Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Pacific Southwest Region | October 2024

Burned Area Emergency Response Assessment
Technical Report
Bridge Fire (CA-ANF-243334)

October 16, 2024

Bridge Fire (USDA FS)

Jonathan Schwartz, Geologist, Los Padres National Forest
Keith (Andy) Stone, Hydrologist, Sequioa National Forest
Anna Plumb, Soil Scientist, Chippewa National Forest
Serena Kuczmarski, Soil Scientist, Ottawa National Forest
Dave Callery, Hydrologist, National Post-Fire Program
Kenny Orihuela, Hydrologic Technician, Angeles National Forest
Todd Ellsworth, Post-Fire/Disaster Recovery Coordinator, Pacific Southwest Regional Office

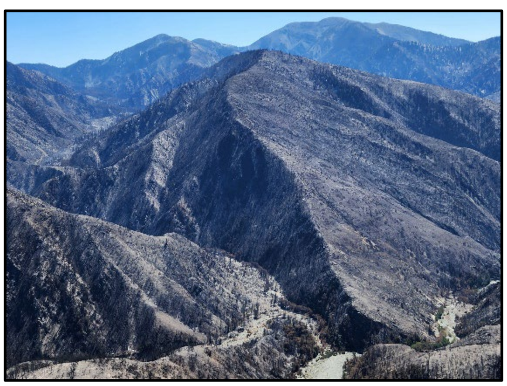
This report and mapping are products of BAER rapid assessment completed by the USFS. Further information concerning the accuracy and appropriate uses of geospatial data as displayed may be obtained from the various sources. The USDA Forest Service makes no warranty, expressed or implied, including the warranties of merchantability and fitness for a particular purpose, nor assumes any legal liability or responsibility for the accuracy, reliability, completeness, or utility of these geospatial data, or for the improper or incorrect use of these geospatial data. These geospatial data and related maps or graphics are not legal documents and are not intended to be used as such. The data and maps may not be used to determine title, ownership, legal descriptions, boundaries, legal jurisdiction, or restrictions that may be in place on either public or private land. Natural hazards may or may not be depicted on the data and maps, and land users should exercise due caution. The data is dynamic and may change over time. The user is responsible to verify the limitations of the geospatial data and to use the data accordingly.

Overview and Process

The Bridge Fire started on September 8, 2024 near the confluence of the East Fork San Gabriel River and Cattle Creek, approximately six miles northeast of Glendora, California. As of October 16, 2024, the fire was considered 99% contained. The fire perimeter encompassed roughly 52,000 acres. Approximately 95% of the burned area lies on National Forest System (NFS) lands, mostly on the Angeles National Forest (NF) with some area on the San Bernardino NF. Roughly 2,900 acres (5%) within the fire perimeter were on non-NFS (mostly private) land. The fire burned primarily in the East Fork San Gabriel River watershed and the Sheep Mountain Wilderness within the San Gabriel Mountains National Monument of the Angeles NF.

The Bridge Fire burned area extends from the north end of the San Dimas Experimental Forest to the Table Mountain Plateau, south of Pinon Hills, in the San Gabriel Mountains National Monument District of the Angeles National Forest. The physiography of the burned area is dominated by steep slopes and rugged canyons largely draining into the East Fork San Gabriel River watershed. The average slope in the San Gabriel Mountains is over 65 percent which leads to high erosion rates in both dry and wet periods. Elevation ranges from 1,850 feet above sea level (asl) at Oaks Day-Use-Area, along the East Fork San Gabriel River, in the southwest, to over 10,000 feet (asl) at Mount San Antonio (Mt Baldy).

A Forest Service (FS) Burned Area Emergency Response (BAER) team was assembled on September 24, 2024, and charged with evaluating post-fire threats and determining level of risk to critical values on NFS land, and to recommend potential treatments to reduce post-fire risks. The BAER team also coordinated closely with interagency partners to identify threats to values downstream of NFS lands. This report describes the rapid characterization of post-fire watershed conditions and recommendations on NFS lands. Similar reports are being prepared by the California Geological Survey Watershed Emergency Response Team (WERT) and the Counties of Las Angeles and San Bernardino.



Picture 1. Burned terrain in the Cattle Canyon watershed (USDA FS)

Burned area emergency assessments are rapid evaluations done to determine if critical values are at risk due to imminent post-fire threats and to develop appropriate actions to manage unacceptable risks. Critical values identified by the BAER team included life and safety, recreation and transportation infrastructure, cultural and heritage sites, critical aquatic and wildlife habitat, and other natural resource values. These assessments are not intended to provide a comprehensive evaluation of all fire or fire-suppression damages, nor to identify long-term rehabilitation or restoration needs.

The first step in a burned area assessment is to identify specific values that are potentially at risk from post-fire events. Once these critical values have been identified, each is assessed for potential threats from post-fire conditions. To characterize post-fire threats, the BAER team makes field observations of soil and watershed conditions that are used in conjunction with analysis methods to estimate anticipated levels of post-fire damage from erosion, flooding, and geologic hazards. A post-fire emergency is identified when a critical value found to be at unacceptable risk of damage due to post-fire conditions. After defining the post-fire emergency, a response strategy that considers natural recovery is developed to mitigate the risk.

General Resource Setting

Geology and Soils

The Bridge Fire occurred on the eastern San Gabriel Mountains rock assemblage, a group of rocks that form part of the east-west oriented Transverse Ranges of Southern California. The formation of this range occurred during the Mesozoic Era about 100 million years ago (Mya), when oceanic rock off the Pacific Plate started to converge with the North American Plate. During this subduction, this parent oceanic rock underwent alteration from heat and pressure to form the metamorphic Pelona Schist that dominates the northern end of the San Gabriel Mountains. The section south of the San Andreas Fault Zone is rich in metamorphosed amphibolite-grade muscovite-plagioclaise schist. South of Vincent Thrust, the Pelona Schist contains thin bands of highly deformed metachert and marble layers.

Picture 2. Upper East Fork San Gabriel River watershed (USDA FS)

In the late Cenozoic Era, the metamorphic formations were uplifted and exposed at the surface. Towards the southern section of the burned area, the formations are both metamorphic and granitic. Rocks in this area commonly include coarse-grained, biotite-rich granodiorite, tonalite and gneiss.

Major fault lines in this area include the Vincent Trust Fault, San Gabiel Fault, and the San Andreas Fault Zone. During the early Miocene, increased friction between the Pacific and North American plates caused a restraining bend that turned the San Andreas Fault to a more east-west orientation (Crowell, 1982). While the relative motions of the plates remain the same, this “big bend” section allowed for a mix of strike-slip and thrust faulting (oblique faulting) that further uplifted the San Gabriels about 7 Mya (Moulin, A. & Cowgill, E., 2023). This tectonic activity continues today and contributes to the faster than average uplift rate relative to other mountain ranges in the United States.

The complex geologic setting of the San Gabriels has enticed prospectors in this area before the Angeles National Forest was designated. Indeed, the San Gabriels was the target for gold mining in the mid-19th Century.

Hydrology

Elevation within the burned area perimeter ranges from around 10,065 feet above sea level (Mount San Antonio/Mount Baldy) to roughly 1,800 feet on the East Fork San Gabriel River on the west side of the burned area. Annual precipitation ranges from approximately 20 inches in the Wrightwood and East Fork areas to over 45 inches on the Baldy Ridge and other higher elevations. Precipitation comes predominantly in the form of rain from winter frontal storms and atmospheric rivers, with a snow zone above roughly 6,000 feet. Areas between approximately 4,000 and 6,000 feet are in a transitional zone in the winter, with occasional snowfall that generally does not persist throughout the winter. Summers are generally dry, with occasional monsoonal thunderstorms that can produce locally heavy rainfall.

