

Date of Report: 05/09/2022**BURNED-AREA REPORT****PART I - TYPE OF REQUEST****A. Type of Report**

- ☒ 1. Funding request for estimated emergency stabilization funds
☐ 2. No Treatment Recommendation

B. Type of Action

- ☒ 1. Initial Request (Best estimate of funds needed to complete eligible stabilization measures)
☐ 2. Interim Request #____
☐ Updating the initial funding request based on more accurate site data or design analysis

PART II - BURNED-AREA DESCRIPTION**A. Fire Name:** Tunnel**B. Fire Number:** AZ-COF-000159**C. State:** Arizona**D. County:** Coconino**E. Region:** R3 Southwestern**F. Forest:** Coconino NF**G. District:** Flagstaff RD**H. Fire Incident Job Code:** P3PK0P (0304)**I. Date Fire Started:** 04/17/2022**J. Date Fire Contained:** 98% on 5/9/22; Est. 5/13**K. Suppression Cost:** \$4,800,000 on 5/9/22**L. Fire Suppression Damages Repaired with Suppression Funds (estimates):**

1. **Fireline repair is ongoing (miles):** 21 miles of dozer line; 1.3 miles of hand line

M. Watershed Numbers:*Table 1: Acres Burned by Watershed - unburned acres not included in table*

HUC #	Watershed Name	Total Acres	Acres Burned	% of Watershed Burned
150200150103	Doney Park	42,165	8,391	20%
150200160104	Upper Kana-a Wash	38,807	5,896	15%
	<i>Doney Park Subwatersheds</i>			
	Lenox	1,847	63	3%
	Pumpkin Patch	216	118	55%
	Thames	1,197	632	53%
	Peaceful Way	2,026	249	12%
	Copeland	473	355	75%
	Rope Arabian	1,003	406	40%
	Siesta Paintbrush	535	67	13%
	<i>Subtotal</i>	<i>7,297</i>	<i>1,894</i>	<i>26%</i>

N. Total Acres Burned:

Table 2: Total Acres within BAER Analysis Perimeter by Ownership - includes unburned acres

OWNERSHIP	ACRES
NFS	16,543
NPS	1812
STATE	0
PRIVATE	705
TOTAL	19,060

O. Vegetation Types:

Ponderosa Pine Forest – This vegetation type makes up approximately 80% of the burned area. Characteristic species include *Pinus ponderosa* (Ponderosa Pine), *Bouteloua gracilis* (Blue grama), and *Festuca arizonica* (Arizona fescue). Ponderosa Pine Forest is in historic fire regime group 1, meaning the average fire return interval is 0-35 years, with low-severity non-lethal events. Across the burned area, this forest type is expressed in many different states. In the reburn of the Schultz fire scar, it is expressed as an early seral state with uncharacteristic grass cover and less than 10% tree cover. Elsewhere within the Tunnel fire footprint, there is young and mid-development ponderosa pine forest with closed canopy. This could be considered a fire disclimax state, where uncharacteristic stocking rates and basal area occurs due to lack of fire. This state is where most of the moderate and high soil burn severity is concentrated. Finally, there is mid development to mature forest with moderate and large trees, and an open canopy. Fire plays an important role in maintaining this state, and low to moderate soil burn severity is common here.

Pinyon Juniper Woodland – This woodland type makes up approximately 15% of the burned area. Characteristic species include *Juniperus monosperma* (Oneseed juniper), *Pinus edulis* (Colorado pinyon), *Fallugia paradoxa* (Apache plume), and *Bouteloua gracilis* (Blue grama). Within the burned area this woodland type is expressed in a mature state with open canopy dominated by medium to large trees with an understory of mixed grasses and shrubs.

Montane / Subalpine Grassland – This vegetation type makes up approximately 5% of the burned area. Characteristic species include *Aristida purpurea* (Fendler threeawn), *Bouteloua gracilis* (Blue grama), *Festuca arizonica* (Arizona fescue), and various *Carex* spp. The Bonito Park area west of sunset crater is the best example of this grassland type within the burned area.

P. Dominant Soils:

The burned area is dominated by geologically young soils in early stages of development. This region of the San Francisco Volcanic Field was active approximately 1000 years ago, and the soils are heavily influenced by that volcanic activity. The dominant parent material is basaltic cinders and ash from the numerous cinder cones that populate the area. Parent material differs in the southwestern portion of the fire. Soils there are formed on alluvial fans are comprised of mixed igneous rock types deposited from approximately 2.6 million years ago until present day (Quaternary Period). The alluvium source is within the San Francisco Peaks. The following soil types make up approximately 60% of the burned area. See the soils report for a complete table of soil types in the burned area.

Table 3. Dominant Soils within the Burned Area

TEUI Map Unit Number	Landform	Surface Texture	Surface Rock Cover (%)	Parent Material	Soil Taxonomy Subgroup	Soil Depth Class	Hydrologic Soil Group	Vegetation Type	Soil Erosion Hazard	Percent of Burned Area
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426	Elevated plains	Coarse Sand	75	Basaltic Cinder Residuum	Typic Ustorthents	Deep	A	Pinyon Juniper woodland	Slight	10
510	Elevated plains	Coarse Sand	75	Basaltic Cinder Residuum	Typic Ustorthents	Deep	A	Ponderosa Pine forest	Slight	16
551	Alluvial fans	Sandy Loam	45	Alluvium from mixed igneous sources	Mollic Eutroboralfs	Deep	B	Ponderosa Pine forest	Slight	21
559	Elevated plains	Coarse Sand	75	Basaltic Cinder Residuum	Typic Ustorthents	Deep	A	Ponderosa Pine forest	Slight	13

Q. Geologic Types:

The landscape within and surrounding the Tunnel fire is made up of relict volcanic features and the landforms developed from those features. The San Francisco peaks, which dominate the skyline in the area are the remnants of a large stratovolcano. Alluvial fans originating in these peaks occur within the burned area. Geologic composition in the peaks varies between Andesite and Dacite. This area of the San Francisco volcanic field was active as recently as 1000 years ago. Around that time multiple basaltic cinder cones were active in the area. Several cinder cones and cinder fields occur within the burned area.

Table 4. Geologic types within the burned area

Geologic Type	Age	Percent of burned area
Q – Alluvium	Quaternary	17
QTb – Basalt	Middle Pliocene to Holocene	81
QTV – Andesite	Middle Pliocene to Holocene	2

R. Miles of Stream Channels by Order or Class:

Table 5. Miles of Stream Channels by Order or Class

STREAM TYPE	MILES OF STREAM
PERENNIAL	0
INTERMITTENT & EPHEMERAL	27

S. Transportation System:

Trails: National Forest (miles): 3.1

Other (miles): not reported

Roads: National Forest (miles): 72.6

Other (miles): 14.76

PART III - WATERSHED CONDITION

A. Soil Burn Severity (acres):*Table 6. Burn Severity Acres by Ownership*

Soil Burn Severity	NFS	NPS	State	Private	Total	% within the Fire Perimeter
Unburned	3,675	869	0	230	4,774	25.0%
Low	11,511	868	0	423	12,802	67.2%
Moderate	1,347	75	0	52	1,474	7.7%
High	10	0	0	0	10	0.1%
Total	16,543	1,812	0	705	19,060	100%

B. Water-Repellent Soil (acres):

The depth and continuity of a fire induced water repellent layer is highly variable across the fire. In areas with significant rock cover from cinders, hydrophobicity was not encountered. Other locations with moderate or high burn severity and less than approximately 50% rock in the surface horizon show moderate to strong hydrophobicity within 0-10 centimeters of the soil surface. Due to the complexity of quantifying hydrophobic acres, an assumption was made to include all high severity acres and half of the moderate severity acres.

