Cameron Peak Fire Risk Assessment

Final Report

March 15, 2021

Prepared for:

Larimer County Office of Emergency Management
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Prepared by:

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on behalf of Synergy Disaster Recovery

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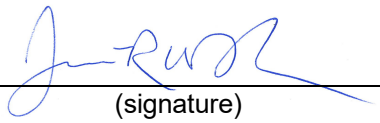
Prepared by  (signature)

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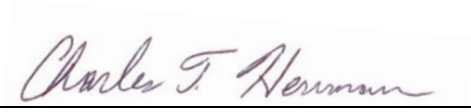
Reviewed by  (signature)

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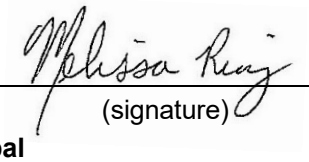
Approved by  (signature)

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Executive Summary

The Cameron Peak Fire burned an area of 208,913 acres in Larimer and Jackson Counties, from August 13, 2020 until full containment on December 2, 2020. It was the largest recorded wildfire in Colorado's history. The risk assessment detailed in this report was completed on behalf of Larimer County as part of the post-fire Emergency Response Phase. The purpose of this report was to assist the County in identification of potential high-hazard areas quickly and efficiently. The focus was on exigent threats to life, property, and the environment at a broad spatial scale within the burn perimeter. Subsequent actions will implement select projects to mitigate identified risks in vulnerable locations.

This report details the results of geospatial data risk analyses, which were completed to facilitate the identification of “priority areas” within the burn perimeter by comparing relative risk among assets. Priority areas are defined as neighborhoods or neighborhood groups that have a comparatively high probability of flooding, water quality issues, and debris impacts to County and private assets. The priority areas identified in this report include:

- Rustic/Poudre City/Glen Echo/Goodell Corner
- Monument Gulch/Pingree Park Road/ Lazy D Ranch
- Upper Buckhorn/ Crystal Mountain/ Crystal Park
- Storm Mountain/ Retreat

In addition to priority area identification, this report also provides specific mitigation methods that could be proactively implemented during the emergency response phase to protect life, property, and the environment.

1.0 PURPOSE

The Cameron Peak Fire was reported on Thursday, August 13, 2020. The fire burned an area of 208,913 acres over several months in Larimer and Jackson Counties, effecting both private and public lands until being fully contained on December 2, 2020. After 62 days of burning, on October 14, the Cameron Peak Fire became the largest recorded wildfire in Colorado's history, surpassing the Pine Gulch Fire that burned near Grand Junction in 2020. On October 18, the Cameron Peak Fire became the first in Colorado history to burn more than 200,000 acres. Prior to 2002, there was never a fire larger than 100,000 acres in Colorado. Weather and fuel conditions influenced fire growth, behavior, and effects of the Cameron Peak Fire. Extreme temperatures, low humidity, rough terrain and gusty winds reaching over 70 miles per hour were just some of the elements that were contributing factors influencing fire development (USFS 2020).

Within its burn perimeter, the Cameron Peak Fire reduced or eliminated above ground vegetation cover and altered soil structure, resulting in varying degrees of post-fire hydrophobicity. These direct changes to vegetation presence, structure, composition, and density will lead to reduced precipitation interception, decreased soil infiltration capacity, and elevated runoff compared to pre-fire conditions. Effects within the burned area will likely include an initial flush of ash, rill and gully erosion, debris-laden flash floods in response to high-intensity rain events, potential debris flows, and diminished water quality. The Soil Burn Severity (SBS), soil erosion, hydrology, and debris flow modelling results obtained and used in this risk analysis indicate that post-fire there will be an increase in watershed response. This means:

- Increased erosion and sedimentation
- Areas that flood or had debris flows pre-fire will have larger magnitude events
- Areas that occasionally flood or had debris flows pre-fire will see more frequent events
- Areas that previously did not have streamflow or debris flow may now flood or have debris flows
- Private and public infrastructure are at an increased level risk of damage to post-fire flood events
- Additional impacts to aquatic and terrestrial habitats are likely to occur

The Larimer County Office of Emergency Management contracted the Synergy Disaster Recovery team (of which Stantec is a part) to assist the County with post-fire emergency response and planning efforts. This report details the results of geospatial data risk analyses, undertaken to facilitate the identification of “priority areas” within the burn perimeter by comparing relative risk among assets. Priority areas are defined as neighborhoods or watershed basins that have a comparatively high probability of flooding, water quality issues, and debris impacts to County and private assets based on available data. In addition to priority area identification, this report also provides specific mitigation methods that could be proactively implemented during the emergency response phase to protect life, property, and the environment.

This report identifies and ranks areas within the Cameron Peak Fire burn perimeter where potential exigent post-fire threats to 1) human life and safety, 2) property, and 3) environment likely exist due to the fire's effects on above- and below-ground biomass (vegetation), the soil/water relationship, and the presence of hazardous trees. The risk analysis was performed using available post-fire data at a neighborhood and a county road segment scale of analysis, with a focus on threats to infrastructure. This threat assessment was also performed for individual county culverts and bridges as well as individual private roads and private residence locations. Potential risk mitigation prescriptions have been developed and are included in Section 6 of this report, however ground-truthing of results, a more detailed hydrological analysis, and an economic evaluation will be necessary to facilitate subsequent mitigation planning and implementation.

2.0 RISKS

2.1 HUMAN LIFE AND SAFETY

Human life and safety are potentially at risk from threats associated with hazardous burned trees, debris flows, increased flooding, and loss of egress/access throughout the burned area. Human life and safety are of paramount importance to the emergency response effort, and as such the risk level is High.

Many issues could be encountered while travelling in vehicles on roadways. Wind will blow over dead or damaged trees and rain or snowmelt could cause sedimentation, falling rock, debris flows, severe erosion, and flooding. Any of these issues could cause vehicle accidents.

Homes and cabins built in precarious geomorphic positions, including within floodplains, within or at the mouth of narrow canyons, on steeps slopes, and homes with nearby large dead or damaged trees provide increased risk to inhabitants, particularly during heavy rain events.

Increased risk while walking or recreating within the burned area is relatively limited, especially in populated areas. However, hazard trees in wind-prone locations, areas that experienced Moderate or High soil burn severity (SBS) and were previously densely stocked with trees, and narrow canyons or valley constrictions - subject to flash flooding during heavy rains - provide increased risk.

The loss of egress/access caused by public and private road damage related to potential debris flows, severe erosion, and flooding increases risk related to emergency services, medical care, and home fire suppression services.

Erosion and potential flood events can also damage county and private roads, resulting in increased response time for first responders to any future event.

