brittain, and Rob Seli. The Joint Fire Sciences Program of the Rocky Mountain Research Station (USDA Forest Service, Missoula, Montana), the Bureau of Land Management and Systems for Environmental Management (Missoula, Montana).

The study area is broken down into grid cells (30 meters x 30 meters each), of which fire behavior is predicted based on fuel, weather and topographic information. Topographic data were acquired from the National Elevation Data set. The fuel layer used for this project was COWRAP 2017. (will add more detail and citation for final report)

The final set of input data for the FlamMap model consist of reference weather and fuel moisture information summarized from a Remote Automated Weather Station (RAWS) site. See the section below for details on RAWS information.

Fire Behavior Inputs

The major factors influencing fire behavior are topography (aspect, slope and elevation), weather and fuels (type and coverage). The following pages contain a brief explanation of each.

Reference Weather Used in the Fire Behavior Potential Evaluation

As stated above, climate and fuel moisture inputs for FlamMap were created by using data collected from a RAWS. The Franktown RAWS was used to capture the climate for the project area because of its location and elevation. Although it is some distance from the study area, it has the longest weather data set of any of the RAWS in the area.

Franktown RAWS Site Information (051606)

Latitude (dd.ddddd)	**39.39º N**
Longitude (dd.ddddd)	**104.75º W**
Elevation (ft.)	**6159**

Table 4 Remote Automated Weather Station (RAWS) information

Weather observations for a 7-year period (2010-2017) were used. June 5 through Nov 30 was used as the fire season. The high condition class (90^{th} to 97^{th} percentile, sorted by Spread Component) was calculated for each variable (1-hour, 10-hour and 100-hour fuel moisture, and 20-foot wind speed) using Fire Family Plus (V 4.2). This weather condition class most closely represents a typical high fire danger, fire season day.

Pre-conditioning of fuel moistures was calculated for both weather scenarios. The models calculate separate dead-fuel moistures for each landscape cell based on the topography and shading from forest canopy cover and clouds, as well as the recorded weather (precipitation, high and low temperatures and high and low relative humidity values) for a characteristic seven-day period. The dead-fuel moistures that have been calculated by the start date and time of the analysis are used to determine the outputs in fire behavior models. The following values, derived from Fire Family Plus, were used as climate/fuel moisture inputs in FlamMap:

High Weather Conditions	
Variable	**Value**
20 ft. Wind Speed Upslope	*26 mph
Herbaceous Fuel Moisture	55 %
Woody Fuel Moisture	85 %
1-hr fuel moisture	4 %
10-hr fuel moisture	5 %
100-hr fuel moisture	10 %

Table 5 Fuel moisture and weather inputs

* *Winds blowing uphill and using a probable momentary gust speed*

Upslope Winds

Upslope winds were used instead of directional winds because aligning slope and wind will give the worst-case results. Directional winds would favor one aspect over another and would show lower fire behavior on the leeward aspects. This is only the case under the given wind direction and would not account for other possible wind directions. Upslope winds reflect a generic worst-case scenario and are therefore better for pre-planning uses.

Wind speeds in RAWS data sets consist of 10-minute averages. During this 10-minute average, conditions are likely to be experienced that may exhibit substantially faster wind speeds than those represented by the 10-minute average. These faster wind speeds could have a profound impact on the ability of a fire to transition from a surface fire to a crown fire. NOAA has created a Wind Gust Estimating Table[5] that estimates probable momentary gusts and one minute speeds.

Dead Fuel Moisture

Dead fuel moisture responds solely to ambient environmental conditions and is critical in determining fire potential. Dead fuel moistures are classed by timelag. A fuel's timelag is proportional to its diameter and is loosely defined as the time it takes a fuel particle to reach two-thirds of its way to equilibrium with its

[5] Crosby, J.S. and Chandler, C. C. Getting the Most from Your Windspeed Observation *Fire Management Today,* Volume 64 (1), Winter 2004, Pages 53-55

local environment. Dead fuels in the National Fire Danger Rating System (NFDRS) fall into four classes: 1-, 10-, 100-, and 1,000-hour.[6]

Live Fuel Moisture

Live fuel moisture is the amount of water in a fuel, expressed as a percent of the oven-dry weight of that fuel. Fuel moisture between 300% and 30% is considered live. Anything below 30% is considered dead fuel. Fuel moistures can exceed 100% because the living cells can expand beyond their normal size to hold more water when available.