There are approximately 380 acres of hydrophobic soil within the Tunnel fire burned area.

C. Soil Erosion Hazard Rating:*Table 7. Soil Erosion Hazard Rating for NFS Lands*

Erosion Hazard Rating USFS lands only	Acres
Slight	12,666
Moderate	3,837
High	30

D. Erosion Potential:

Hillslopes with the highest post-fire erosion potential were identified. Significant erosion potential is defined as:

1. Moderate or high erosion hazard rating due to inherent soil properties **and/or**
2. The predicted soil loss in year 1 post-fire meets or exceeds 3 times soil loss tolerance for the soil type.

These hillslopes will continue to be the dominant sediment producing areas until approximately 3-5 years post fire or until ground cover conditions return to pre-fire levels. Figure 1 shows where in the burn scar accelerated hillslope erosion is expected.

Table 8. Hillslopes with the highest post-fire erosion potential

Hillslope ID	TEUI Map Unit Number	HSG	Acres	Average Slope(%)	Majority Soil Burn Severity Class	Tons/Acre Year 1	Erosion Hazard Rating
38	15	A	32	36	Low	18.37	Moderate

78	15	A	38	36	Low	18.37	Moderate
72	15	A	384	33	Low	17.46	Moderate
65	15	A	138	25	Low	12.88	Moderate
71	15	A	69	25	Low	12.88	Moderate
1	513	A	216	36	Low	18.37	Moderate
93	513	A	92	23	Moderate	16.47	Moderate
39	513	A	44	25	Low	12.88	Moderate
56	511	A	82	36	Low	18.37	Moderate
52	511	A	153	25	Low	12.88	Moderate
53	511	A	90	24	Low	12.55	Moderate
57	511	A	86	23	Low	12.2	Moderate
17	561	A	36	40	Low	19.61	Moderate
10	561	A	287	30	Low	16.5	Moderate
74	561	A	265	26	Low	13.2	Moderate
43	561	A	54	24	Low	12.55	Moderate
40	553	B	126	21	Low	21.14	Slight
23	441	A	154	25	Moderate	17.38	Moderate
64	441	A	51	25	Low	12.88	Moderate
20	441	A	40	35	Low	11.88	Moderate
89	441	A	59	34	Low	11.82	Moderate
80	427	A	56	28	Low	9.97	Moderate

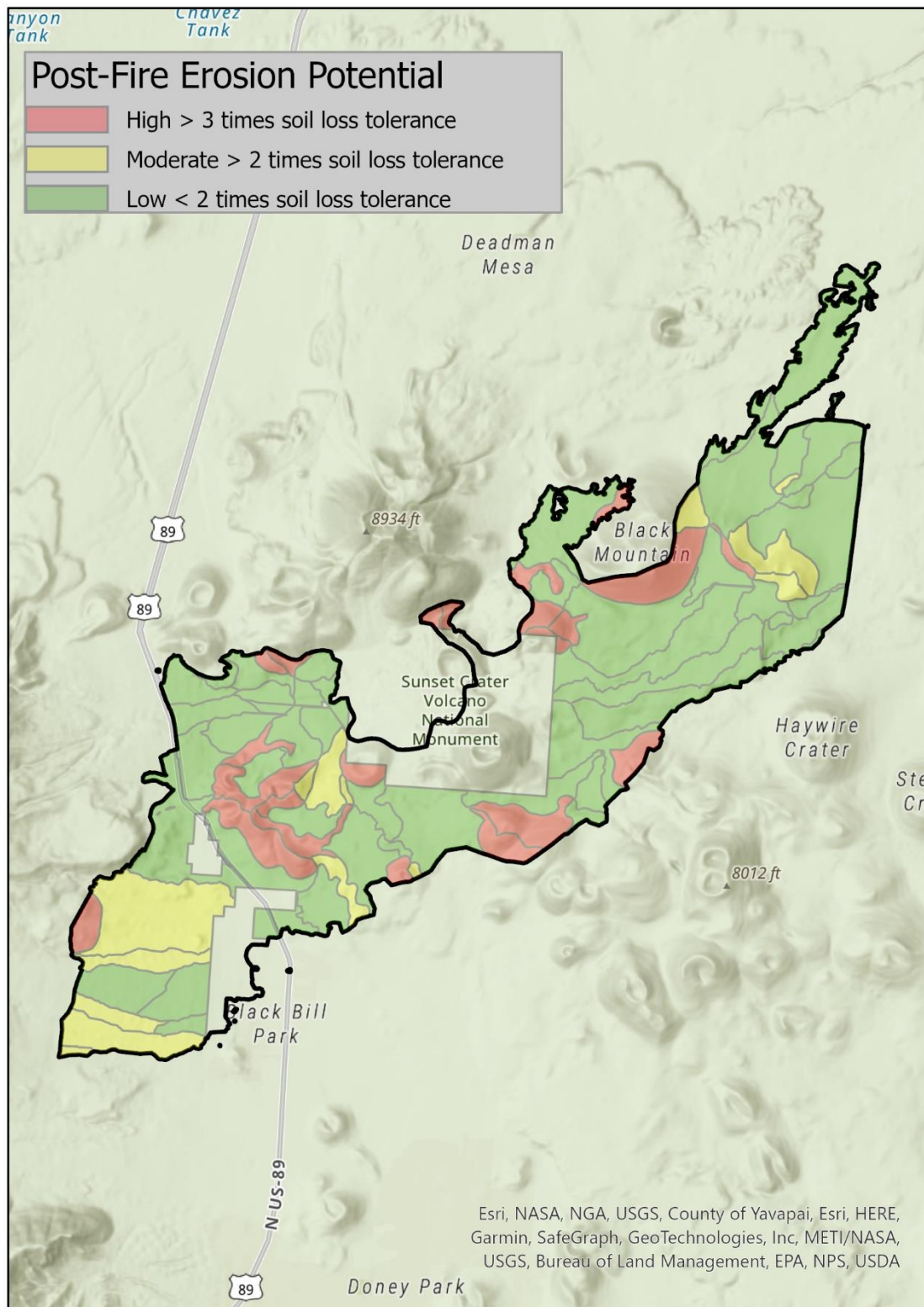


Figure 1: Modeled Hillslope Erosion Potential

E. Sediment Potential:

Sediment potential is a single number for expected sediment delivery that is averaged across the entire fire (all burn severities and hillslopes). Referencing this number alone could mask the site-specific impacts that are expected for hillslopes with high erosion potential. The predicted unburned, pre-fire sedimentation rate averaged across the Tunnel Fire for NFS lands is approximately 0.23 tons per acre with a 10% probability of exceedance. The predicted post-fire sedimentation rate averaged across the Tunnel Fire for NFS lands is approximately 7.07 tons per acre with a 10% probability of exceedance.

F. Estimated Vegetative Recovery Period (years):

Vegetation recovery is estimated 3-5 years for shrubs and forest understory, 20 years for forest overstory.

G. Estimated Hydrologic Response (brief description):

1. *Streams:* No perennial streams or water bodies exist within the fire boundary, nor the HUC-6 watersheds burned in the fire. The most notable streams are intermittent and ephemeral streams that are part of the alluvial fan landform on the west side of the fire. These streams originate from high on the mountainside, descend through the alluvial fan, and collect in small basins which are occupied with housing developments. The streams on the alluvial fan are important for draining high energy convective storm precipitation that often occurs with high intensity in the high elevations.