2.2 PROPERTY

2.2.1 County Roads

County road infrastructure and function is potentially at risk from threats associated with debris flow, flood damage, and severe erosion. Culverts and bridges could be damaged as a result of large debris clogging the flow paths and creating subsequent flooding which could overtop, undermine, and blow out road surfaces and shoulders. Road surfaces and culverts could be covered and filled with sediment due to upslope erosion of hillsides and from debris flows. Undersized culverts and roads built in precarious geomorphic positions are particularly at risk. From a Larimer County emergency management perspective, the risk level associated with County Roads is High.

2.2.2 Structures and Private Roads

Homes, buildings, and private roads/driveways are potentially at risk from threats associated with hazard trees, debris flow, flood damage, and severe erosion. As with public roads, private culverts, bridges, and road surfaces could be subject to storm damage. Homes and private roads built in precarious geomorphic positions are particularly at risk. From a Larimer County emergency management perspective, the risk level associated with structures and private roads is High.

Other structures potentially at risk include utilities, dams and irrigation infrastructure. Potentially affected dams as compiled by the Colorado Division of Water Resources are shown in **Appendix A - Figure 1**. Several of these facilities are generally clustered near the ignition site of the fire near Cameron Pass; most others are located around the edge of the burn perimeter - some just within the burned area, some outside of it.

2.3 ENVIRONMENT

2.3.1 Water Quality (aquatic, public drinking supply, irrigation)

Water quality throughout the burn perimeter and areas downstream are potentially at risk from threats associated with previous active fire suppression activities, as well as post-fire debris flows, flooding, and severe erosion. Soil erosion and subsequent sedimentation increases are predicted throughout the burned area as well as areas downstream, particularly in years immediately following the fire. The cumulative effect of increased peak flows and sediment-laden runoff from the burned area increases the risk of degraded water quality. From a Larimer County emergency management perspective, the risk level associated with water quality is High.

2.3.2 Soil Productivity

Soil productivity is potentially at risk from threats primarily associated with severe erosion. Soil loss and associated productivity due to post fire erosion should be put into context of western forests being

disturbance driven ecosystems, with wildfire being the primary catalyst of disturbance. Erosion immediately following fire would be expected, but not all erosion should be considered an unacceptable loss (USFS 2020). Rather, elevated rates of erosion that exceeds a sites ability to recover and support native vegetation, or severe erosion that poses an immediate threat to life or critical infrastructure should be considered unacceptable, and potentially addressed in such locations. From a Larimer County emergency management perspective, the risk level associated with soil productivity is Low.

2.3.3 Flora

Native and naturalized plant communities are potentially at risk due to the threat of invasive species and type conversion (e.g., forest/woodland cover type conversion to grass- or shrub- dominated communities). Noxious weeds are present throughout the burned area and may potentially spread under post-fire conditions. The potential for spread of invasive plants is highest in areas disturbed by suppression activities areas, and those areas with Moderate to High soil burn severity (SBS). From a Larimer County emergency management perspective, the risk level associated with native flora is Low.

2.3.4 Fauna

Native and naturalized populations of game and non-game wildlife and fish are potentially at risk from threats primarily associated with the spread of noxious weeds. As indicated above, invasive plant species would adversely affect multiple resources including native plant communities which in turn affects habitat for wildlife and fisheries, as well as soil productivity. From a Larimer County emergency management perspective, the risk level associated with native fauna is Low.

2.3.5 Historic and Cultural Resources

No historic or cultural resources have been identified as part of this assessment. These resources will be evaluated on a location-by-location basis once specific priority areas have been chosen by Larimer County as post-fire treatment projects, and the mitigation techniques to be employed have been determined.

3.0 ASSESTS AT RISK

3.1 COUNTY ROAD INFRASTRUCTURE

County roads within and nearby the burned area total approximately 41 miles and include Redstone Road, Buckhorn Road, CR 32C, Devils Gulch Road, Pingree Park Road, CR 44H, Dunraven Glade Road, Boy Scout Road, Pingree Hill, Manhattan Road, and Laramie River Road. Larimer County has divided these roads into 22 individual road segments. Segments were evaluated individually for risk. Maps of road segments are provided in **Appendix A - Figures 3 and 4**.

All of these road segments contain county owned culverts and bridges. Individual culverts and bridges were evaluated for increased risk, however risk associated with culvert and bridge size suitability (for the watershed) has not been evaluated as of the issuance of this report. Culverts and bridges are at risk to due potential for increased flows and potential for debris to clog flow paths. Road surfaces are at risk of increased potential for washouts and sedimentation deposits requiring repair and cleanup.

In addition to road surfaces, shoulders, culverts, and bridges, the county maintains adjacent road right-of-way (ROW) which contains road ditches to collect and transport stormwater safely away from road surfaces. Damaged stormwater systems, such as plugged culverts and sediment filled ditches also add risk to county road infrastructure and require timely maintenance to prevent additional risk to life and safety. The ROW also contains trees damaged or killed by the fire. Dead trees in the ROW also add risk to county road infrastructure, life, and safety.

3.2 PRIVATE PROPERTY

3.2.1 Structures and Private Roads

The fire area contains private property with structures inclusive of homes, businesses, farms, ranches, and outbuildings. Nine-hundred and twenty-eight (928) addresses, divided into 35 neighborhood pods, have been provided by the county along with structure locations. Neighborhoods, private roads, and individual residences were evaluated for exigent post-fire threats. Maps of neighborhood pods, structures, and private roads are provided in **Appendix A - Figures 1 and 2**.

4.0 RISK ASSESSMENT METHODS

4.1 DATA SOURCES

Geospatial data employed in this risk analysis were obtained from multiple cooperating agencies. These include Larimer County, the Coalition for the Poudre River Watershed (CPRW), Colorado Forest Restoration Institute (CFRI), Northern Water, U.S. Forest Service (USFS), U.S. Geological Survey (USGS), and U.S. Fish and Wildlife Service (USFWS). Data employed in this risk analysis include the Cameron Peak Fire final burn perimeter and Soil Burn Severity (SBS) mapping, infrastructure, neighborhood access points, roads, hydrography, land use, slope, and debris flow modeling. A comprehensive list of GIS data sources used in this analysis may be found in **Appendix B**.

4.2 MAPPING AND RISK ANALYSIS

Neighborhoods, county road segments, private roads, residences, culvert, and bridge locations were provided by Larimer County. USFS provided Soil Burn Severity mapping. USGS provided potential debris flow lines. FEMA and Larimer County provided (pre-fire) mapped flood zone areas.

The percent High, Moderate, Low, and Unburnt or Very Low soil burn severity (SBS) were calculated for each neighborhood pod, private and county road segment, and within a 200-foot buffer of residence locations, culverts, and bridges. Potential debris flow lengths were totaled for neighborhood pods and within a 200-foot buffer of residence locations, culverts, and bridges. Potential debris flow intersect crossings were tallied for county and private road segments. Percent of neighborhoods, 200-foot buffers of residence locations, culverts, and bridges areas and percent of length of county and private road lengths within flood zones were calculated. Data output were typically ranked from most-impacted to least-impacted to allow prioritization, and graphed in histograms where appropriate to visualize the results and compare relative potential impacts across locations. Those areas deemed at "High" risk typically occur within the top 20% of the results for each asset class examined. The risk ranking developed in this report is thus relative, and not absolute. This methodology was used to rapidly identify those areas that have the highest potential risk associated with the post-fire environment, and to guide subsequent emergency actions.