Picture 3. Cattle Canyon floodplain at Coldwater Creek (USDA FS)

The upper East Fork San Gabriel River and its tributaries draining the burned area generally flow through steep, rugged canyons. Some of these tributary watersheds are drained by ephemeral channels that only flow during snowmelt or rainfall events, while others have perennial streams. Tributary channels are generally steep, and bedrock or cobble-dominated.

High-energy, flashy flows occur in response to high-intensity rainfall (especially at higher elevations), often resulting in channels scoured to bedrock. Most upper reaches lack extensive fine sediment deposits, indicating sediment input from the surrounding landscape is transported out during common flow events. Floodplain development in lower reaches includes extensive deposits of loosely consolidated alluvial cobbles and boulders, and includes patchy vegetative cover consisting of trees, shrubs, and groundcover. Relatively frequent high-energy flood flows transport large amounts of rock and fine sediment, limiting riparian vegetation development in many locations.

Analysis and Results – Post-Fire Conditions

Soil Burn Severity

Assessment of soil burn severity is one of the first steps in the USDA FS BAER process. Post-fire soil burn severity is often mapped with the intention of identifying the degree to which the fire has affected soil characteristics that impact soil health and hydrologic function, and hence erosion rate and runoff potential. Soil burn severity is not a simple assessment of vegetation consumption, but rather an integration of vegetation loss, changes in soil structure and infiltration capacity, remaining vegetation and duff layers, ash, and soil color, all of which may indicate relative degrees of soil heating. From the soil burn severity map, geologists can predict debris flow hazards, hydrologists can predict changes to runoff and flood flows, and soil scientists can predict erosion potential.

The final soil burn severity maps were developed with *ESRI ArcGIS* software using satellite-imagery-derived Burned Area Reflectance Classification (BARC) and field survey data collected in collaboration with the California Geological Survey Watershed Emergency Response Team (WERT). Field work to document and confirm soil burn severity was completed from September 24 to 28, 2024. Field work included assessment of ash characteristics, ground cover, roots, soil structure, soil water-repellency, and vegetation burn severity as described in the *Field Guide for Mapping Post-fire Soil Burn Severity* (Parsons et al. 2010*)*.

Picture 2. Overview of the Bridge Fire (USDA FS)

Hydrophobicity was measured in the field but was not used as a determining factor of soil burn severity. In some forest vegetation types, strong surface hydrophobicity was found within and outside of the burned area in unburned conditions. In burned areas, it was often present in forested sites, but its severity was variable. Field assessment sites covered as many burned conditions within each vegetation type as possible in the time available, however the process is still considered a rapid assessment and is not guaranteed to capture all variability. Field data were used to adjust the BARC map to produce the final soil burn severity (Figure 1).

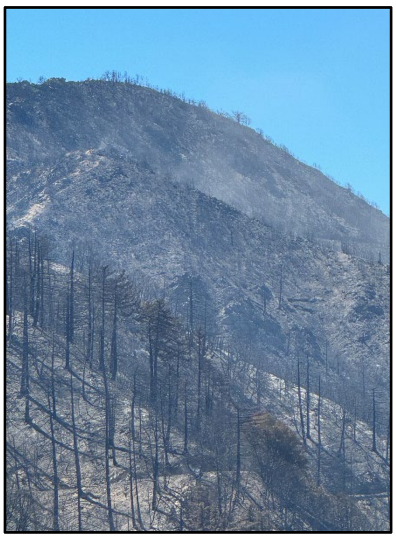
Picture 3. Recovery as seen in chaparral landscapes in the Bridge Fire (USDA FS)

Grasses and sparse shrubs usually experience extremely rapid consumption and spread rates during a wildfire, with very little heat residence time at the soil surface (Picture 4, Picture 7). The result is very little alteration of soil organic matter and little or no change in soil structural stability. Water repellency, occasionally present under shrubs before the fire, may or may not be exacerbated by the fire. Very low and low soil burn severity was classified in areas where the surface organic material was charred or partly consumed. Roots close to the soil surface were usually still pliable, and soil structure was mostly unchanged. Most grassland areas burned at very low to low severity; however, low severity conditions were found in all vegetation types. Vegetation recovery is anticipated to be rapid in these areas and sprouting was observed in some grasslands during the assessment. Post-fire erosion response in areas of low soil burn severity will be somewhat variable. Some low-severity areas under forest vegetation will have litter and organic material additions before the wet season; however, some of the grass and shrublands have little or no surface cover remaining except rock.

Picture 4. Low soil burn severity areas of the Bridge Fire (USDA FS)

Dense vegetation, with a deeper litter and duff layer, results in longer duration heat on the surface soils, and thus, more severe effects on soil properties (Picture 5, Picture 7). For example, deep ash after a fire usually indicates a deeper litter and duff layer prior to the fire. This promotes loss of soil organic cover and organic matter, which are important for erosion resistance and the formation or exacerbation of water repellent layers at or near the soil surface. The results are increased potential for runoff and soil particle detachment, and transport by water and wind. High soil burn severity was not widespread (9% of the burned area), but where it occurred, effects could be deep and severe. Most high burn severity had complete consumption of organic material with the surface layers of the soil resulting in a change to single-grain structure. Fine roots were commonly charred or consumed 3-5 cm deep. The highest-severity areas often had a loose, dusty appearance, and no longer had any cohesion or soil strength. This condition was found where forested vegetation had accumulated enough fuel on the soil surface to cause high severity, or long-duration heat impact to the soil.

The moderate class of soil burn severity is far more diverse in observed soil conditions and can include various vegetation types, ranging from forests to shrub communities. In forested areas the litter layer may be largely consumed, but scorched needles and leaves remain in the canopy and will rapidly become mulch. This is important in re-establishing protective ground cover and soil organic matter. Generally, there will be less destruction of soil organic matter, roots, and structure in an area mapped as moderate compared to an area mapped as high SBS. In a shrub ecosystem, even where pre-fire canopy density was high, the litter layer is generally thin, and while the shrub canopy may have been completely consumed by the fire, the soil structure, roots, and litter layer may remain intact beneath a thin ash layer. On the Bridge Fire, moderate soil burn severity was found in areas where the surface organic material was completely consumed by the fire, fine roots close to the soil surface were charred up to 3 cm deep, and the soil structure was often altered at the surface. Moderate severity occurred under forest canopy or under chapparal. Some areas have potential for inputs of litter to increase ground cover, but more commonly no surface organic matter remains, which can increase post-fire erosion.



Picture 6. Post-fire wind erosion on the Bridge Fire (USDA FS)

Significant areas of moderate and high SBS had signs of wind erosion. This was observed as exposed tan subsurface soil and by exposed roots that were not consistently charred. This was likely caused by strong fire-induced inflow/outflow winds as well as the strong wind events occurring during the burn. The wind erosion removed much of the ash layer and the loose surface soil once the structure was lost (Picture 6). The loss of these materials could reduce the ash loads being deposited in the drainages during the initial rain events, but also reduces the soils water holding capacity. This reduction in water holding capacity will expedite runoff during the onset of precipitation events. This loss of the surface "A" horizon will also significantly reduce the soil productivity in these areas. Before the fire, the A horizon would have varied from chaparral to timbered ground, however it would have held rich organic matter that supported the vegetation vs the weakly developed horizons below.

The Soil Burn Severity product is used as an input for all the methods presented in this report; it is the basis for determining the anticipated level of post-fire watershed response. Unburned or very low SBS covered 11% of the fire perimeter, low SBS covered 31%, moderate SBS covered 51%, and high severity covered 9% (Figure 1).