2. *Fire and Flood History:* The alluvial fan and adjacent higher mountain terrain were burned in 2010 during the Schultz Fire, with high amounts of high and moderate soil burn severities on the steep slopes. Since the fire event, several storm events have occurred in the burned area and have caused debris flows in the high elevations and major scouring on the alluvial fan. These events have caused serious hazards to the housing community below the alluvial fan, threatening life and safety.

3. *Flood Mitigation Efforts:* Since the occurrence of the Schultz Fire and subsequent flooding, the Coconino County Flood Control District has taken measures to mitigate the risk of flooding to the community from the Schultz Fire burn scar. Several structures have been installed at various locations on the alluvial fan on Forest Service property, through special use permits, attempting to capture debris and sediment that would be carried in flood events down to the community. The most notable features are cross-channel debris dams constructed with timbers, and sediment settlement basins. At the time of this investigation, many of the debris dams were full of debris and sediments and the timbers were burned in the Tunnel Fire.

4. *Tunnel Fire Effects:* 7 sub-watersheds along the alluvial fan were burned during the Tunnel Fire. While only 26% of the sub-watersheds' acres burned, several of the wooden flood control structures (constructed by Coconino County to moderate Schultz Fire flooding) along their stream channels were burned sufficiently to compromise their structural integrity. It is highly likely that any of these burned structures could fail during the next moderate flood event. The failure of any of these structures that are full of debris and sediments could present a threat to downstream life and property as well as natural resources on Forest Service lands. Failure could cause major headcuts in the stream channels, threaten proper stream channel function, soil productivity, and vegetation communities along their corridor. The release of the backed-up debris and sediment during a flood event could be catastrophic for the downstream community.

5. *Cumulative Fire Effects:* Aside from the burned flood control structures in the sub-watersheds of the alluvial fan, most of the Tunnel Fire acres resulted in low soil burn severity effects. However, residual fire effects are found on the alluvial fan from the high and moderate burned areas of the Schultz Fire. Natural forest vegetation communities in these areas are not fully recovered from the fire impacts. Ponderosa pines are about 10 years old. Forest litter is spotty to sparse. Grasses and forbs are common, but do not provide full cover of forest soils. Bare soils are common in the high and moderate burned areas from the Schultz Fire. These legacy fire effects were accounted for in the modeling of post-fire run-off scenarios. 7,297 acres is the combined area of the 7 burned sub-watersheds of the alluvial fan. 6,128 acres (84%) of that area burned in the Schultz Fire. And 1,455 acres (20%) reburned in the Tunnel Fire. Across the entire Tunnel Fire, 2,648 acres overlap with the Schultz Fire.

6. Post-fire Recovery: Reburned watersheds may experience abnormal recovery. First, areas unburned from the Tunnel Fire, but burned with high and moderate severity in the Schultz Fire have yet to return to pre-fire conditions and will continue to contribute to increased watershed response. Second, low severity burns of the Tunnel Fire that reburned previous high and moderate areas of the Schultz Fire will not recover as quickly as a typical low severity area would recover. That is because with most of the overstory burned and downed, and then reburned, there is no substantial source of new litter and woody debris for ground cover improvements. Yet, grass and forbs may return as expected for low severity effects in this ecosystem.

7. Post-fire Run-off Estimates: Pre-fire and post-fire runoff were estimated for each sub-watershed using the Wildcat5 model (Table 9, Figure 2). A 10-year return interval, 1.5 inches in 1 hour storm intensity scenario was modeled. Runoff response was spatially weighted by curve numbers available in a forest soils unit survey geodatabase. Curve numbers were adjusted post-fire by spatially weighting the soil burn severity classes that occurred within each watershed. Cumulative fire effects were included in the Curve Number adjustments, where applicable.

Table 9. Modeled Alluvial Fan Sub-Watersheds

Sub-Watershed Name	Pre-fire Flow (cfs)	Post-fire Flow (cfs)	Post-fire Flow Increase
Lenox	146	221	51%
Pumpkin Patch	62	212	244%
Thames	163	572	251%
Peaceful	5	135	2710%
Copeland	84	501	493%
Rope Arabian	120	409	240%
Siesta-Paintbrush	97	172	77%

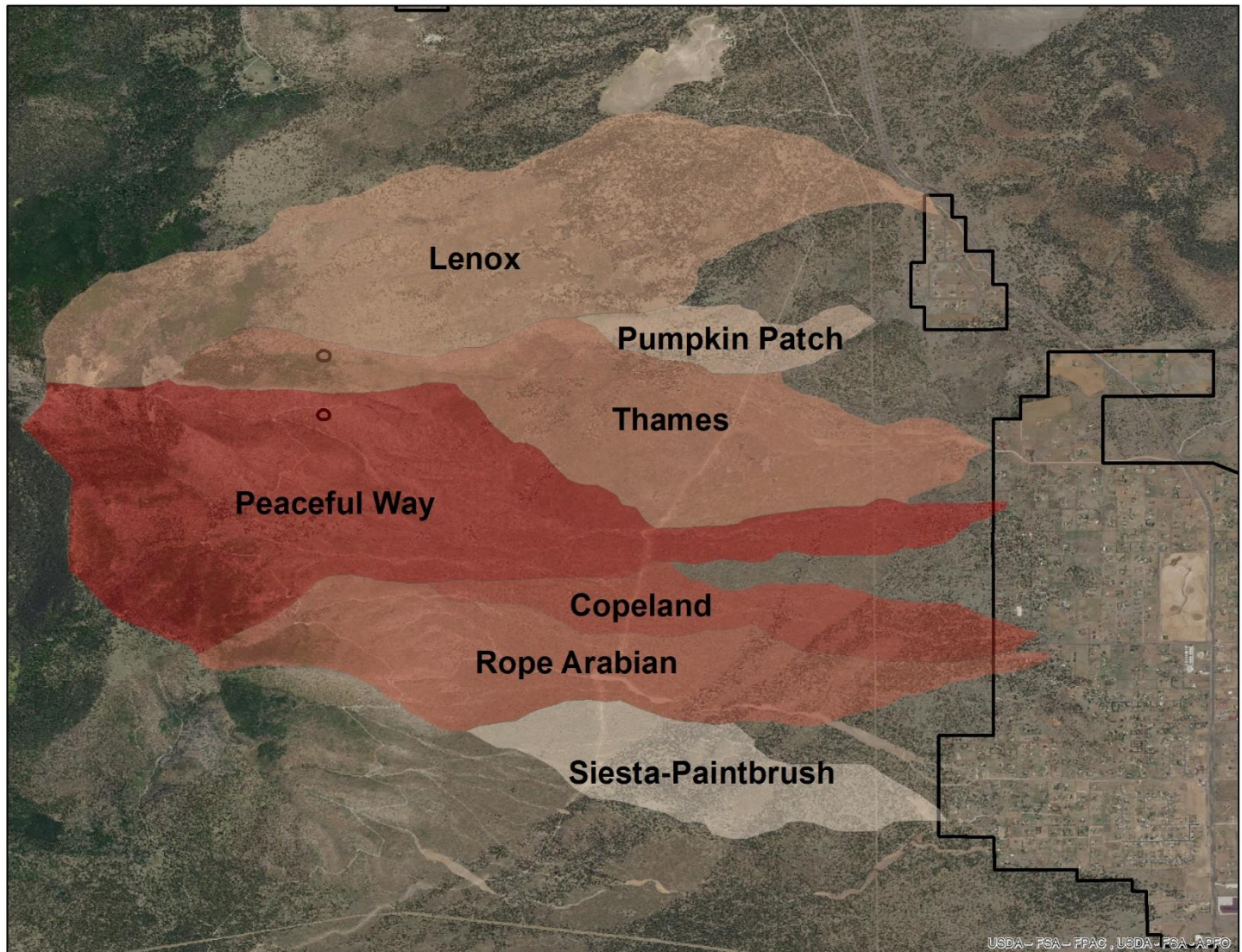


Figure 2: Modeled Alluvial Fan Sub-Watersheds.