Ground-truthing was conducted through general observation of soil burn severity, slopes and drainages within potential debris flow areas, and evidence of prior flooding along stream corridors in close proximity to structures and road infrastructure. No mapping or data associated with the analysis has been modified as a result of the ground-truthing. Ground-truthing was primarily conducted to affirm assumptions related to the data, to inform prioritization of mitigation areas, and to assist with development of risk mitigation recommendations.

5.0 RESULTS

Data were analyzed to specifically address potential risks to the following assets within the Cameron Peak fire perimeter: neighborhood pods, county roads, private roads, individual residences/structures, culverts, and bridges. A summary of primary findings based on these results is presented below. Complete tabular results of this risk assessment are contained in **Appendix C**.

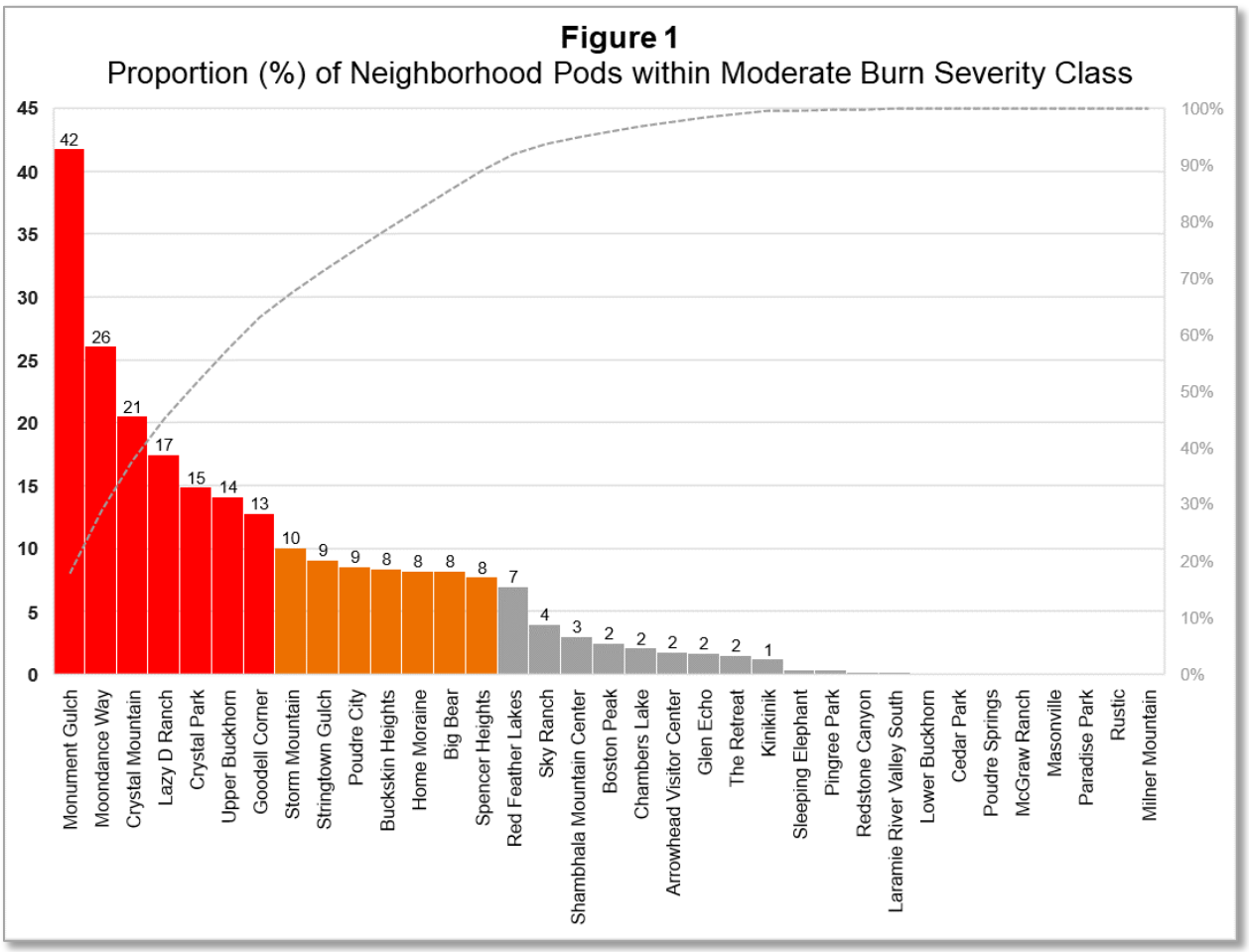
5.1 NEIGBORHOOD "PODS" ANALYSIS

Neighborhoods (as delineated by polygons received from Larimer County called "Pods") were assessed to determine: 1) the proportion of each neighborhood within mapped USFS soil burn severity classes [High, Moderate, Low, or Very Low/Unburned]; 2) the total length of potential USGS debris hazard [High, Moderate, Low, None] within each neighborhood; and 3) the proportion of each neighborhood within a mapped FEMA flood zone.

5.1.1 Neighborhood Soil Burn Severity Assessment

This examination of neighborhood and post-fire burn severity resulted in the identification of 10 neighborhoods that experienced a significant amount (>10% of the neighborhood) of Moderate- or combined High + Moderate burn severity. These neighborhoods include the following: Crystal Mountain,