Picture 7. Photos of the three classes of soil burn severity. On the left, low soil burn severity. In the center, moderate soil burn severity. On the right, high soil burn severity. (USDA FS)

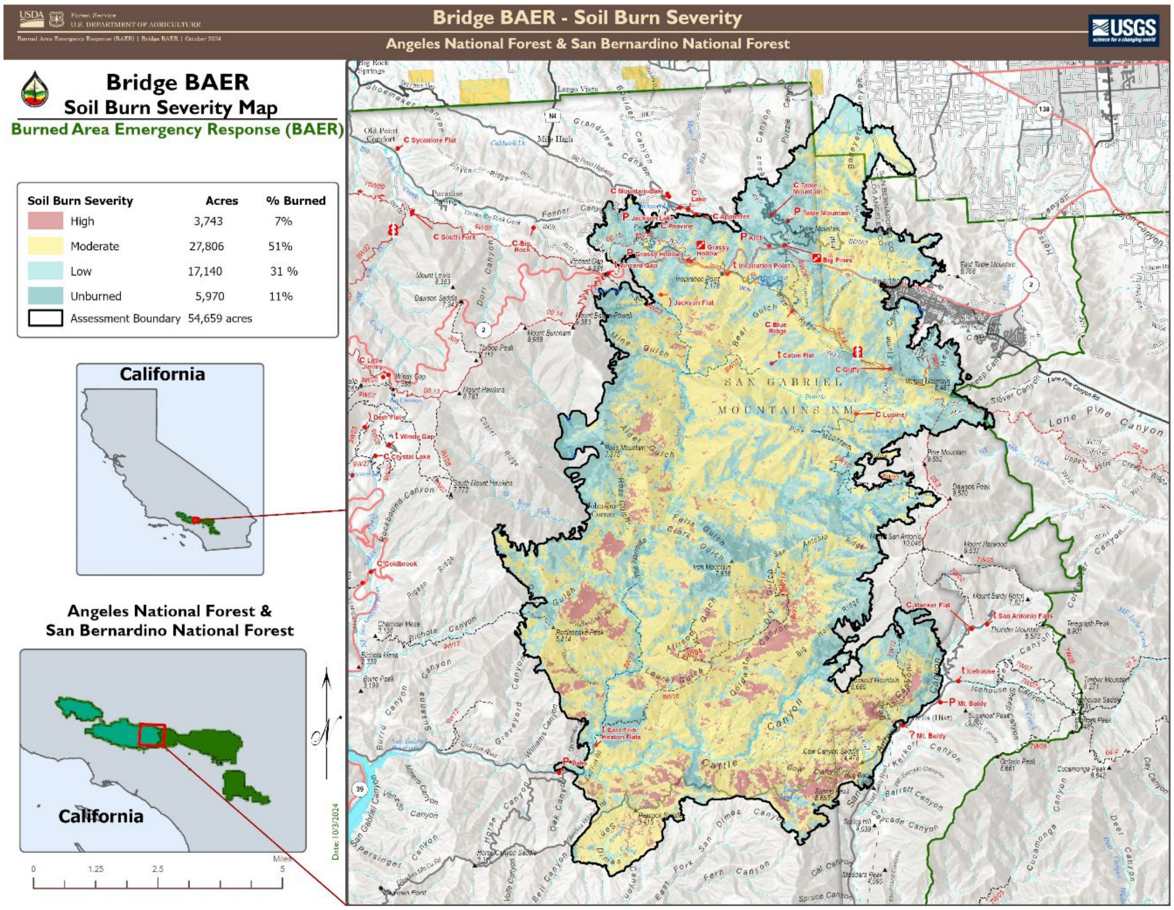


Figure 1. Soil burn severity map for the Bridge Fire.

Soil Erosion

Erosion rates following wildfires are determined by several key factors, including soil burn severity (SBS), topography, soil type, precipitation, and pre-fire vegetation type. In the case of the Bridge Fire, these variables interact in complex ways across different elevations, influencing the overall erosion risk and post-fire recovery. The ERMiT (Erosion Risk Management Tool) model was used to predict the erosion rates and spatially display erosion source areas (USFS, RMRS-GTR-188, 2007). On the Bridge fire, post-fire erosion is expected to increase by roughly 120% compared to pre-burn conditions for a two-year event (Appendix A. Map Products).

At higher elevations within the Bridge Fire area, moderate SBS was predominant, but there were also significant portions with low SBS. In contrast, the lower elevations, particularly in chaparral-dominated areas, experienced greater high SBS, particularly on steeper slopes and in the upper parts of watersheds. The influence land management near Wrightwood, and the influence of the Mojave Desert climate at higher elevations may have altered fire behavior, resulting in differences in SBS distribution in the northeastern part of the fire.

In the lower elevations, high SBS was more prevalent. The erosion rates for the lower third of the fire area are expected to be higher due to the region's climate, which differs slightly from the higher elevations. In the lower elevations, most of the precipitation occurs as rain during the winter, leading to greater soil exposure to erosive events. In contrast, at higher elevations, snow provides a protective layer over the soil during the winter months, helping to mitigate erosion from precipitation.

In areas of high SBS within the chaparral, coarse-textured soils are common. These soil types allow heat from the fire to penetrate more deeply, causing more extensive soil damage and higher SBS, which in turn leads to increased erosion rates.

The ERMiT model used for predicting erosion rates does not factor in the stabilizing effects of root regrowth, particularly in areas with intact seed banks. In low SBS areas, we expect some soil stabilization to occur due to the regrowth of herbaceous plants and forbs before winter arrives, as well as ground cover provided by needle cast in timbered areas. This regrowth will likely help reduce erosion in these lower SBS areas.

In high and moderate SBS areas, sediment delivery is expected to be less severe than the model suggests, as much of the topsoil has already been lost to wind erosion during the fire itself. Additionally, dry ravel, or the downslope movement of loose soil and debris, has already occurred, contributing material to drainages and reducing the likelihood of further sediment transport during winter precipitation events.

Table 1 below provides a summary of SBS and predicted erosion rates for several drainage basins of interest. These basins have been identified as critical for the Forest Service's post-fire response and management.

Table 1. Summary of modeled 2-year erosion rates for watersheds of interest.

Pour Point	2-year storm event - Average Sedimentation Rate (tons/Ac)	Acres	Outside Bridge Fire Boundary	Unburned %	Low %	Moderate %	High %
BYA Harmony, Lions Camps	4.8	20	0	3	16	0	0
Unnamed tributary above McClellan Flat	1.3	20	0	16	5	0	0
Unnamed tributary at Mt Baldy village	9.1	28	1	0	13	14	0
Unnamed tributary at Lupine CG	7.7	174	0	17	69	88	0
Hummingbird Creek SDEF	17.4	220	0	0	0	166	54
Jackson Lake picnic area	5.1	235	19	65	115	32	4
Unnamed tributary at Apple Tree CG	4.7	270	0	53	152	63	2
Hwy 2 West Sawmill Canyon	4.7	303	0	9	71	223	0
Tanbark Creek SDEF	15.4	329	1	7	24	287	11
Hwy 2 East	5.8	345	0	8	118	219	0
YMCA Camp Elk	4.8	388	101	76	201	9	0
Oaks picnic area	18.4	730	678	14	17	21	0
Bear Creek at forest boundary	11.2	1,081	1	35	235	618	191
Cattle Creek above Cow Creek	13.1	2,525	675	368	581	852	48
Prairie Fork at Cabin Flat CG	6.4	3,805	249	235	1,421	1,884	15
Coldwater Creek above Cattle Creek	15.1	4,849	160	242	800	2,877	771
Cattle Creek at EF confluence	13.4	13,039	848	796	1,914	7,546	1,934
East Fork San Gabriel River above Cattle Cr confluence	11.3	37,185	9,063	2,898	8,714	15,078	1,432

Hydrology

Hydrologic response following wildfire in the Bridge Fire burned area will include reduced interception and infiltration of precipitation, increased runoff and erosion, higher stream flow volumes for a given precipitation or snowmelt input, and a more rapid rise of stream and river levels compared with those of unburned conditions. Additionally, the probability of severe erosion, debris flows, and hillslope failure is substantially higher, and will remain so for at least the next few years.