8. Bonito Campground: This is a Forest Service owned campground approximately 2 miles west from Sunset Crater. A large channel flows between the main campground and the O'Leary Group Campsite. This stream channel was modeled for post-fire runoff under the same 10-year return interval storm of 1.5 inches in 1 hour. The adjacent area of Bonito Park, which is a large meadow to the west of the campground, had some burned areas from the Tunnel Fire. The contributing area is 1,979 acres. 1,498 of those acres (76%) burned in the Tunnel Fire. 68% of the contributing area was rated at low soil burn severity. Post-fire recovery should be normal for low severity fires relative to the ecosystem. There is no Schultz Fire overlap to the contributing area. The Wildcat5 model returned an increase of 140% from 899 to 2162 cfs. The campground is situated on high ground above the channel and would unlikely be threatened by the modeled stream flows.

9. Upper Kana-a Wash Watershed: This HUC-6 watershed has a turbulent landscape with many cinder cones and large lava flows. Stream channels are sparse and underdeveloped in this area. Stormwater runoff would infrequently occur in this area due to the dominant deep, coarse sandy soils and gravels. Increases in run-off due to fire effects is not certain to occur, and flooding threats are not expected nor fully understood at this time.

PART V - SUMMARY OF ANALYSIS

Introduction/Background

The Tunnel Fire, located approximately 14 miles northeast of Flagstaff along U.S. Highway 89 was reported at 4:22 p.m. on Sunday, April 17, 2022. The cause is unknown but is currently under investigation. Firefighters responded to the fire immediately and the fire was designated contained by that evening. Extremely strong winds reignited embers on the morning of Tuesday, April 19, 2022 and caused this fire to rapidly spread in a northeast direction. The fire was located in an area with dry grass and brush, with scattered Ponderosa pine. Growing to 19,060 acres total, the fire threatened 1,335 structures, consumed 30 homes and 24 outbuildings in the area of Timberline Estates, Wupatki Trails and Girls Ranch neighborhoods.

The USFS BAER team began its assessment of the burn scar on April 30th. Soil Burn Severity (SBS, Figure 3) mapping was accomplished by ground truthing and adjusting an initial Burned Area Reflectance Classification (BARC) map using the methods outlined in RMRS-GTR-24, resulting in a final field validated soil burn severity map. Additional field review and identification of watershed response threats, hazards to human life and safety, threats to the NFS transportation system, threats to soils and water quality, threats native vegetation communities, and threats to cultural resources was by the BAER survey team.

The SBS data set, hydrologic modeling outputs, and the results of the USGS Post-Fire Debris Flow Hazard Assessment (Figure 4) have been shared with Coconino County Flood Control District personnel, who are currently completing an assessment of risks to private lands and infrastructure on the west side of the fire below the USFS boundary. Ongoing coordination between the USFS and Coconino County is recommended to ensure timely implementation of any flood control measures that may be necessary to protect off forest critical values from flood and debris flow threats that originate on NFS lands.

The remainder of this report will focus on threats to Critical BAER values identified in FSM 2523 – Emergency Stabilization – Burned Area Emergency Response.

A. Describe Critical Values/Resources and Threats (narrative):

Table 10. Critical Value Matrix used in the assessment of threats to Critical BAER Values

Probability of Damage or Loss	Magnitude of Consequences		
	Major	Moderate	Minor
	RISK		
Very Likely	Very High	Very High	Low
Likely	Very High	High	Low
Possible	High	Intermediate	Low
Unlikely	Intermediate	Low	Very Low

1. Human Life and Safety (HLS):

- a. Human life and safety of Forest visitors and employees traveling on NFS roads and trails in the burn scar is threatened by the potential for injury or loss of life from hazard tree strikes, falling rocks, flash floods, debris flows, and other burned area hazards. The probability of damage or loss is **possible** as the NFS transportation system contains many motorized and non-motorized routes adjacent to and through the burned area. The magnitude of consequence is **major** since an overhead hazard strike, entrapment in a flood or debris flow, or motorized vehicle collision with downed trees or fallen rocks could result in serious injury or loss of life. The risk level is **high**. BAER treatments are recommended as well as general hazard awareness social media messaging when the current closure order is lifted, and again at the start of monsoon season. See treatment P1a.
- b. Human life and safety of Forest visitors and employees at USFS developed campgrounds and day use sites is threatened by the potential for injury or loss of life from hazard tree strikes.

The probability of damage or loss is **unlikely** as very few hazard trees remain on site (most were mitigated by the suppression resources). The magnitude of consequence is **major** since an overhead hazard strike could result in serious injury or loss of life. The risk level is **intermediate**. BAER treatments are not recommended. However, a thorough review of the sites should be conducted by District recreation staff to ensure the sites are safe to open. Two potential hazard trees were identified at the Painted Desert Vista day use site.

2. **Property (P):** Segments of NFSR 420 are threatened by expected increases in postfire runoff following high intensity precipitation events. The probability of damage or loss is **likely** because the existing drainage structures on the threatened segment are not sized to pass the increased post-fire runoff from upslope areas of the burn scar. A unique set of SBS indicators were observed above this road. The area above NFSR 420 was mapped at low SBS following the Tunnel fire, however the same areas sustained high SBS during the 2010 Shultz fire and had not yet recovered. Ground cover was found to be sparse at best. As such, there is a cumulative effect of increased post-fire runoff from both burn scars that was considered for this risk assessment. The low severity fire of the Tunnel fire consumed all the forest litter, and without a significant overstory, additional forest debris will not be added in the foreseeable future. Significant amounts of bare ground will be exposed for a prolonged period. The magnitude of consequence is **moderate** because the route contains undersized culverts and unhardened crossings that are expected to plug and erode, resulting in a loss of control of water and damage to the road prism. The threatened segments require BAER treatments to ensure the road surface is not significantly damaged. The risk level is **high**. Treatments are recommended. See treatments RT2, RT3, RT12.

- b. The remaining components of the NFS road network are threatened by increased runoff during high intensity precipitation events that could result in loss of control of water within the existing drainage structures. The probability of damage or loss is **unlikely** as these routes are located on or below lower angle slopes that are mostly unburned or burned at low SBS. The magnitude of consequence is **minor** because any damage that would occur is expected to be limited in economic value and to a small number of NFS transportation system investments. The risk rating is **very low**. BAER treatments are not recommended.
- c. The trail prisms for the Deer Hill and Brandis trails are threatened by expected increases in postfire runoff. The probability of damage or loss is **possible** because of the trails' proximity to areas of moderate and low SBS. The magnitude of consequence is **moderate** because the potential economic losses from the damage are expected to be relatively low when compared to the trail system value. The risk rating is **intermediate**. Treatments are not recommended.
- d. Campground and day use site infrastructure at the O'Leary, Bonita, and Painted Desert Vista sites are threatened by fire damaged trees that could hit the infrastructure if the trees die in the coming months and are subjected to high winds. The probability of damage or loss is **possible** because some fire damaged trees are scattered throughout the sites. The magnitude of consequences is **moderate** because a tree strike could damage the facilities at the sites. The risk rating is **intermediate**. BAER treatments are not recommended, however ongoing monitor for tree die off that could result in unacceptable hazards is recommended.