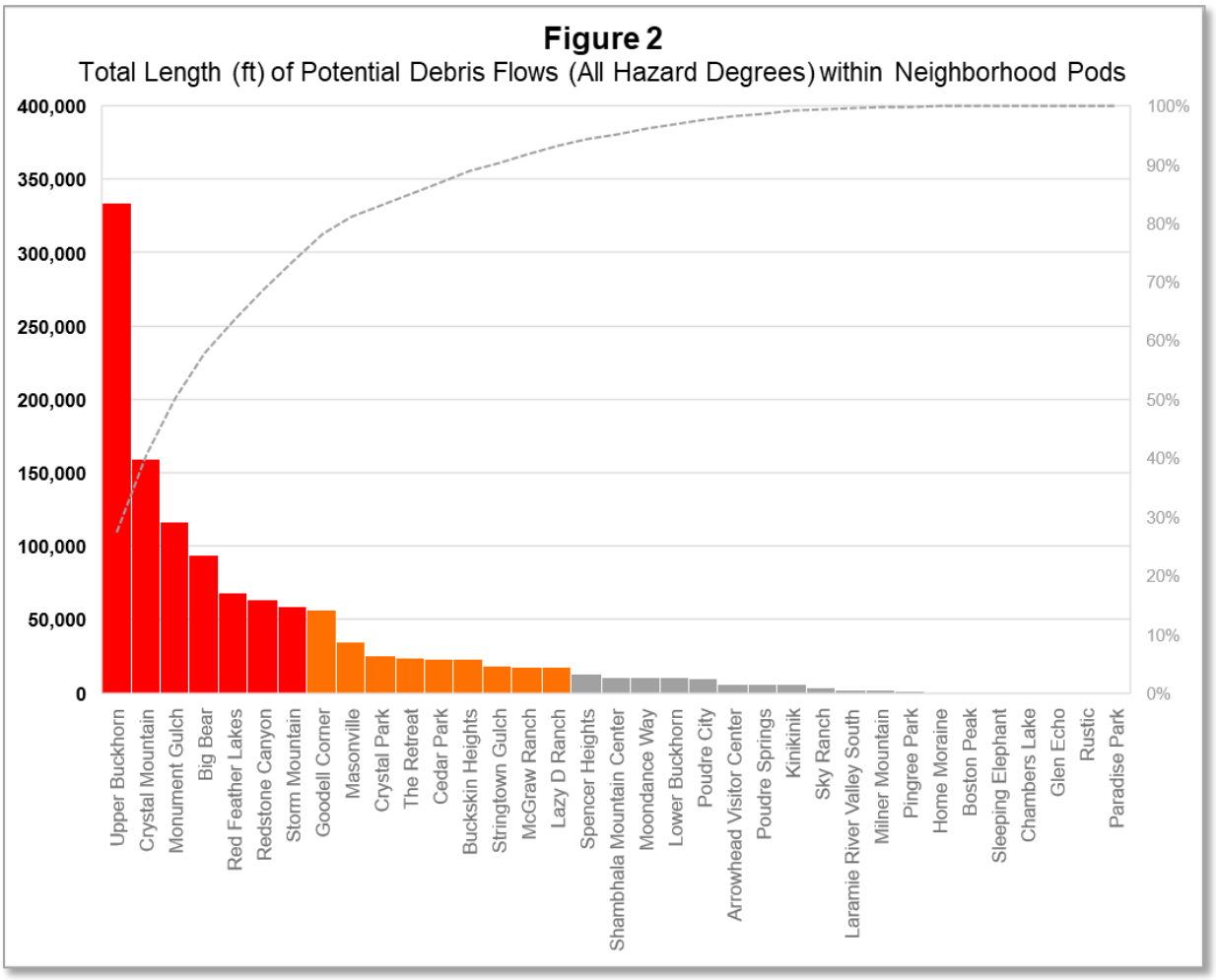
Crystal Park, Goodell Corner, Home Moraine, Lazy D Ranch, Monument Gulch, Moondance Way, Poudre City, Storm Mountain, and Upper Buckhorn. No neighborhood experienced High burn severity greater than 4 percent. Moderate burn severities were far more commonly experienced by neighborhoods within the fire burn perimeter. A histogram depicting the percentage of neighborhoods within the Moderate burn severity class is presented below (**Figure 1**). Neighborhoods represented by red bars represent those pods in the 20th percentile. Neighborhoods represented by orange bars represent those pods in the top 40th percentile. The gray bars represent neighborhoods below the 40th percentile.



5.1.2 Neighborhood Debris Flow Assessment

Neighborhoods were assessed to determine the total length of potential debris flows (length in feet) across all debris flow severities [High, Moderate, Low, or None] within each of the 35 neighborhood polygons. In addition to analyzing by hazard class, the sum of all hazard classes was calculated for each neighborhood.

This examination of neighborhood by debris flow potential resulted in the identification of 8 neighborhoods that have potential to experience significant debris flows (>50,00 feet total) within the neighborhood pod. These neighborhoods include the following: Big Bear, Crystal Mountain, Goodell Corner, Monument Gulch, Red Feather Lakes, Redstone Canyon, Storm Mountain, and Upper Buckhorn. A histogram depicting the total length of debris flows by neighborhood pod is presented below (**Figure 2**). Neighborhoods represented by red bars represent those pods in the 20th percentile. Neighborhoods represented by orange bars represent those pods in the top 40th percentile. The gray bars represent neighborhoods below the 40th percentile.



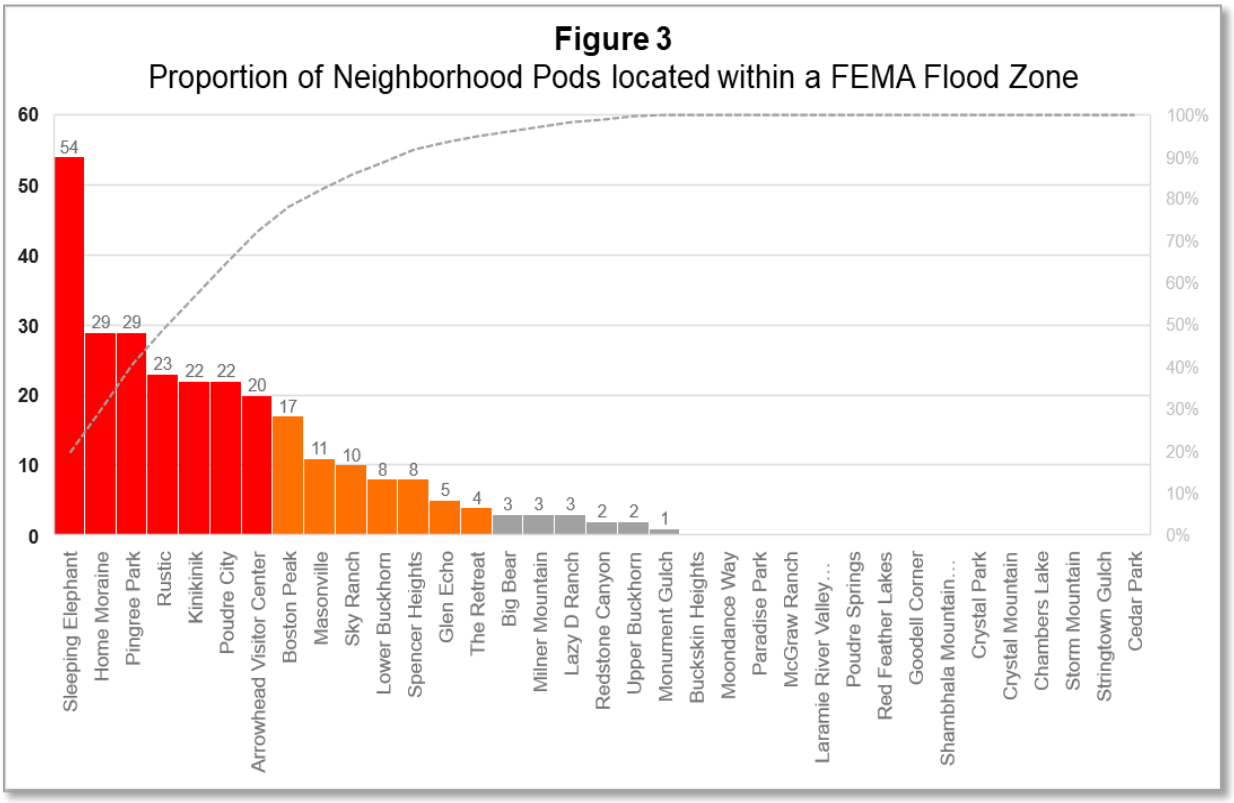
5.1.3 Neighborhood Flood Zone Assessment

Neighborhoods were assessed to determine the proportion of each neighborhood within a FEMA flood zone. This includes the 100-year Flood Zone, the 100-year Floodway, and the 500-year Flood Zone. In

addition to analyzing the neighborhoods by each individual hazard class, the sum percentage of each neighborhood within all classes was calculated as a summary statistic.