Water quality in streams that drain the burned area will be impaired during runoff events, particularly following high-intensity winter rain events. An initial flush of ash and fine sediment is likely in response to the first intense rain events of fall and winter. Suspended sediment loading and turbidity levels in streams within and below the burned area will likely be elevated in response to rainfall and snowmelt in subsequent years, until groundcover becomes re-established. Even after groundcover stabilizes hillslopes in the burned area, eroded fine sediment that is deposited in draws, stream and river channels, and floodplains in the next few years will continue to move through the system for many years to come. Large woody debris will likely accompany the initial flush of fine sediments and ash, with continued downstream delivery of large debris during high-intensity rain events. Additionally, levels of some nutrients will likely be elevated in concert with higher turbidity and suspended load. Lastly, stream temperature in perennial streams is likely to increase relative to pre-fire conditions where shade has been lost. Riparian vegetation will recover in a relatively short period of time, but shading for larger channels from tall trees will take decades to recover. Changes in water quality will persist within and downstream of the burned area and will impact aquatic resources and habitat.

Picture 8. Box culvert at Hummingbird Creek on San Dimas Experimental Forest (USDA FS)

Elevated sediment and debris loading as well as water quality degradation can impact impoundments downstream of the burned area over the next few years, including the San Gabriel and San Dimas Reservoirs, and the San Antonio Canyon flood-control impoundment.

Typical USDA FS BAER hydrology analytical methods include a field assessment to identify critical values vulnerable to flood and related damage, an estimation of post-fire hydrologic response to rain and snowmelt events, and evaluation of potential mitigation measures to reduce risk of damage to critical values. Prior to the field assessment, the burned area is reviewed using maps and aerial imagery, ideally including the initial BARC data. Buildings, transportation infrastructure (e.g. roads, culverts, bridges), water developments, natural resources, and recreation areas adjacent to streams within and below the burned area are identified and prioritized for field assessment. In the field, these critical values are examined to determine their vulnerability to damage from post-fire flooding. The field survey typically includes qualitative assessments, as well as quantitative data collection where modeling is warranted.

Following the field assessment, the approximate change between pre-fire and post-fire runoff for one or more probability events (precipitation or runoff) is typically estimated for areas of concern. A range of models and techniques are used to estimate post-fire runoff and erosion. Each approach has its advantages and shortcomings. Given the short timeframe in which BAER assessments occur, and the challenge of modeling ungauged basins in a post-fire environment, any estimation of post-fire watershed response is imprecise at best. BAER assessment teams thus generally avoid reporting stream runoff estimates as specific flow values, but instead report the estimated magnitude of change in runoff response between pre- and post-fire conditions. These estimates assist in determining where measures should be considered to reduce the risk of damage to critical values from elevated runoff response.

A common approach for estimating runoff from mountainous southern California burned areas was selected for the BAER runoff assessment. USGS runoff regression equations developed for southern California were used to estimate pre-fire flood flows in several catchments draining to BAER critical values. Following consultation with the California WERT team, a method commonly used in this region was employed to approximate post-fire runoff using the pre-fire regression-estimated values and soil burn severity data (Foltz et al., 2009). This method entails increasing the proportion of runoff from burned areas using an adjustment factor based on SBS and assumes that each unit of area within a drainage contributes the same amount of runoff to the aggregated flow at the outlet. For this assessment, the regression-derived 50%-probability (two-year recurrence interval) flood was evaluated. Catchment areas burned at low SBS were assumed to contribute runoff at the 20%-probability flood, area at moderate SBS contributed runoff at the pre-fire 10%-probability level, and area in high SBS contributed runoff at the pre-fire 4%-probability level. This flood has an 88% chance of occurring in the next three years, the approximate time it will take for groundcover vegetation to recover to pre-fire conditions barring extended drought conditions over this interval.

The estimated change in runoff due to burned-area conditions described in this report represents an increase in clear water flow. In a post-fire setting, flow volumes are further increased by additional sediment loading, as well as other debris. This flow "bulking" is anticipated to increase flood flow volumes below the Bridge Fire burned area, especially in smaller or more heavily burned catchments. Additional woody debris and sediment made available by the fires will likely pose a threat to critical downstream values during typical rainy season peak-flow events.

Fifteen catchments were selected for analysis with outlets located at or near critical values. Three additional small (under 30 acres) catchments were delineated above critical values, though flood flows were not estimated for these as they are below the size threshold appropriate for use of the USGS regression equations. These small, steep catchments are more likely to respond to moderate to intense rainfall input with debris flows rather than floods or hyper-concentrated flows.

The conditions that would result in a 50%-probability flood under pre-fire conditions were predicted to result in considerably higher post-fire flow rates in the evaluated catchments. In keeping with the SBS-based method for estimating post-fire flow, the basins with the most area burned at moderate-to-high SBS levels showed the most dramatic predicted flow increase. Catchments with the highest magnitude of change include two tributaries to upper Sheep Creek that drain to Highway 2, Cattle Canyon and its main tributaries, Bear Canyon above the Mount Baldy community, and drainages above the San Dimas Experimental Forest (Table 2). As noted above, these estimates are for a relatively common flood event. Heavier (lower-probability) rain storms or rain-on-snow events could produce dramatically higher flood flows or debris flows in most of the burned area. Debris flows are discussed in detail in the Geology specialist report.

Table 2. Estimated percent increase in two-year (50% annual probability) flood for selected watersheds.

Pour point ID	Catchment Name	watershed area (ac)	% area high and moderate SBS	pre-fire peak flow (cfs/mi)	post-fire peak flow (cfs/mi)	magnitude of change (%)
9	East Fork San Gabriel River above Cattle Creek	37,185	44%	14	69	4.9
2	Cattle Creek above East Fork confluence	13,038	73%	20	147	7.3
10	Coldwater Creek above Cattle Creek	4,850	75%	29	201	6.9
12	Prairie Fork at Cabin Flat Campground	3,804	50%	30	119	4.0
11	Cattle Creek above Cow Creek	2,523	36%	36	114	3.2
17	Bear Canyon at national forest boundary	1,080	75%	48	279	5.8
1	Oaks Canyon at picnic area	730	3%	44	49	1.1
14	Unnamed tributary at YMCA Camp Elk	387	2%	13	18	1.4
19	Unnamed tributary at Hwy 2	345	64%	13	130	10.0
6	Tanbark Creek at San Dimas Experimental Forest	330	90%	58	270	4.6
18	Sawmill Canyon at Forest boundary	303	74%	15	169	11.4
4	Unnamed trib at Appletree Campground	270	24%	14	69	4.8
13	Unnamed tributary at Jackson Lake picnic area	235	15%	16	60	3.7
7	Hummingbird Creek at San Dimas Experimental Forest	220	100%	76	434	5.7
5	Unnamed trib at Lupine Campground	174	51%	92	287	3.1

There are many non-Forest Service values within and downstream of the Bridge Fire burned area that are at elevated risk of damage from flooding, debris flows, and increased sediment and debris deposition. People in houses and other structures or other private property located in on fan deposits, valley bottoms adjacent to streams or in other flood-prone areas are potentially at risk of injury or loss of life in the event of post-fire runoff events. The structures and other property are also likely at increased risk of damage from post-fire flooding or debris flows. In several locations, structures and gathering areas are located on alluvial and debris flow fans or in flood-prone areas adjacent to or downstream from burned drainages. Areas of concern include but are not limited to the Wrightwood and Mount Baldy communities, several organizational camps and recreation residences in the Wrightwood, Mount Baldy, Big Pines, and McClellan areas.