3. **Natural Resources (NR):** Soil productivity and hydrologic function on NFS lands above Coconino County's permitted fire-damaged flood control structures are threatened by potential head cutting through the structures during flood events. The grade control component of the existing structures was built with fire killed trees from the Shultz fire. Those logs burned during the Tunnel fire and no longer are viable grade controls that could stop upstream headcut migration should a flood event occur. The probability of damage or loss is **likely** because the constructed elevation drop in the stream channel is not protected by a viable grade control and gully formation is expected to occur

during the modeled high flow event. The magnitude of consequence is **moderate** because considerable soil loss would occur in the channel, resulting in long term effects. The risk rating is **high**. BAER treatments are not recommended however, the Forest is advised to permit emergency maintenance on the damaged flood control structures.

- b. Soil productivity and hydrologic function on high erosion slopes is threatened by increased post-fire soil loss and loss of hydrologic function. The probability of damage or loss is **likely** because these slopes have a modeled soil loss >3x the soil loss tolerance for the soil type. The magnitude of consequence is **moderate** because the expected amount of soil loss could result in long-term effects to soil productivity. The risk rating is **high**. Seeding and/or mulching were considered, however neither is recommended. Seeding is not recommended because it would not effectively reduce the risk of significant erosion within the first year following the fire. Mulching is not recommended because each hillslope exhibits one or more of the following limiting factors: excessive steepness, limited treatable area, or >50% surface rock.
- c. Soil productivity and hydrologic function on low erosion slopes is threatened by increased post-fire soil loss and loss of hydrologic function. The probability of damage or loss is **possible** because these slopes have a modeled soil loss <3x the soil loss tolerance for the soil type. The magnitude of consequence is **minor** because the expected amount of soil loss is recoverable, resulting in localized long-term effects to soil productivity. This is expected within the natural variability of a fire-adapted ecosystem. The risk rating is **low**. Treatments are not recommended.
- d. Mexican Spotted Owl Critical Habitat adjacent to the burned area is threatened by the potential for a bark beetle infestation in fire damaged trees. The probability of damage or loss is **possible** because a bark beetle outbreak may extend beyond the fire perimeter, into nearby drought stressed trees. The magnitude of consequence is **minor** because the habitat impacts would be localized and are the result a natural process in a fire-adapted ecosystem. The risk rating is **low**. Treatments are not recommended.
- e. There is an increased risk to native or naturalized plant communities on NFS lands from invasive species and other weeds. Specialists have identified Yellow Bluestem as the weed species that will most likely take root in burned areas. The probability of damage or loss is **possible** because Yellow Bluestem is an aggressively spreading perennial bunchgrass that is a prolific seed producer in burned areas. It can easily outcompete native grasses and forbes. Yellow Bluestem is allelopathic and can suppress native plant recovery. The magnitude of consequence is **major** because an invasion east of the origin of the fire and in the areas adjacent to highway 89 could irreversibly alter the grassland community. Once established, Yellow Bluestem can be incredibly persistent and difficult to control. Eradication is only possible for this species if the plants are documented and treated early and before they are allowed to get established. The risk rating is **high**. Treatments are recommended. See treatment L1a.
- f. There is an increased risk to native or naturalized plant communities on NFS lands from invasive species and other weeds. Specialists have identified scotch thistle, diffuse knapweed, yellow bluestem, and dalmatian toadflax as possible weed species that will likely take root in suppression activity disturbed areas within or adjacent the burned area. The probability of damage to native or naturalized plant communities is **likely** because suppression activities caused soil disturbances in areas where invasion of noxious plants is expected to occur. Multiple years of growth of invasives, if unchecked, can lead to more robust seedbanks for these species, which make future control much more time consuming and difficult. The lack of a weed washing station during fire suppression activities will likely facilitate the introduction of invasive species into these areas. The ICP was located in an area with known weeds. The magnitude of consequence from this damage is **moderate** because there will be long-term effects of weed invasion to existing intact native plant communities. The risk is **high**. Treatments are recommended. See treatments L1b and L2.

- 4. Cultural and Heritage Resources:** Two NRHP eligible and one potentially eligible, unevaluated cultural resource sites are threatened by the loss of intact subsurface cultural deposits from erosion, flooding, and hazard trees falling and ripping out buried deposits. The probability of damage or loss is **very likely** because the sites are located on slope positions that are vulnerable to accelerated erosion and tree fall that could expose buried, intact deposits. The magnitude of consequence is **major** because the loss would result in an irreversible loss of intact subsurface cultural deposits including deposits of great concern to consulting tribal nations. The risk rating is **very high**. Treatments are recommended. See treatments L6.

- b. 378 remaining archaeological sites and the San Francisco Peaks Traditional Cultural Property are threatened by the loss of intact subsurface cultural deposits from erosion, flooding, and hazard trees falling and ripping out deposits. The probability of damage or loss is **unlikely** because they are in unburned or low severity locations. The magnitude of consequence is **major** because the loss would result in an irreversible loss of intact subsurface cultural deposits including deposits of concern to consulting tribal nations. The risk rating is **intermediate**. BAER treatments are not recommended, however ongoing monitoring of site conditions is advised.

B. Emergency Treatment Objectives:

Raise awareness of postfire hazards throughout the burned area, minimize postfire damage to the NFS transportation system, minimize the establishment of invasive plants and noxious weeds, protect cultural and heritage resources from the loss of irreplaceable artifacts, deposits, and scientific information.

C. Probability of Completing Treatment Prior to Damaging Storm or Event:

Land: 90%
Channel: N/A
Roads/Trails: 90%
Protection/Safety: 95%

D. Probability of Treatment Success

Table 11. Probability of Treatment Success

	1 year after treatment	3 years after treatment	5 years after treatment
Land	85%	90%	90%
Channel	N/A	N/A	N/A
Roads/Trails	80%	90%	90%
Protection/Safety	90%	80%	70%

E. Cost of No-Action (Including Loss): \$200,000

This valuation assumes an 85% chance of loss of the .56 miles of ML3 NFS roads that are threatened (valued at \$100,000/mile), 3 years of weed treatment on 64 acres of suppression disturbed areas at

\$10,000/year in CYs 2023-2025, and 3 years of weed treatment on 346 acres of fire disturbed areas at \$39,000/year in CYs 2023-2025.

The cost of taking no action to protect cultural sites cannot be accurately calculated as the loss of irreplaceable artifacts, deposits, and historical information does not have a monetary value. Similarly, injury or loss of human life that may result from taking no action to minimize risk to Forest visitors in the form of the protection and safety treatments does not have a monetary value.

F. Cost of Selected Alternative (Including Loss): \$108,475

This valuation assumes a 15% chance of loss of the .56 miles of NFS road; the cost of the road drainage stabilization treatments which will reduce the chance of loss from 85% to 15%; 3 years of weed treatment on 64 acres of suppression disturbed areas at \$5,000/year in CYs 2022-2024, the final two of which would be accomplished with non-BAER funds; 3 years of weed treatment on 346 acres of fire disturbed areas at \$19,500/year in CYs 2022-2024, the final two of which would be accomplished with non-BAER funds.