Fuel Models

Due to the unique size and condition of the study area, the fuel models from the national data set were deemed to be overly coarse. Therefore, a refined fuel layer that started with 2014 LandFire fuels models and were reviewed and adjusted where necessary for Colorado. The methodology and adjustments are documented in the *"Colorado Wildfire Risk Assessment Fuels Calibration Final Report, Sept 2017"*.

The WUI buffer extended 0.5 mile from the study area boundary. These wildland fuels are interspersed with developed and cleared areas around the structures and along the roadways. These non-combustible areas have been factored into the fuel classifications.

In the context of fire behavior modeling, "fuel models" are a set of numbers that describe fuels in terms that the fire behavior modeling equations can use directly. There are seven characteristics used to categorize fuel models:

- Fuel Loading
- Size and Shape
- Compactness
- Horizontal Continuity
- Vertical Arrangement
- Moisture Content
- Chemical Content

Each of the major fuel types present in the study area is described below, in terms of the characteristics that coincide with that fuel model. Unless otherwise noted, fuel model descriptions are taken from Scott

[6] U.S. National Fire Danger Rating System Overview: INT-GTR-367 - FIRES: Fire Information Retrieval and Evaluation System - a Program for Fire Danger Rating Analysis.

and Burgan's Standard Fire Behavior Fuel Models[7]. Scott and Burgan describe 40 fuel models in the following six groups: Non-Burnable (NB), Grass (GR), Grass/Shrub (GS), Shrub (SH), and Timber Litter (TL).

The study area is represented primarily by the following fuel models (FM)*:

Grass	Grass/Shrub	Shrub	Timber Litter	Non-Burnable
FM101 (GR1)	FM 122 (GS2)		FM182 (TL2)	NB9 (99) Bare Ground
FM102 (GR2)			FM 188 (TL8)	

Table 6 Fuel models found in the study area

* Some other fuel models may exist, but not in quantities (less than 5% on the landscape) sufficient to significantly influence fire behavior across the landscape.

Grass Fuel Type Models (GR)

The primary carrier of fire in the GR fuel models is grass. Grass fuels can vary from heavily grazed grass stubble or sparse natural grass to dense grass more than 6 feet tall. Fire behavior varies from moderate spread rate and low flame length in the sparse grass to extreme spread rate and flame length in the tall grass models.

All GR fuel models are dynamic, meaning that their live herbaceous fuel load shifts from live to dead as a function of live herbaceous moisture content. The effect of live herbaceous moisture content on spread rate and intensity is strong.

[7] Scott, J.H. and R. Burgan. 2005. Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model, United States Department of Agriculture Forest Service, RMRS-GTR-153.