This examination of neighborhood by FEMA Flood Zone resulted in the identification of 6 neighborhoods having a significant proportion (>20%) of the neighborhood located within a mapped flood zone. These six neighborhoods include the following: Home Moraine, Kinikinik, Pingree Park, Poudre City, Rustic, and Sleeping Elephant. A histogram depicting the proportion of neighborhood pods located within a FEMA flood zone is presented below (**Figure 3**). Neighborhoods represented by red bars represent those pods in the 20th percentile. Neighborhoods represented by orange bars represent those pods in the top 40th percentile. The gray bars represent neighborhoods below the 40th percentile.

Figure 3
Proportion of Neighborhood Pods located within a FEMA Flood Zone



5.1.4 Neighborhood Pods Results Summary

Based on the metrics of mapped burn severity, potential for significant debris flows, and percentage of neighborhood area within a FEMA flood zone, the following neighborhood pods (**Table 1**) exhibit comparatively high risk, from post-fire flooding and debris flows:

Table 1 Neighborhood Pod Relative Risk Summary Table (based on Burn Severity, Potential Debris Flows, and FEMA Flood Zones)

High Risk Neighborhood Pods
Big Bear
Crystal Mountain
Goodell Corner
Home Moraine
Monument Gulch
Poudre City
Upper Buckhorn
Storm Mountain

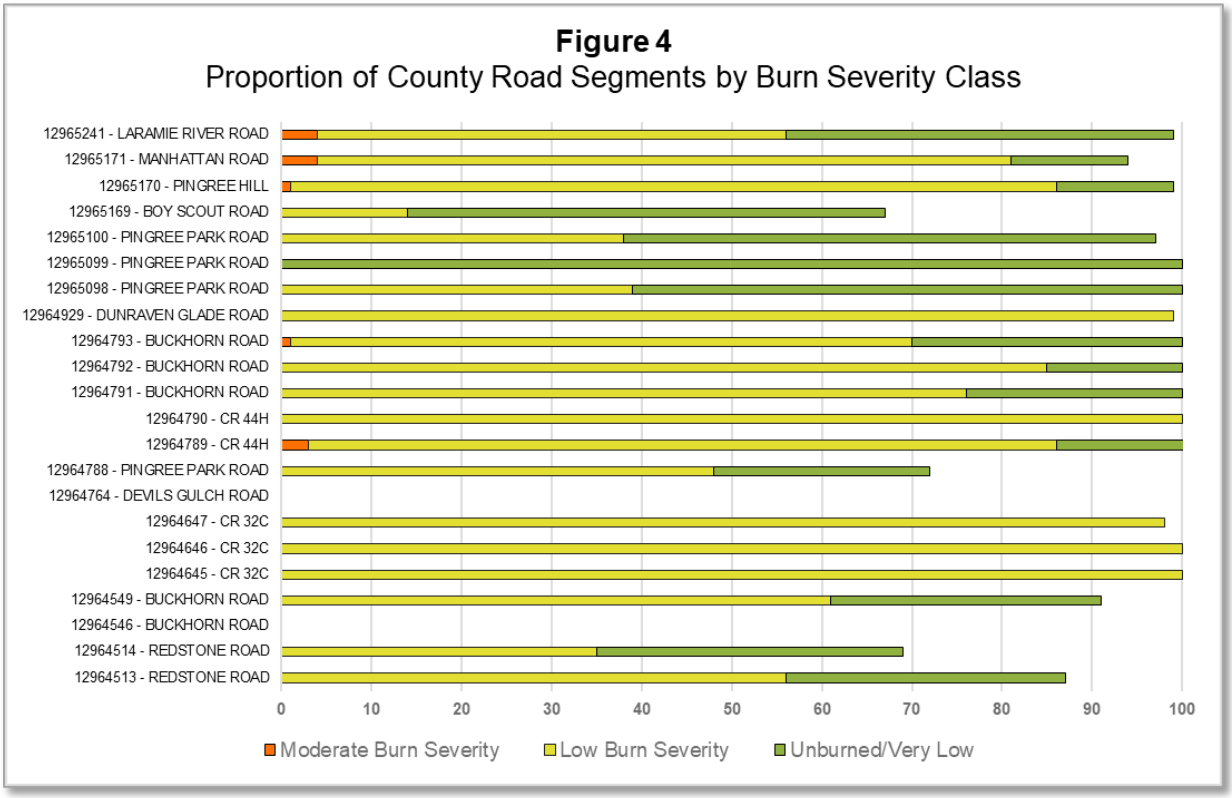
5.2 COUNTY ROADS ANALYSIS

County Roads were assessed to determine: 1) the proportion of each County Road segment (segments were delineated as road sections within the fire's burn perimeter) within mapped burn severity classes [High, Moderate, Low, or Very Low/Unburned]; 2) the total number of locations where potential debris flow hazards [High, Moderate, Low, None] intersect with each road segment; and 3) the proportion of each road segment within a mapped FEMA flood zone.

5.2.1 County Roads Soil Burn Severity Assessment

The assessment of County Roads and post-fire burn severity resulted in the identification of 5 County Roads that experienced Moderate burn severity. These road segments include the following: Buckhorn Road [CR 44H] (Segment ID 12964789), Buckhorn Road [CR 44H] (Segment ID 12964793), Pingree Hill Road [CR69] (Segment ID 12965170), Manhattan Road [CR 69] (Segment ID 12965171), and Laramie River Road [CR 103] (Segment ID 12965241). No County Road segments occurred within a High Severity Burn mapping unit. Most (19 of 22 segments examined) County Road segments within the burn perimeter occur in areas of Low burn severity. A stacked bar chart depicting the percentage of County Road Segments within each burn severity class is presented below (**Figure 4**).