The State Corrections Camp 19 along the East Fork lies within the flood-prone area and is likely to be inundated in larger flood events. A low bridge over the river is the only road access to the camp, and is vulnerable to inundation and damage or loss from debris-laden flood events. Mid-slope and valley-bottom areas of the ski resorts on the south side of Highway 2 are also vulnerable to debris flows. Representatives from appropriate agencies (e.g. County Disaster and Emergency Services, California Watershed Emergency Response Team, National Weather Service, USDA Natural Resources

Conservation Service) have begun to reach out to property owners in these areas to determine where risk assessments and mitigation measures may be appropriate. The managers of Camp 19 should be strongly encouraged to evaluate risk and appropriate mitigation measures at this site.

State, private and county roads are located within and immediately downstream from the burned area. Potential post-fire impacts include injury or loss of life to travelers on these routes, as well as damage to the road system and/or loss of access due to increased runoff rates that overwhelm the capacity of bridges and culverts, plugging of structures by debris or sediment, erosion of the road surface, or deposition of sediment or debris on road surfaces. State Highway 2 serves as a major east-west route for recreational users of the Wrightwood area and adjacent NFS lands. Several county-jurisdiction roads also may be vulnerable to damage at stream crossings and also at ditch-relief culverts and other drainage features that may now be vulnerable to plugging with debris or sediment. Responsible agencies should be encouraged to evaluate the vulnerability of their road systems in the post-fire environment and take appropriate measures to mitigate any risks identified.

Several flood control reservoirs lie downstream of the burned area, including the San Gabriel, San Dimas, Big Dalton, and San Antonio reservoirs. These structures provide flood mitigation for the Los Angeles area. These impoundments are at varying levels of risk from elevated runoff and sedimentation in the post-fire environment. The owners and managers of this infrastructure are aware of the risks posed to their facilities, and continued cooperation between the FS and these entities is encouraged.

Geologic Hazards

Geologic hazards commonly exacerbated by fire are debris flow and rockfall. Rockfall is most common on steeper slopes, especially along stream banks and roadcuts. Under post-fire conditions, burned watersheds with steep slopes and first-order channels that contain significant volumes of stored sediment are likely to experience increases in runoff and erosion from a lack of protective vegetation cover, soil hydrophobicity, and loss in cohesive root strength, which provide the potential to generate debris flows (Kean et al., 2011; Parise and Cannon, 2012; and Kean et al., 2019). Post-fire debris flows initiate as result of progressive bulking or accumulation of slurry in stream channels (Cannon, 2000, 2001; Cannon et al., 2001a). Runoff generated slurry typically has high sediment concentrations (40–65 percent) and can scour colluvial and fluvial stream deposits. The flow can then progressively grow in size as it moves downstream by recruiting boulders and woody debris, resulting in destructive debris flows (Iverson, 1997). Hydrologic processes such as debris flows, and hyper-concentrated flows threaten life, property, and infrastructure. They can destroy houses, block, or erode roads and cause transportation impacts, sever pipelines, damage utilities and add large quantities of sediment to stream channels that impact water resources (Schwartz et al., 2021).

Picture 9. Steep chutes above East Fork San Gabriel River loaded with sediment (USDA FS)

Reconnaissance of the burned area included ground surveys, an aerial reconnaissance flight, an analysis of the USGS debris flow model and an analysis of aerial imagery. The GIS coverages of bedrock and geomorphology for the Angeles National Forest was verified in the field. Assessment of the burned area included identification of critical values in and downstream of the burned area, identification of pre-fire slope failures and pre-fire slope and channel failure deposits, measurements of slopes, identification of geological units, field verification of soil burn severity, notes of observations and photography. In addition to ground surveys, a review of published geologic maps, GIS data and geoscience publications was conducted.

From ground surveys and an aerial reconnaissance flight, it is evident that pre-fire mass wasting as rock-fall, shallow landslides, and some old debris flow deposits exists throughout major portions of the burned area. Throughout the Bridge Fire burn scar most slopes and drainages are loaded with unsorted, unconsolidated materials comprised of rocks of all sizes including boulders, cobbles, gravels, and fine sediments, available to be transported. This is related to the type of parent materials, the steep slopes and continues gravitational and hydrological mobilization of rocks and sediments down slopes and drainages. Scanning the burn scar from south to north, some of the drainages in the burn scar that present large amounts of unsorted, unconsolidated materials available to be transported included: Tanbark Creek, Hummingbird Creek, Bear Creek, Cow Canyon, Cattle Canyon, Coldwater Canyon, East Fork San Gabriel River, Fish Fork, Vincent Gulch, Prairie Fork, Sheep Canyon, Heath Canyon, Flume Canyon, Government Canyon, and Sawmill Canyon. In most of these watersheds, in addition to the fact that large amounts of sediments are present and available to be transported, major portions of these watersheds experienced moderate to high soil burn severity. From ground surveys and aerial reconnaissance, it is evident that many of the steep chutes flowing into the major creeks in the burn scar are loaded with sediments (Picture 9).

As a result of the fire and the removal of supportive vegetation, post-fire dry ravel and rockfall was observed on slopes, impacting roads, and further loading channels with fine sediments and rocks (Picture 10). In addition to the fact that many of these drainages impacted by the fire experienced a moderate to high soil burn severity, many of the slopes in the burn area are steep (40-60%) or very steep (60+%) slopes.

Picture 10. Post-fire dry ravel and rockfall impacting roads and loading channels (USDA FS)

Within the Bridge Fire burn scar, widespread evidence of debris flow deposits was identified in many watersheds, and creek bottoms (Picture 11). For the most case, these debris flow deposits were mobilized during storms under pre-fire conditions. Now that the Bridge Fire burned such a high percentage of the landscape at the headwaters of watersheds and on steep slopes, debris flow initiation and mobilization is expected to dramatically increase due to post-fire conditions.

USGS Debris Flow Assessment

To assess the probability and potential volumes of debris flows in the burned area the assistance of the US Geological Survey (USGS) - Landslide Hazards Program was obtained. Using data and conclusions from their ongoing debris flow research, geologists at the USGS have developed empirical models for forecasting the probability and estimating the likely volume of debris flow events in a particular watershed. To run their models, the USGS uses geospatial data related to basin morphometry, burn severity, soil properties, and rainfall to estimate the probability and volume of debris flows that may occur in response to a design storm (Staley, 2013). Estimates of probability, volume, and combined hazard are based upon a design storm with a peak 15-minute rainfall intensity of 12 to 40 millimeters per hour (mm/h) rate. We selected a design storm of a peak 15-minute rainfall intensity of 32 mm/h (1.25 inch/h) rate to evaluate debris flow potential and volumes, as this intensity is roughly the annual recurrence probability event (NOAA Atlas 14).