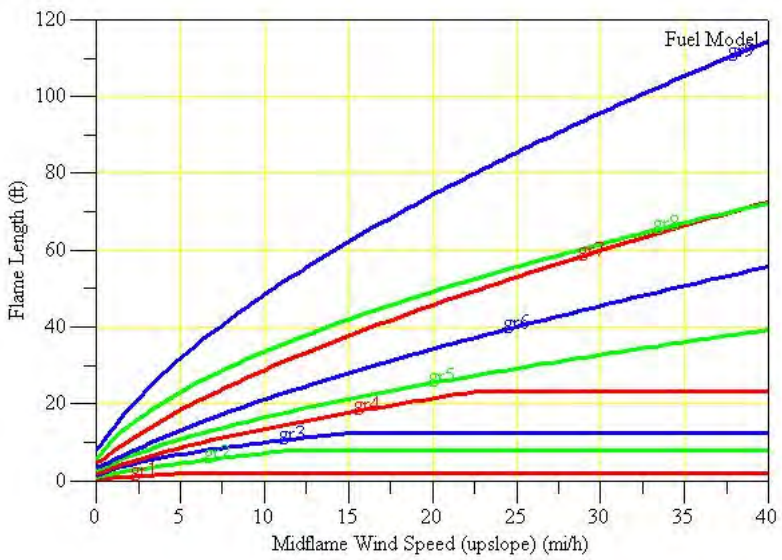

Figure 71 Modeled flame lengths for GR fuel models

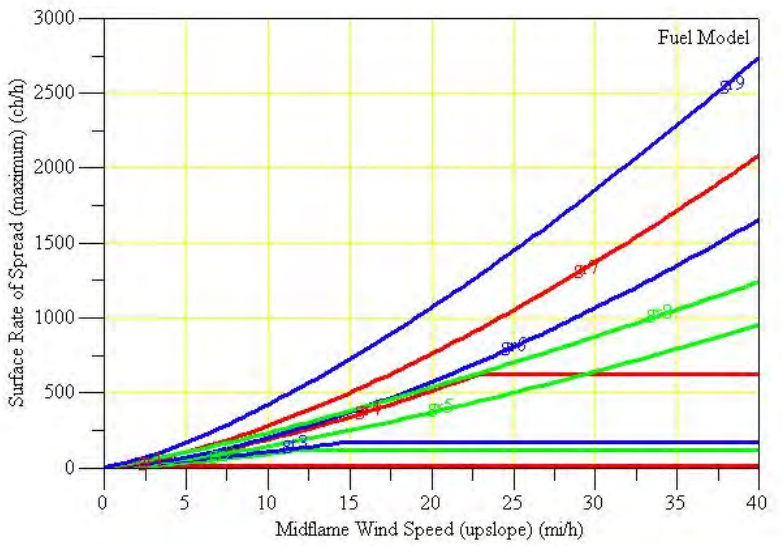

Figure 72 Modeled rates of spread for GR fuel models

Grass-Shrub Fuel Type Models (GS)

The primary carrier of fire in the GS fuel models is a combination of grass and shrubs; both components are important in determining fire behavior. All GS fuel models are dynamic, meaning that their live herbaceous fuel load shifts from live to dead as a function of live herbaceous moisture content. The effect of live herbaceous moisture content on spread rate and intensity is strong and depends on the relative amount of grass and shrub load in the fuel model.