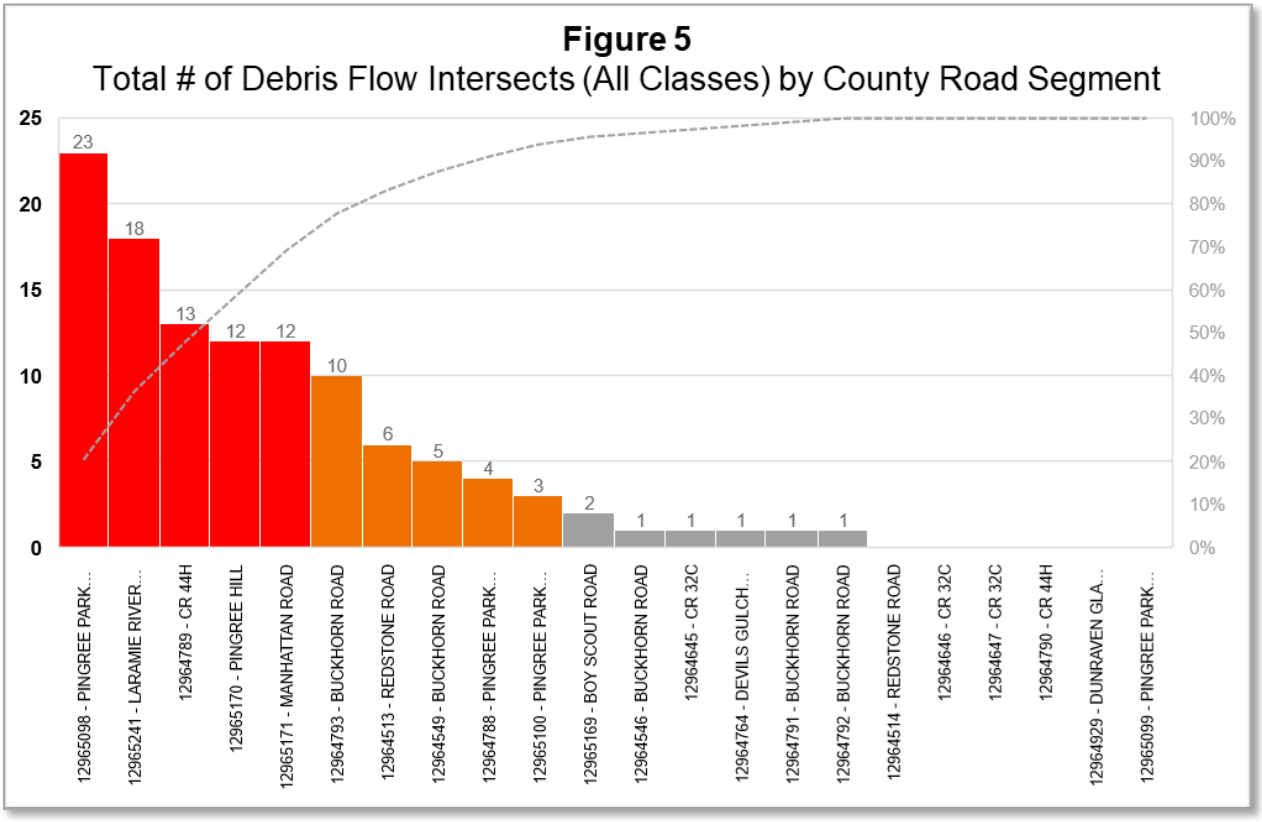
Figure 4
Proportion of County Road Segments by Burn Severity Class



5.2.2 County Road Debris Flow Assessment

County Roads were assessed to determine the total number of potential debris flows intersects across all severities [High, Moderate, Low, or None] with each of the 22 road segments. In addition to analyzing by each hazard class individually, the sum of debris flow intersections for all hazard classes was calculated for each road segment.

The intersection of County Roads and debris flow potential resulted in the identification of 6 road segments that exhibit potential to experience significant debris flows (>10 total intersects) along the county road. These road segments include the following: Buckhorn Road [CR 44H] (Segment ID 12964789), Buckhorn Road [CR 44H] (Segment ID 12964793), Pingree Park Road [CR 63E] (Segment 12965098), Pingree Hill Road [CR69] (Segment ID 12965170), Manhattan Road [CR 69] (Segment ID 12965171), and Laramie River Road [CR 103] (Segment ID 12965241). A histogram depicting the total number of debris flow intersects by County Road segment is presented below (**Figure 5**). Road segments represented by red bars represent those pods in the 20th percentile. Road segments represented by orange bars represent those pods in the top 40th percentile. The gray bars represent road segments below the 40th percentile.