Picture 11. Debris flow levees and deposit – Prairie Fork (USDA FS)

Based on the USGS debris flow modeling, it appears that under conditions of a peak 15-minute rainfall intensity storm rate of 32 millimeters per hour (1.25 inches/hour), corresponding to a 1-year return interval, a majority of the drainages in the burn scar show high to very high likelihood of debris flow initiation (80-100%) with a high combined hazard (volume + likelihood) rating (Appendix A. Map Products). Volume estimates show that 0-2 order drainages have the potential to produce 1,000 – 10,000 cubic meters, but cumulative volume output for most basin and the segment outlets range from 10,000 to 100,000 cubic meters. In areas of high soil burn severity, steep slopes, and high channel loading, some catchments exceed 100,000 cubic meters cumulative output.

The conclusion of our field observations is that whether the primary post-fire process is rock-fall, debris slides, debris flows or hyper-concentrated flows (sediment laden flooding), the cumulative risk of various types of slope instability, sediment bulking, and channel flushing is elevated along most slopes and drainages in and below the burn area following the Bridge Fire. Based on the above, special attention and caution is recommended in areas where people are living or traveling through, working, or recreating in or below the burned areas during and immediate after storm events.

Summary of Post-fire Watershed Response

- Soil burn severity was moderate to high across roughly 60% of the burned area.
- Erosion will be elevated in most of the burned areas, and substantially elevated on and near areas of moderate and high soil burn severity on roughly the southern third of the fire.
- Ash and fine sediment will likely be transported to stream channels and washed downstream during the first fall rainstorms.
- Mobile woody debris in many of the stream channels throughout the burned areas will likely be entrained in flood flows.
- Water quality in streams and the nearshore environment will be impaired by ash, fine sediment, nutrients, and dissolved organic carbon during and following rainfall on the burned areas.
- The probability of debris flows was predicted by USGS models to be high for many of the small watersheds within the burned area with a 15-minute rainfall intensity of 32 mm/hour (about 0.3 inches in 15 minutes), a storm intensity that is likely to occur at least once annually.
- Debris flows in headwater draws and canyons will add material to floodwaters in the larger streams draining the burned area, and have the potential to temporarily dam larger streams, causing backwater effects as well as flood surges when the temporary dams fail.
- Debris-laden flood waters and debris flows threaten anyone in or near streams and rivers within and downstream of the burned area.
- The threat of damage from flooding and debris flows extends to in-channel structures such as culverts, bridges, and diversions, as well as any structures or improvements located on existing debris fans, runout zones, and other flood-prone areas. Areas of concern include the communities of Mount Baldy and Wrightwood, permitted developments on NFS land (recreation residences, organizational camps, ski areas, and others), and state and county roads.
- Rockfall and hillslope instability on steeper slopes throughout the burned area are threats to life and safety as well as infrastructure.
- Debris-laden floodwaters and debris flows threaten critical habitat for the ESA-listed mountain yellow legged frog and Santa Ana sucker.

Recommended Treatments on National Forest Lands

- Roads - stabilization and drainage improvement
- Hazardous Materials – containment and stabilization
- Trails – stabilization and drainage improvement
- Weeds – Early detection/Rapid Response Suppression and Burn Related
- Safety - Signs and Barriers
- Continued Interagency Coordination

Capacity and Collaboration

This BAER assessment was a coordinated, shared response, including close coordination with the California Watershed Emergency Response Team (WERT) and Los Angeles and San Bernardino Public Works. The BAER team reached out to many non-Forest Service entities (e.g., USGS, CAL-OES, CalFire, NWS, NRCS, etc.) to ensure cross boundary coordination and information sharing during the BAER assessment. These partners can assist in establishing a post-fire assessment and response process.

Many non-forest entities, and partners have infrastructure in and adjacent to the fire area and are actively repairing damaged infrastructure and/or implementing mitigations to reduce post-fire runoff damage. The BAER team will continue to share results and findings with non-Forest entities so that they can develop appropriate response plans to properly inform public safety, protect/prepare infrastructure, and critical natural resources from anticipated post-fire watershed response events. These partners can assist in establishing a post-fire assessment and response process.

The BAER team has participated in Los Angeles County led interagency "Watershed Recovery Task Force" meetings. The Forest is a key partner in to prepare for winter runoff events. Currently, meetings are held weekly and will continue into the rainy season. The BAER Team participated in a virtual Mt. Baldy community meeting describing the BAER process and how post-fire evaluations are a coordinated response with main partners including the State WERT, County DPW, NWS and NRCS. The BAER Team also organized and attended an Interagency field trip in the Mt. Baldy neighborhood to discuss assessment and potential post-fire response again re-iterating the integrated approach to the assessment to provide the most comprehensive, cohesive product.

The Forest Service BAER team will continue to participate in interagency coordination efforts to assist in interpreting BAER information and prepare response plans. We also welcome further collaboration and learning through professional exchange including refining the model of the federal BAER team working with State WERT and county personnel during the assessment and response phases of post-fire recovery.

Picture 12. Interagency field day at Mount Baldy Visitor Center (USDA FS)

Monitoring

Monitoring burned area conditions and recovery can assist managers in planning for public safety as of watershed conditions recover. We recommend recurring evaluation of recovery over time in conjunction with monitoring of runoff response to rainstorms and snowmelt, especially after heavy rainstorms. Informal implementation and effectiveness monitoring is an important part of the BAER process with results linked back to refining processes and recommendations.

State of California (WERT) often completes more quantitative debris flow and flood flow monitoring in conjunction with other partners to gain furthering understanding of and refinement of debris flow and flood flow models.

References

Foltz, R.B., Robichaud, P. R., and Rhee, H. 2009. A synthesis of post-fire road treatments for BAER teams: methods, treatment effectiveness, and decision-making tools for rehabilitation. Gen. Tech. Rep RMRS-GTR-228 Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, 152 p.

Foltz, R.B., and Wagenbrenner, N.S. 2010. An evaluation of three wood shred blends for post-fire erosion control using indoor simulated rain events on small plots. Catena 80, 86-94.

Fortini, L.B., Kaiser, L.R., Perkins, K.S., Xue, L., and Wang, Y., 2023. Estimating the Impact of Climate and Vegetation Changes on Runoff Risk across the Hawaiian Landscape. Conservation 2023, 3 291-302. https://doi.org/10.3390/conservation3020020

Parsons, A., Robichaud, P., Lewis, S., Napper, C., Clark, J., and Jain, T. 2010 Field Guide for Mapping Post-Fire Soil Burn Severity. Gen. Tech. Rep. RMRS-GTR-243. Moscow, ID: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