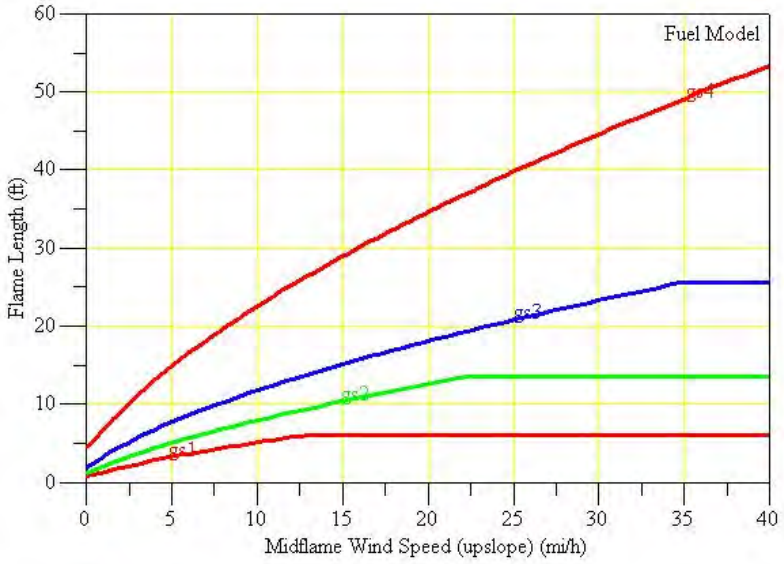

Figure 73 Modeled flame lengths for GS fuel models

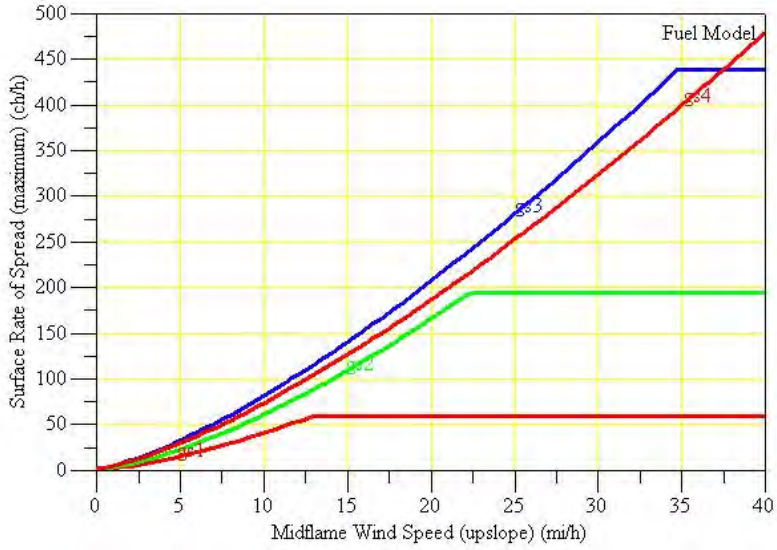

Figure 74 Modeled rate of spread for GS fuel models

Timber Litter Fuel Type Models (TL)

The primary carrier of fire in the TL fuel models is dead and down woody fuel. Live fuel, if present, has little effect on fire behavior.