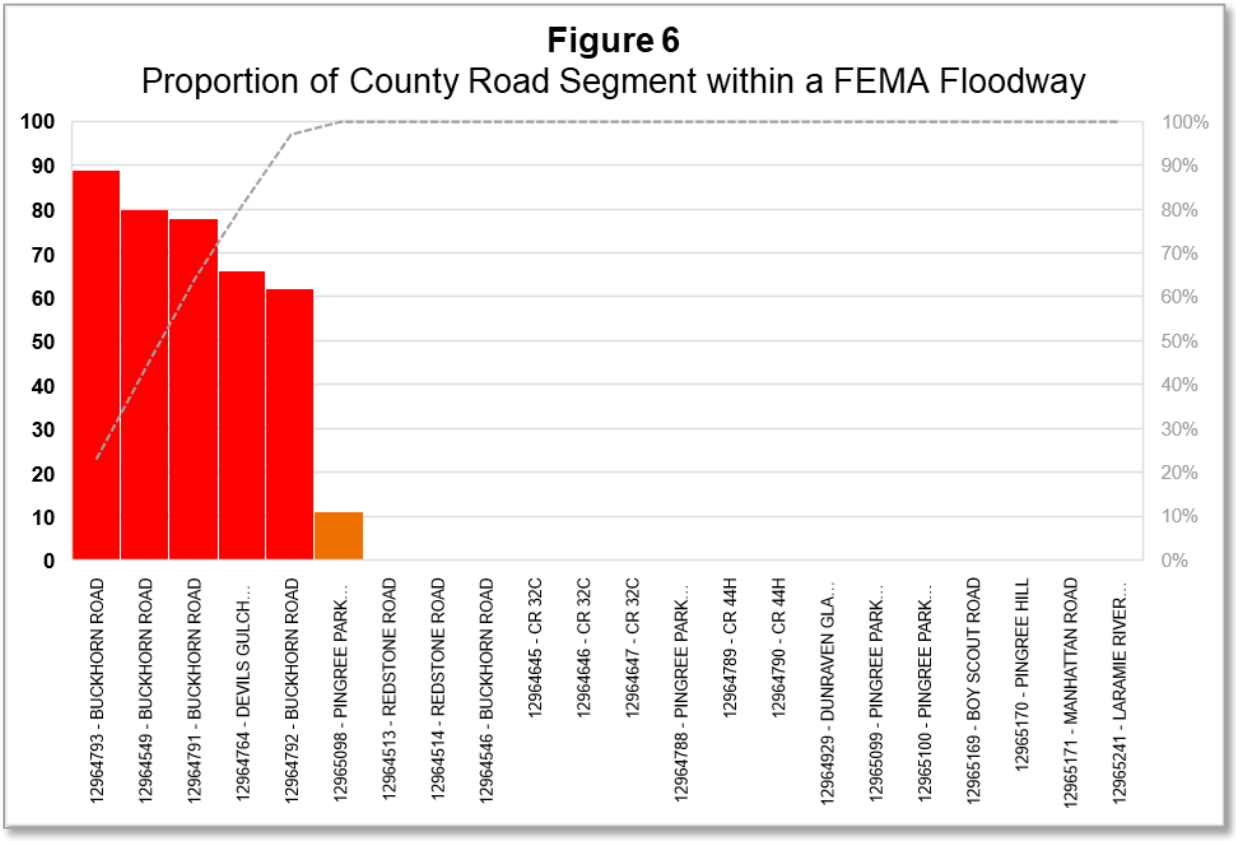


5.2.3 County Road Flood Zone Assessment

County Roads were assessed to determine the proportion of each road segment within a FEMA flood zone. This includes the 100-year Flood Zone, the 100-year Floodway, and the 500-year Flood Zone. In addition to analyzing the road segments by each individual hazard class, the sum percentage of each road segment within all classes was calculated as a summary statistic.

This examination of County Road by FEMA Flood Zone resulted in the identification of 6 road segments having a proportion of their length in a 100-year Flood Zone, or a significant proportion of their length (>50%) in any hazard class. These six road segments include the following: Buckhorn Road [CR 44H] (Segment ID 12964549), Devils Gulch Road [CR 43] (Segment ID 12964764), Buckhorn Road [CR 44H] (Segment ID 12964791), Buckhorn Road [CR 44H] (Segment ID 12964792), Buckhorn Road [CR 44H] (Segment ID 12964793), and Pingree Park Road [CR 63E] (Segment 12965098). A histogram depicting the proportion of County Road segments located within a FEMA flood zone is presented below (**Figure 6**). Road segments represented by red bars represent those pods in the 20th percentile. Road segments represented by orange bars represent those pods in the top 40th percentile. The gray bars represent road segments below the 40th percentile.

Figure 6
Proportion of County Road Segment within a FEMA Floodway



5.2.4 County Roads Results Summary

Based on the metrics of mapped soil burn severity, number of potential debris flow intersections, and proportion of County Road segment within a FEMA flood zone, the following road segments (**Table 2**) exhibit comparatively high and moderate risk, respectively, from post-fire flooding and debris flows:

Table 2 County Road Relative Risk Summary Table (based on SBS, Potential Debris Flows, and FEMA Flood Zones)

High Risk CR Segments	Moderate Risk CR Segments
12964789 - CR 44H	12964549 - BUCKHORN ROAD
12964793 - BUCKHORN ROAD	12964791 - BUCKHORN ROAD
12965098 - PINGREE PARK ROAD	12964792 - BUCKHORN ROAD
12965171 - MANHATTAN ROAD	12965170 - PINGREE HILL
12965241 - LARAMIE RIVER ROAD	---

5.3 PRIVATE ROADS ANALYSIS

One-hundred and sixty-seven (167) private road locations have been provided by the county and were analyzed using the same methodology as the county roads, using soil burn, debris flow, and flood potential to determine risk. Fifty-seven (57) private roads were found to have high or moderate elevated risk.

5.4 RESIDENCE/STRUCTURES ANALYSIS

Nine-hundred and twenty-eight (928) private residence or structures have been provided by the county. Structures were analyzed using a 200-foot buffer and using the same methodology as the neighborhood pods, using soil burn, debris flow, and flood potential to determine risk. Many residences and structures located in high and moderate soil burn areas have been lost to the fire. Soil erosion to due to soil burn severity poses a low risk to structures. Debris flow and flooding present high risks. Potential flooding or debris flows were found to be present within 200 feet of three-hundred and eighty-nine structures.

Additional desktop and ground-truthing will be necessary to refine this analysis as many structures flagged as having increased risk are located in suitable geomorphic positions and therefore risk will be low.

5.5 COUNTY ROAD CULVERT AND BRIDGE ANALYSIS

Six-hundred and twenty-five (625) county culverts and nine (9) bridges locations have been provided by the county. Culverts and bridges were analyzed using a 200-foot buffer and using the same methodology as the county road segments, using soil burn, debris flow, and flood potential to determine risk.

Two-hundred and fifteen (215) culverts and one (1) bridge are located in or within 200-feet of moderate or high soil burn areas. Two-hundred and sixty (260) culverts and three (3) bridges are located within 200 feet of potential debris flow areas. Ninety-four (94) culverts and five (5) bridges are located with floodplains.

Soil erosion due to soil burn severity, debris flows, and debris laden floodwaters present high risks to culverts and bridges.

Additional hydraulic analysis will be needed to refine prioritization of culvert and bridge risk.

5.6 AREAS OF GREATEST POTENTIAL HAZARD (PRIORITY AREAS)

5.6.1 Rustic/Poudre City/Glen Echo/Goodell Corner

Risks to roads and structures in this area include flooding associated with Seven Mile Creek and debris flows stemming from high and moderate soil burn areas within multiple relatively steep and narrow canyons with relatively large watershed areas.

Water quality impact risks are very high in this area.

5.6.2 Monument Gulch/Pingree Park Road/ Lazy D Ranch

Risks to roads and structures in this area include flooding associated with Fish Creek, Pennock Creek, Little Beaver Creek, and the South Fork of the Poudre River. Debris flow risk is high within Monument Gulch.

Water quality impact risks are very high in Fish Creek, Little Beaver Creek, and the Monument Gulch areas.

5.6.3 Upper Buckhorn/ Crystal Mountain/ Crystal Park

Risks to roads and structures in this area include flooding associated with Buckhorn Creek and debris flows stemming from high and moderate soil burn areas within multiple relatively steep and narrow canyons with relatively large watershed areas. Single point access to structures in this area is common and many of the access roads lie within canyons with elevated risk.

Water quality impact risks are comparatively moderate in this area.

5.6.4 Storm Mountain/ Retreat

Risks to roads and structures in this area include flooding associated with Black Creek, Miller Fork, and the North Fork of the Big Thompson. Debris flow and erosion potential stemming from steep high and moderate soil burn areas is common within the higher elevation areas for both the Storm Mountain and Retreat neighborhoods. Single point access to structures in this area is common and many of the access roads lie within areas of elevated risk. The entire Storm Mountain neighborhood relies on one access located within a steep and narrow canyon, however the contributing watershed is outside of the burn area.

Water quality impact risks are moderate to high in the Retreat area and low in the Storm Mountain Area.