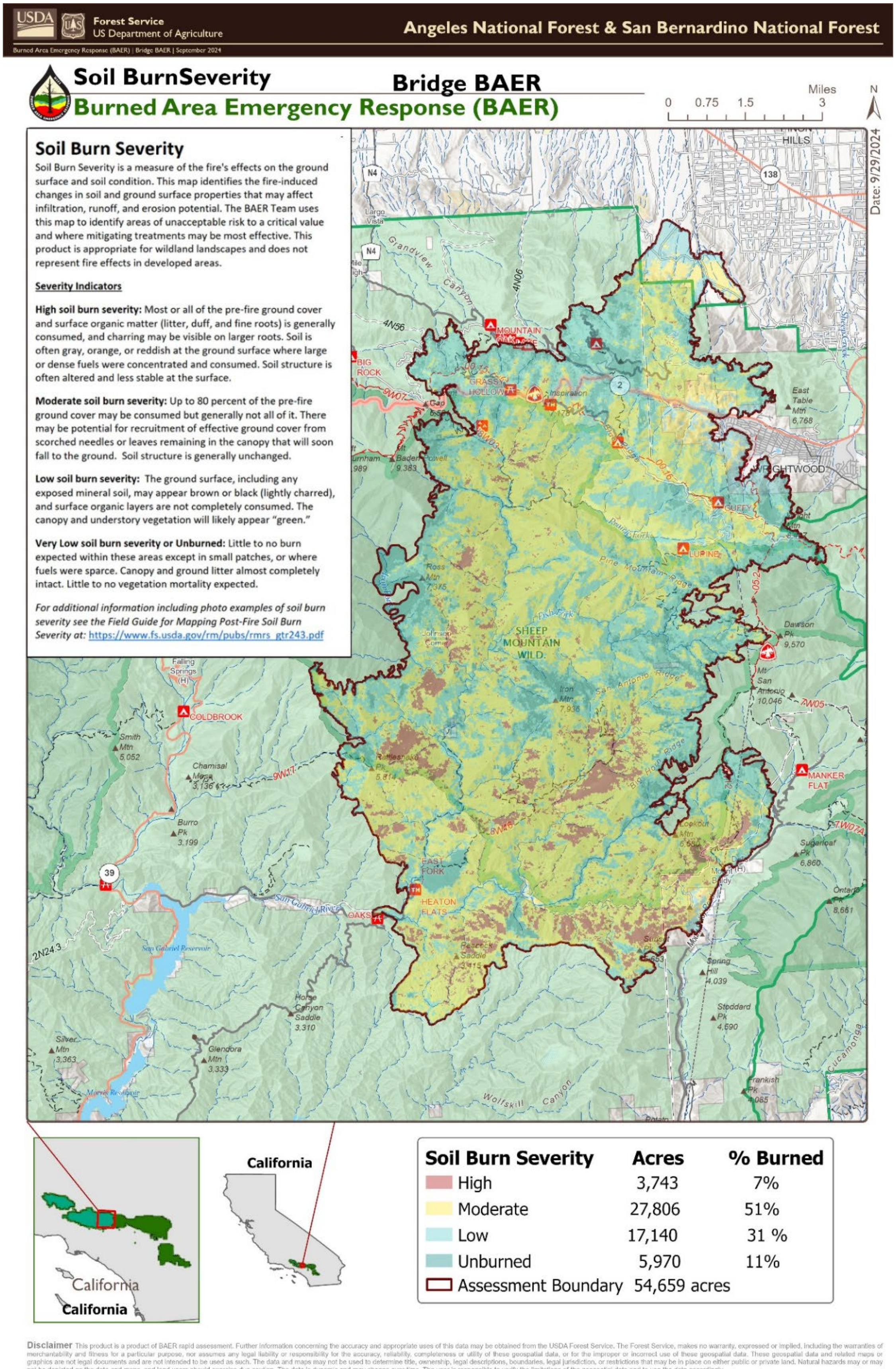
Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, Charles,2012, Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl.

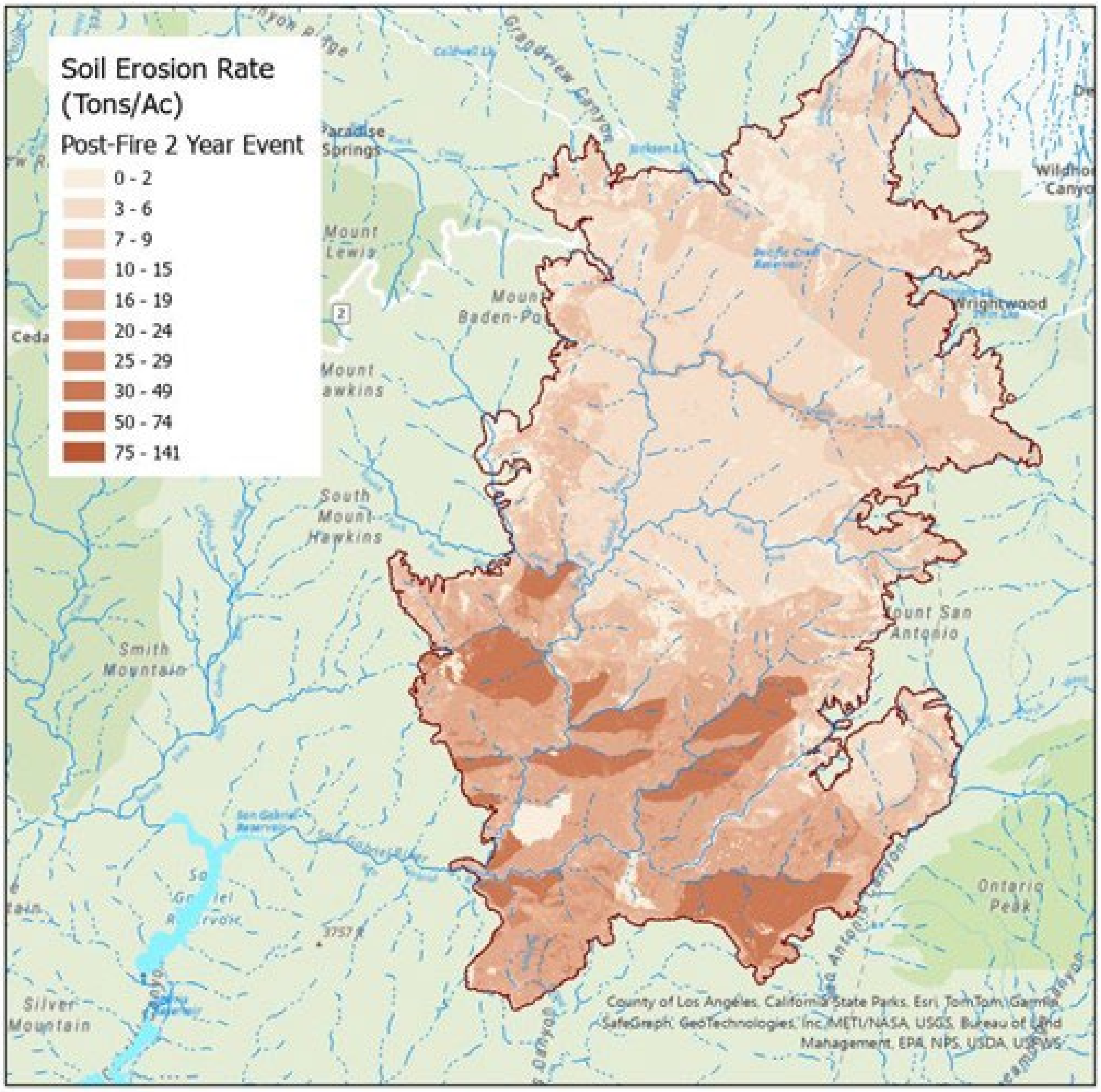
Robichaud, P. R., Ashmun, L.E., Foltz, R.B., Showers, C.G., and Groenier, J.S. 2013. Production and aerial application of wood shreds as a post-fire hillslope erosion mitigation treatment. General Technical Report RMRS-GTR-307, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