G. Skills Represented on Burned-Area Survey Team:

- ☒ Soils
- ☒ Hydrology
- ☒ Engineering
- ☒ GIS
- ☒ Archaeology
- ☒ Weeds
- ☒ Recreation
- ☐ Fisheries
- ☒ Wildlife
- ☒ PIO

Team Leader: Brendan Waterman

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Forest BAER Coordinator: Matt O'Neill

Email: matthew.oneill@usda.gov Phone(s): 928-226-4616

Team Members: Table 12. BAER Team Members by Skill

Skill	Team Member Name
Team Lead(s)	Brendan Waterman; Matt O'Neill (t)
Soils	Rob Ballard
Hydrology	Dan Bone
Engineering	Nick Warnke; Kaitlyn Tighe (t); Taylor Connolly (t)
GIS	Mark Christiano
Archaeology	Jeanne Stevens; Cameron Maurin (t); Kristin Francis (t)
Weeds	Katie Landry (t); Andy Pigg (t)
Recreation	Paul Dawson; Victoria Allen (t)
Wildlife	Mark Bellis (t)
PIO	Dick Fleishman

H. Treatment Narrative:

The following narratives summarize the response actions recommended to decrease risks to BAER Critical Values. It is important to note that these treatments are not designed to eliminate risk. They are designed to reduce risk to an acceptable level, per FSM 2523.1 - Exhibit 02. Detailed specifications, cost estimates, and maps identifying the spatial location for the treatments are in the BAER Assessment project record. The documents can be obtained by contacting the Forest BAER Coordinator. Figure 5 shows proposed treatments on the Tunnel Fire burn scar.

All treatment costs were estimated based on the assumption that off-forest Agency personnel or contract crews would be implementing the authorized treatments without the use of local unit NFSE salary funding. If personnel from the local unit are identified for implementation, current BAER salary and expense guidance regarding the use of H-funds would be adhered to. Project budgets represent the best estimate of the BAER assessment team and may be adjusted with interim funding authorization requests to reflect current market values at the time of contracting and implementation.

Land Treatments:

L1a. EDRR BAER: Surveys and eradication treatments for new or expanding invasive plant/noxious weed infestations associated with the Tunnel wildfire will be conducted over a total of 2 entries during 2022 and spring 2023 in areas of native plant communities with little to no noxious/invasive plant species present prior to the fire. Survey efforts may be coordinated with other federal, state, or local agencies/partners. BAER funded surveys will be completed within one year of fire containment. Survey, monitoring or treatment activities that extend beyond the first year will be accomplished through non-BAER funding sources.

Detection surveys and eradication treatments will be conducted on NFS lands that have moderate to severe fire effects and are susceptible to infestation by invasive plant species. These areas were identified from the Soil Burn Severity map, site visits, and the proximity to other weed populations and vector sources such roads and trails. Burned areas with a moderate or high SBS on NFS lands that are adjacent to known weed populations and/or along motorized travel corridors have been prioritized for EDRR treatment. There is a potential for weed infestation to occur in other areas of moderate and high SBS throughout the burn scar, however the overall risk is lower given the distance from known threats/vectors such as existing infestations and designated motorized travel corridors.

EDRR BAER activities will be conducted at identified locations at an intensity/frequency necessary to identify the occurrence/spread of weed infestations, with a focus on Yellow Bluestem. Surveys will be conducted on foot or from vehicles (UTV/truck). Specific information (e.g., species, location, size, photos) regarding identified infestations will be collected and added to the appropriate database of record.

Timely surveys will allow for new or expanding weed infestations to be identified, and proper measures implemented for eradication/control to protect native plant communities where invasive plants are currently absent or present in minor amounts.

Implementation personnel will survey and treat any newly detected invasive plants or noxious weeds immediately upon detection. The estimated cost per acre is based on the assumption that much of the targeted acreage will only require a brief survey and not an extensive eradication treatment.

Table 13. L1a EDRR BAER Costs

Item	UOM	Unit Cost	# of Units Treated per Entry	Entries Needed	Total Treatment Cost
L1a EDRR – BAER	acre	\$7.23	346	2	\$5,000

L1b. Early Detection Rapid Response (EDRR) Suppression: Surveys and treatment for new or expanding invasive plant and noxious weed infestations associated with fire suppression activities will be conducted by over a total of 3 entries during 2022 and Spring 2023. EDRR activities that extend beyond the first year will be accomplished through non-BAER funding sources. EDRR Suppression efforts will only occur along areas that were disturbed by unmitigated suppression activities and suppression rehab, including areas of hand line and dozer line construction. These areas were delineated by the BAER Weeds Specialist using suppression disturbance lines and points provided by the IMT GISS. If an effort to accurately capture the actual size of the on the ground disturbance, the points and lines were buffered into polygons that most accurately represent the actual disturbed area. The buffer assigned to the GIS line and point features varied by feature type. The rehabilitated dozer lines are assumed to have a 25' total disturbance width and handlines are assumed to have a 4' total disturbance width. Treatment is not proposed beyond the extent of the soil disturbance associated within the control features.

EDRR Suppression activities will be accomplished by a crew of 2 individuals on foot. The invasive species of concern in these suppression areas are Dalmatian Toadflax, Diffuse Knapweed, Scotch Thistle, and Yellow Bluestem. The estimated cost per acre is significantly higher than L1a EDRR BAER because the areas will require survey by foot and more frequent eradication work is expected because known infestations were disturbed by suppression equipment at the ICP and during line construction. The EDRR suppression surveys will be focused on disturbed areas that were free of weeds or only contained small, discrete populations that were disturbed during control line construction.

Table 14. L1b. EDRR Suppression Costs

Item	UOM	Unit Cost	# of Units Treated per Entry	Entries Needed	Total Treatment Cost
L1b EDRR – Suppression	acre	\$101.56	64	3	\$19,500

L2. Invasives - Native Seeding: Seeding using compatible native plant seed and materials for the Coconino National Forest will be conducted in conjunction with EDRR treatments. A targeted and selective approach to seeding will occur in areas of moderate and high burn severity on low angle slopes that are in suppression disturbed sites on or near the fire perimeter. Increasing the amount of available native seed in these targeted areas on the perimeter will create an additional buffer to prevent the encroachment of invasive plants into the interior areas of the burn scar. Using native seed and plant material in this way is a part of an integrated approach to mitigate invasive plant impacts.

Seeding during fall or snow seeding in late winter will be a successful tactic for increased germination rates. The recommended application rate of seed can vary from 50-130 lbs./acre depending on burn severity, plant type and seeding time. A prescription of 50 lbs. of seed per acre is recommended per treatment which is less than half the recommendation for the higher rate of seeding per acre. Two seeding periods at a lower rate per acre will enhance germination success. Snow seeding can take advantage of increased moisture around seed to enhance germination rates once snows recede in late winter to early spring.

Table 15. L2 Invasive -Native Seeding Costs

Item	UOM	Unit Cost	# of Units Treated per Entry	Entries Needed	Total Cost
L2. Invasives - Native Seeding	acre	\$675	4	2	\$5,400

L6. Other Cultural Site Protection: All sites are located within moderate or high burn severity. Each site is either eligible to or potentially eligible to be listed on the National Register of Historic Places and site types are large, complex habitation sites used by the Sinagua. The Sinagua Culture, unique to northern Arizona, are ancestors to the modern Hopi Tribe, Pueblo of Zuni, and Pueblo of Acoma. The sites include Pithouse villages and Roomblock features.

Recommended treatments include directional felling to take down hazard trees and stabilize severely burned slopes as well as the filling of burned-out stump holes. This work is needed to protect subsurface deposits from erosion and/or exposure following storm events that have the potential to uproot trees adjacent to the sites or generate accelerated erosion that could expose deposits. Lump sums include sawyers/laborers, cultural specialist monitoring during work, materials, data management, and SHPO consultation.

Table 16. L6 Other Cultural Site Protections Costs

Item	UOM	Unit Cost	# of Units	Total Cost
L6. Other Cultural Site Protection	Job	\$1,048	3	\$3,144

Channel Treatments: None recommended.