6.0 RISK MITIGATION RECOMMENDATIONS

6.1 POTENTIAL MITIGATION METHODS, TOOLS AND TECHNIQUES

The following list includes methods and actions that can be used to reduce risk to Life and Safety, Property, and the Environment during the emergency response phase:

- Upgrading and fortifying road infrastructure – culvert and bridge replacement, adding rip-rap to road shoulders, resurfacing.
- Planning for road infrastructure repair – planning for rapid culvert or bridge replacement or maintenance in the event of stormwater/floodwater induced damage or failure.
- Increasing monitoring and maintenance of roadways – installation of cameras and/or stream monitoring devices at stream-road intersections, increased fallen-rock/debris-flow/fallen tree patrols following large and intense rain events, regular maintenance of stormwater conveyance (ditches and culverts).
- Removing debris from streams to prevent damage to bridges and culverts and damage from increased flooding.
- Removing danger trees to prevent potential emergency vehicle access disruption, traffic hazard, local access, and structure damage.
- Installing warning signs to notify motorists, bikers, and hikers they are entering a burn area subject to flash flooding and debris flow hazards.
- Structure protection to prevent potential flood or debris flow damage.
- Soil stabilization to prevent soil particle detachment as a result of rain, wind, and gravity.
- Slope protection and upland channel protection to prevent sediment and ash from eroding into waterways or onto roadways or structures.
- Sediment basin construction to collect sediment and ash prior to washing into waterways.
- Stream bank stabilization
- Revegetation / Reforestation – revegetation planning, planting of native vegetation, monitoring, and treating invasive species. Seeding of sterile annual cereal grains (e.g., triticale) should also be considered in disturbed locations to prevent colonization by invasive species and serve as a living mulch.

6.2 EXIGENT PLANNING AND IMPLEMENTATION

6.2.1 Larimer County Road Department

The Larimer County Road Department is in the process of designing several culvert replacements and road/stream bank fortification projects.

Additional hydraulic analysis is being completed by the State and results will be provided to the County for additional evaluation and consideration in terms of necessary culvert and bridge replacements as well as maintenance, monitoring, and post-damage/failure replacement planning considerations.

6.2.2 Larimer County Emergency Management Debris Removal and Danger Tree Mitigation

Larimer County has received an estimate of debris removal and danger tree treatment needs from streams, county road right-of-way, and private land and is in the process of contractor procurement.

6.2.3 Larimer County Emergency Management Structure Protection

The initial risk analysis provides addresses within a 200-foot buffer of a potential debris flow or a mapped floodplain. Larimer Counties' Emergency Management Department is in the process of detailed analysis and a ground-truthing exercise to further refine the address list that contain structures placed in areas of concern for flooding and/or debris flow structure damage and life safety concerns.

Property owners will be notified, and voluntary mitigation options will be presented such as gabion rock bags, sandbags, or concrete barriers.

The County is in the process of contractor and barrier procurement for installation of structure protection measures.

6.2.4 Larimer County Emergency Management Soil Stabilization and Slope Protection

Larimer County Office of Emergency Management has identified 4 priority soil stabilization and slope protection areas that are currently being evaluated for feasibility of installing erosion control wattles for slope and channel protection along County and private roadways, along ephemeral, intermittent, and perennial waterways, and above structures built into steep hillslopes.

Feasibility for the application of wood mulch (obtained from debris clearing operations) and use of a temporary cover crop (sterile seed) is also under consideration.

Property owners will be notified, and voluntary mitigation options will be presented such as wattle installation, mulching, and/or seeding with a cover crop.

In addition, the County will be working with the USFS for permission to install soil stabilization and slope protection measures on the National Forest in areas adjacent to county and private infrastructure.

The County is in the process of contractor, wattle, and seed procurement for installation of soil stabilization and slope protection.

6.2.5 Cooperating Stakeholders

The Coalition for the Poudre River Watershed, Big Thompson Watershed Coalition, the City of Fort Collins, the City of Greeley, the City of Loveland, and Northern Water Conservation District have been working in collaboration with Larimer County on risk mitigation efforts on a fire-wide basis. Soil stabilization and slope protection measures have- and will continue to be- installed around the reservoirs near Cameron Pass. Large scale aerial mulching with wood fiber is also being proposed in many locations.

Any mitigation actions within the burn area are likely to have a positive impact for a broad range of stakeholders with interests including public safety, infrastructure protection, water quality improvement, recreation, invasive species management, forestry, farming, grazing, and economic stability.

At the time of this report, it is still unclear what management actions might be allowable on lands administered by the U.S. Forest Service, and what management actions Larimer County can effectively implement on private property. These questions will require clarification in advance of project implementation on such lands.

6.3 LIMITATIONS AND FUTURE CONSIDERATIONS

The risk assessment detailed in this report was completed as part of an emergency response action to identify potential areas of elevated hazard quickly and efficiently. The focus was on exigent threats to life, property, and the environment at a broad spatial scale within the burn perimeter. The geospatial data used for this risk assessment were obtained from cooperating partners, examined using straightforward queries in GIS, and rapid field verification of post-fire conditions in locations throughout the burn perimeter was conducted. Additional data may be needed to better understand specific threats in specific locations. At minimum, a more detailed hydrological analysis is recommended for priority project areas identified to further assess threats and refine management prescriptions. Regardless, no portion of the burned area exists in isolation, and a holistic management perspective is important. The priority areas identified in this report occur in small watersheds, which are nested within larger watersheds. Cumulative effects (upstream to downstream) have the potential to be significant drivers of risk given the expansive area and rugged topography encompassed by the burn perimeter, and these need to be carefully considered moving forward.

The Emergency Response Phase will result in priority treatment actions in the coming months. Emergency actions should consider potential long-term impacts, particularly to the environment, as such actions can produce novel forms of disturbance in these watersheds. Following implementation of

Emergency Response-phase projects, the focus of planning efforts will transition to long-term post-fire rehabilitation efforts. The Long-Term Recovery and Restoration Phase will utilize non-emergency actions to improve fire-damaged lands that are unlikely to recover naturally and to repair or replace infrastructure damaged by the fire that are not critical to life and safety. This phase may include restoring burned habitat, reforestation, other planting or seeding, monitoring watershed effects, treating noxious weed infestations, addressing recreational needs, implementing projects to enhance watershed resilience and sustainability, and addressing other long-term priorities. This long-term recovery phase should focus on present and future community needs, watershed health and sustainability, and the desired future conditions of landscapes impacted by the Cameron Peak Fire.

7.0 REFERENCES

U.S. Forest Service (USFS). 2020. Cameron Peak Fire Forest Service Burned Area Emergency Response Executive Summary. Arapaho Roosevelt National Forest. December 15, 2020. Available online: https://inciweb.nwcg.gov/photos/COARF/2020-09-20-1235-Cameron-Peak-PostFire-BAER/related_files/pict20201117-152815-0.pdf

APPENDICES

Cameron Peak Fire Risk Assessment Report

Appendix A RISK ASSESSMENT RESULTS (MAPPING)

Please find Appendix A as separate attachment

Appendix B GIS DATA SOURCES

Please find Appendix B as separate attachment

Appendix C RISK ASSESSMENT RESULTS (TABLES)

Please find Appendix C as separate attachment