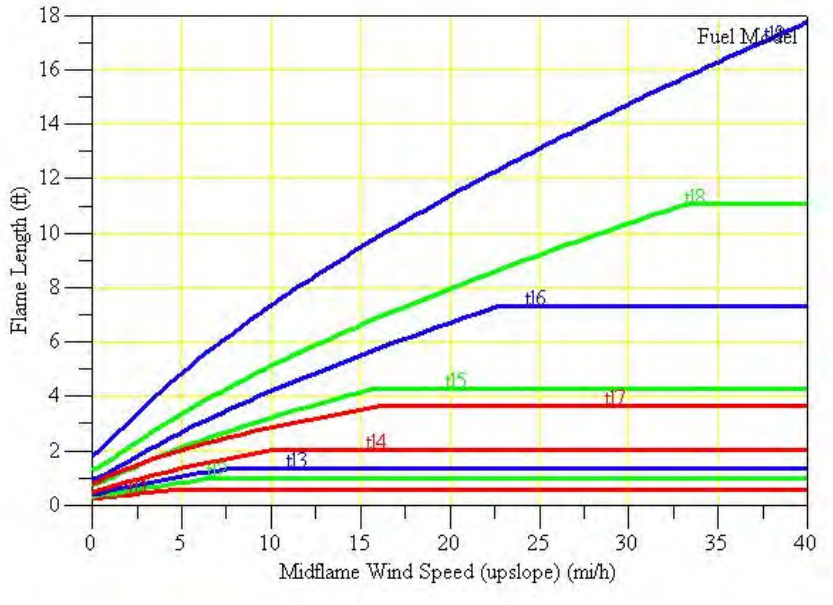

Figure 75 Modeled flame lengths for TL fuel models

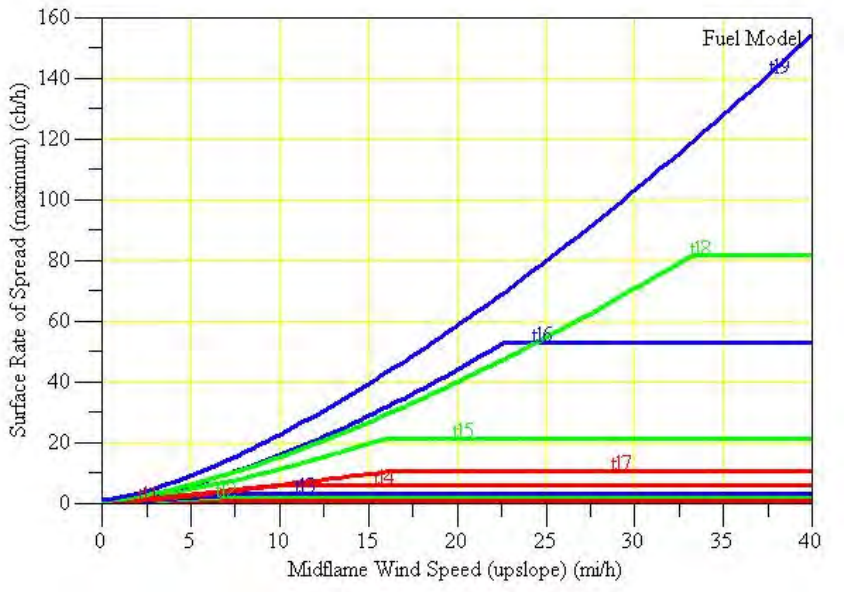

Figure 76 Modeled rate of spread for TL fuel models

Fuel Type	Fuel Moisture	Fuel Type	Fuel Moisture
1 hr	6%	LHFM	60%
10 hr	7%	LWFM	90%
100 hr	8%		

Table 7 Fuel moisture values used for the above graphs.

Modeling Limitations and Discussions

This evaluation is a prediction of likely fire behavior given a standardized set of conditions and a single point source ignition at every point. It does not consider cumulative impacts of increased fire intensity over time and space. The model does not calculate the probability that a wildfire will occur. It assumes an ignition occurrence for every 30-meter x 30-meter cell. These calculations may be conservative (under-predict) compared to observed fire behavior.

Weather conditions are extremely variable, and all possible combinations cannot be accounted for. These outputs are best used for preplanning and not as a stand-alone product for tactical planning. Whenever possible, fire behavior calculations should be done with actual weather observations during the fire. The most current Energy Release Component (ERC) values should also be calculated and distributed during the fire season to be used as a guideline for fire behavior potential.

The FlamMap draws heavily on calculations from the BEHAVE fire behavior prediction and fuel modeling system (see below).[8] BEHAVE is a nationally-recognized set of calculations used to estimate a surface fire's intensity and rate of spread given topographical, fuel, and weather information.

The BEHAVE modeling system has been used for a variety of applications, including predictions of current fires, prescribed fire planning, fuel hazard assessment, initial attack dispatch and fire-prevention planning and training. Predictions of wildland surface fire behavior in BEHAVE are made for a single point in time and space, given user-defined fuels, weather, and topography. Requested values depend on the modeling choices made by the user.

Assumptions of BEHAVE:

- Fire is predicted at the flaming front. (Fire behavior is not modeled for the time after the flaming front of the fire has passed.)
- Fire is free burning (uncontrolled by suppression efforts).
- Behavior is heavily weighted toward the fine fuels (grasses and small-diameter wood).
- Fuels are continuous and uniform.
- Fires are considered to be surface fires. (Crown fire activity is modeled separately.)

[8] Patricia L. Andrews, producer and designer, Collin D. Bevins, programmer and designer, The Joint Fire Sciences Program of the Rocky Mountain Research Station (USDA Forest Service, Missoula, Montana) and Systems for Environmental Management (Missoula, Montana).

BEHAVE makes calculations at a single point. In order to make calculations for an entire landscape (important for preplanning the effects of a wildfire at the community, district, or county scale), fire behavior is modeled using FlamMap, which models surface fire predictions and the potential for crown fire development.[9]

Assumptions of FlamMap:

- Each calculation in a given area is independent of calculations in any other area. Fire is not modeled dynamically across the landscape but statically as a series of individual calculations.
- Weather inputs such as wind and fuel moistures do not change over time.
- Fire behavior modeling calculations are performed in a series of uniform squares (or "pixels") across the landscape. These pixels determine the level of detail and nothing smaller than a pixel (30 meters x 30 meters in this case) is included in the modeling.

Crown fire activity, rate of spread, flame length, and fireline intensity are derived from the fire behavior predictions. A limitation of FlamMap is that crown fire and flame length are not linked. The flame length outputs are based on surface calculations and do not reflect the larger flame lengths associated with torching or active crowning. In order to correct this, areas that had torching in the crown fire calculation were multiplied by 1.2 in the flame length outputs. Similarly, if active crown fire was predicted then flame lengths were multiplied by 1.5.

[9] Van Wagner, C.E. 1977. "Conditions for the start and spread of a crown fire." *Canadian Journal of Forest Research*. 7: 23-24.