Roads and Trail Treatments:

RT2. Storm Inspection and Response: Storm inspection and response on NFSR 420 keeps drainage features treated under RT3 and RT12 functional by removing accumulated sediment and debris between or during storm events. Following heavy rains and significant spring snowmelt the inspection will involve identification of drainage hazards such as accumulated debris and sediment that are limiting functionality of the road drainage features. The response will use equipment to remove obstructions in catch basins, dips, lead-off ditches, riprap armor, and other drainage features. Excess material and debris removed from the drainage features will be placed where it cannot re-enter the stream. Problems will be corrected before they worsen or jeopardize the road drainage features. This treatment is used in lieu of more costly structural upgrades, such as culvert upsizing.

Table 17. RT2 Road Storm Inspection and Response Costs

Item	Units	Unit Cost	# of Units	Total Cost
RT2. Road Storm Inspection and Response – ML3	mile	\$10,000.00	0.25	\$2,500

RT3. Culvert Removal: Removal of the existing culvert on NFSR 420 at MP 3.93 is needed to protect the road prism from damage and potential loss during post-fire runoff events. The existing pipe was found to be undersized for the anticipated increase in post-fire runoff and debris/sediment flows. Following removal of the pipe and fill, the template will be reshaped, and a drivable dip will be installed to facilitate motorized travel on the route. This treatment will be installed at the same time as RT12. The total mobilization cost of \$5,000 has been split evenly between the 4 work locations.

Table 18. RT3 Culvert Removal Costs

Item	UOM	Unit Cost	# of Units	Total Cost
Mobilization	Lump Sum	\$1,250.00	1	\$1,250
Design	Lump Sum	\$375.00	1	\$375
Remove Pipe	Job	\$1,200.00	1	\$1,200

Re-shape Road	Mile	\$6,500.00	0.0625	\$406
RT3. Culvert Removal Total Cost				\$3,231

RT12. Fill Slope Stabilization: Fill slope stabilization is needed at 3 locations on NFSR 420 (MPs 3.37, 3.57, and 3.64). The road surface is currently constructed to match the contour of the ephemeral crossings at these locations. However, the downslope side of the crossings is not sufficiently armored to accommodate the expected increases in post-fire run. The recommended response action at these three locations will include reshaping the template and placing Class IV riprap on the downslope/side of the crossing to ensure the road is protected from post-fire runoff. This treatment will be installed at the same time as RT3. The total mobilization cost of \$5,000 has been split evenly between the 4 work locations.

Table 19. RT12 Fill Slope Stabilization Costs

Item	UOM	Unit Cost	# of Units	Total Cost
Mobilization	Lump Sum	\$1,250.00	3	\$3,750
Design	Lump Sum	\$375.00	3	\$1,125
Rip Rap, Class IV	CY	\$110	85	\$9,350
Re-shape Road	Mile	\$6,500.00	0.1875	\$1,219
RT12 Fill Slope Stabilization Total Cost				\$15,444

Protection/Safety Treatments:

P1a. Burned Area Warning Signs: The purpose of the Burned Area Warning signs is to reduce risks to human life and safety by informing forest visitors of potential dangers and/or hazards when entering burned areas on NFS lands. Entering burned areas presents a high risk to human and life and safety, with increased threats from post-fire effects such as falling trees, rolling rocks, flash floods, and debris flows. It is necessary to inform the public of burned-area hazards that are a direct result of wildfire; hazards which are substantially different compared to unburned forest setting and with which many forest visitors may be unfamiliar. Burned area warning signs will be installed to inform the public of the possible dangers associated with the burned area on major entry points into the burned area. Lump sum costs include signs, posts, hardware, and installation.

Table 20. P1a Road Warning Sign Costs

Sign Type	UOM	Unit Cost	# of Units	Total Cost
FW8-14d 60"x42"	Lump Sum	\$875	3	\$2,625
FW8-18c 30"x30"	Lump Sum	\$675	1	\$675
FW8-14e 60'x30"	Lump Sum	\$800	3	\$2,400
FW8-18c 30"x30"	Lump Sum	\$525	2	\$1,050
P1a Road Warning Sign Total Cost				\$6,750

I. Monitoring Narrative:

Forest personnel will periodically review safety signs to ensure they are not being vandalized. Road drainage stabilization treatments will be monitored through implementation of the storm inspection and response plan. EDRR treatments will be monitored during follow up early detection surveys to ensure new weed infestation expansion is minimized. Archaeologists will monitor the effectiveness of the heritage site treatments following storm activity to ensure ongoing protection of subsurface deposits is achieved.

PART VI – EMERGENCY STABILIZATION TREATMENTS AND SOURCE OF FUNDS

			NFS Lands				Other Lands			All
		Unit	# of		Other		Fed	# of	Non Fed	Total
Line Items	Units	Cost	Units	BAER \$	\$	# of units	\$	Units	\$	\$
A. Land Treatments										
L1a. EDRR BAER	survey	2,500	2	\$5,000	\$10,000		\$0		\$0	\$15,000
L1b. EDRR – Suppression	survey	6,500	3	\$19,500	\$39,000		\$0		\$0	\$58,500
L2. Invasives - Native Seed	job	2,700	2	\$5,400	\$0		\$0		\$0	\$5,400
L6. Cultural Site Protection	site	1,048	3	\$3,144	\$0		\$0		\$0	\$3,144
Insert new items above this line!				\$0	\$0		\$0		\$0	\$0
Subtotal Land Treatments				\$33,044	\$49,000		\$0		\$0	\$82,044
B. Channel Treatments										
None				\$0	\$0		\$0		\$0	\$0
Insert new items above this line!				\$0	\$0		\$0		\$0	\$0
Subtotal Channel Treatments				\$0	\$0		\$0		\$0	\$0
C. Road and Trails										
RT2. Road SIR	mile	10,000	0	\$2,500	\$0		\$0		\$0	\$2,500
RT3. Culvert Removal	job	3,231	1	\$3,231	\$0		\$0		\$0	\$3,231
RT12. Fill Slope Stabilization	job	5,148	3	\$15,444	\$0		\$0		\$0	\$15,444
Insert new items above this line!				\$0	\$0		\$0		\$0	\$0
Subtotal Road and Trails				\$21,175	\$0		\$0		\$0	\$21,175
D. Protection/Safety										
P1a. Road Warning Signs	job	6,750	1	\$6,750	\$0		\$0		\$0	\$6,750
Insert new items above this line!				\$0	\$0		\$0		\$0	\$0
Subtotal Protection/Safety				\$6,750	\$0		\$0		\$0	\$6,750
E. BAER Evaluation										
Initial Assessment	Report	\$53,025		---	\$0		\$0		\$0	\$0
				\$0	\$0		\$0		\$0	\$0
Insert new items above this line!				---	\$0		\$0		\$0	\$0
Subtotal Evaluation				\$0	\$0		\$0		\$0	\$0
F. Monitoring										
				\$0	\$0		\$0		\$0	\$0
Insert new items above this line!				\$0	\$0		\$0		\$0	\$0
Subtotal Monitoring				\$0	\$0		\$0		\$0	\$0
G. Totals										
				\$60,969	\$49,000		\$0		\$0	\$109,969
Previously approved										
Total for this request				\$60,969						

PART VII - APPROVALS

1.

Forest Supervisor_____
Date

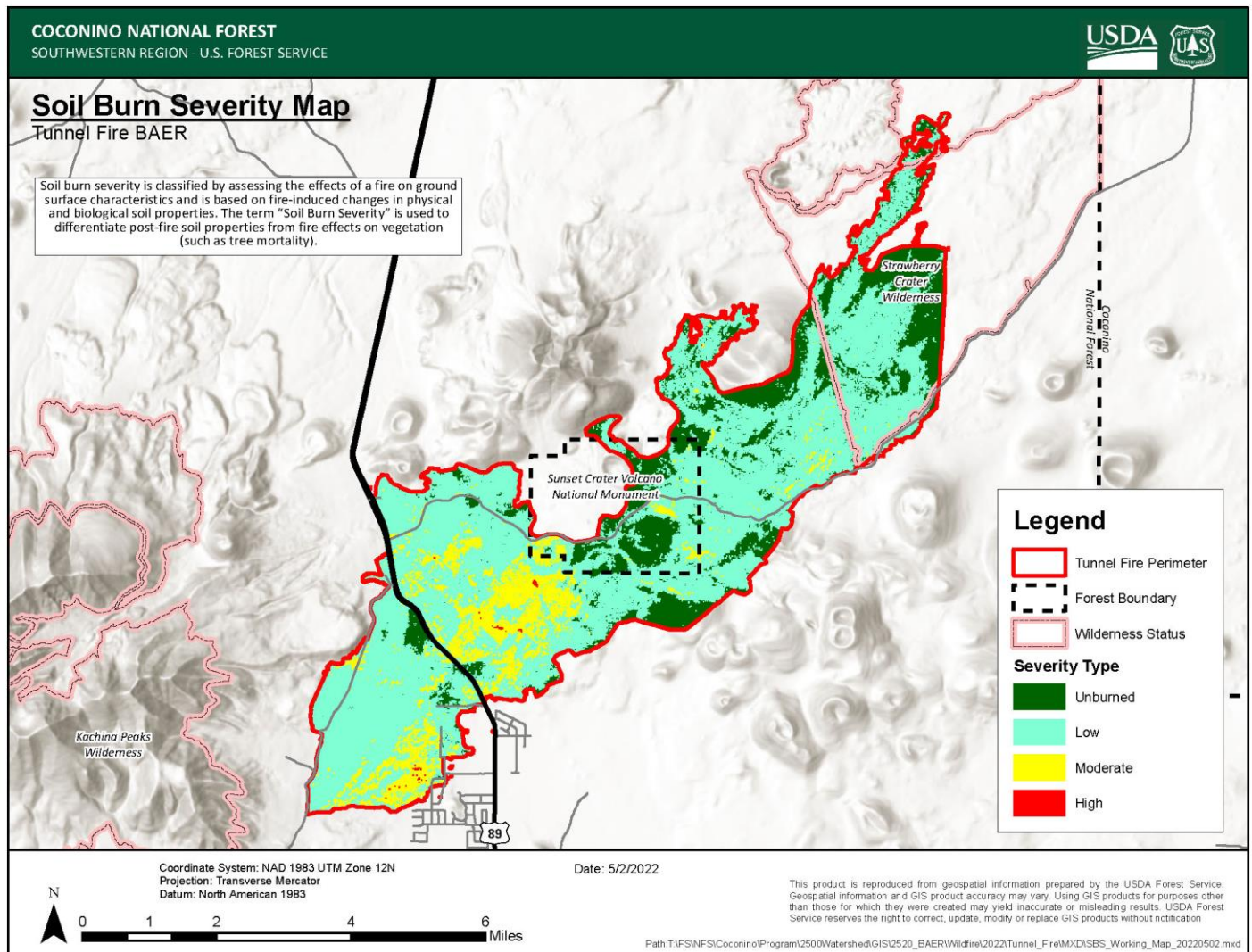


Figure 3: Soil Burn Severity map as determined by satellite imagery and ground validation.

Figure 4: Debris flow hazard (combined debris flow probability and debris flow volume) calculated by USGS.

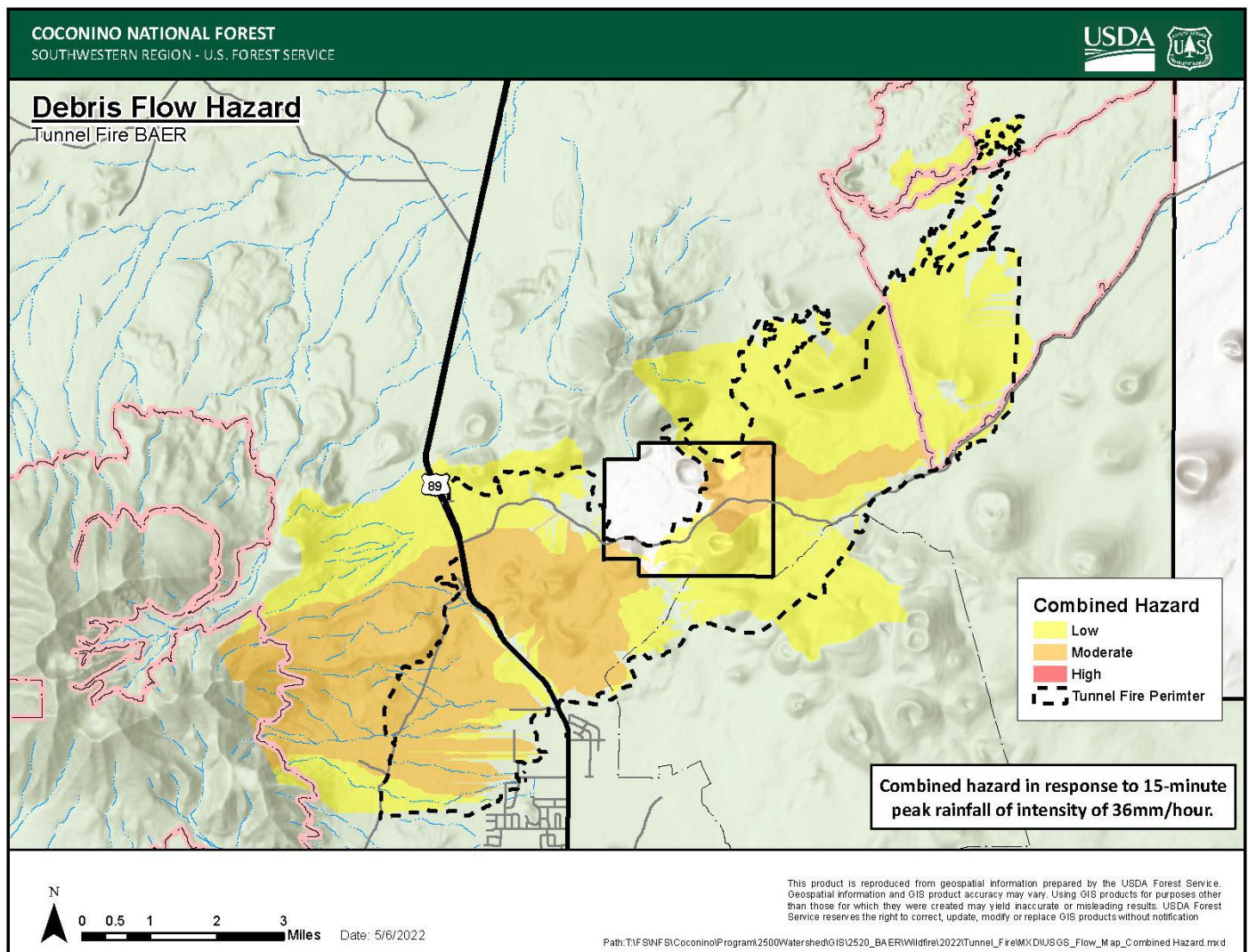


Figure 5: Treatments proposed to mitigate Tunnel Fire effects to BAER critical values.