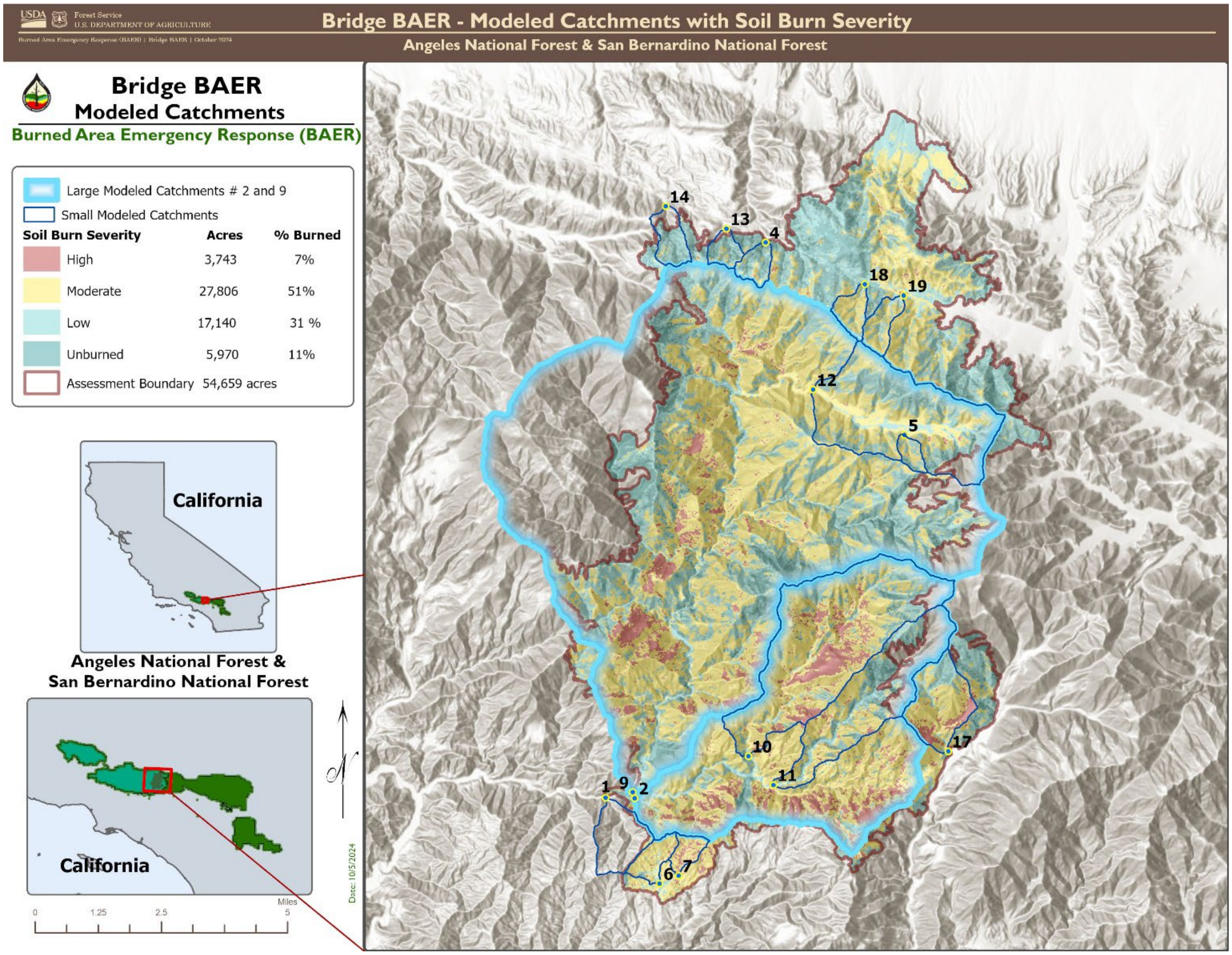
Robichaud, P.R., Elliot, W.J., Pierson, F.B., Hall, D.E., Moffet, C.A., and Ashmun, L.E. 2007. Erosion Risk Management Tool (ERMiT) user manual (version 2006.01.18). Gen. Tech. Rep. RMRS-GTR-188. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 24 pages. https://forest.moscowfsl.wsu.edu/fswepp/

United States Department of Agriculture, Soil Conservation Service, 1973. *Engineer Field Manual for Conservation Practices.* Chapter 2: Peak Rates of Discharge for Small Watersheds.

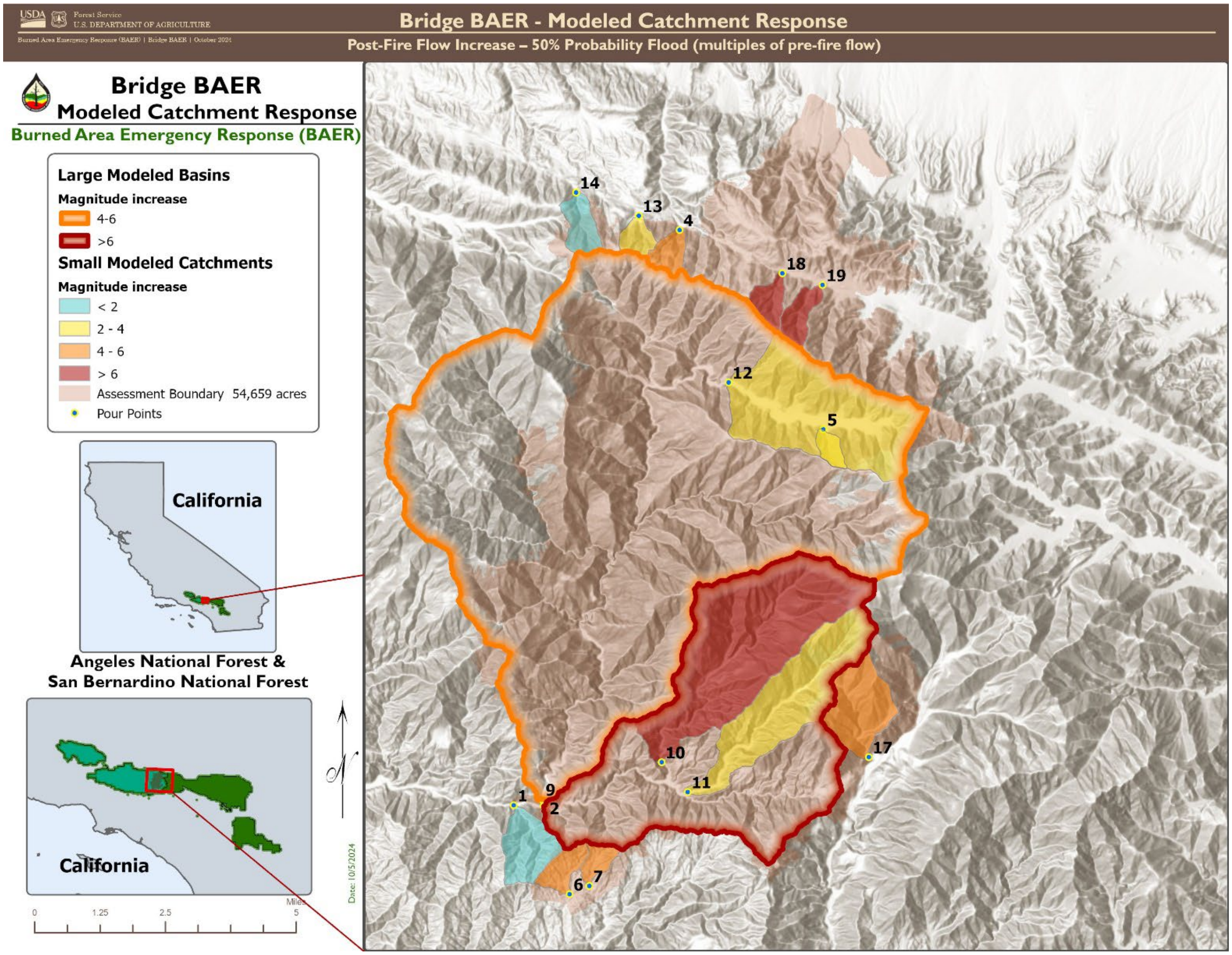
Appendix A. Bridge Fire BAER Map Products

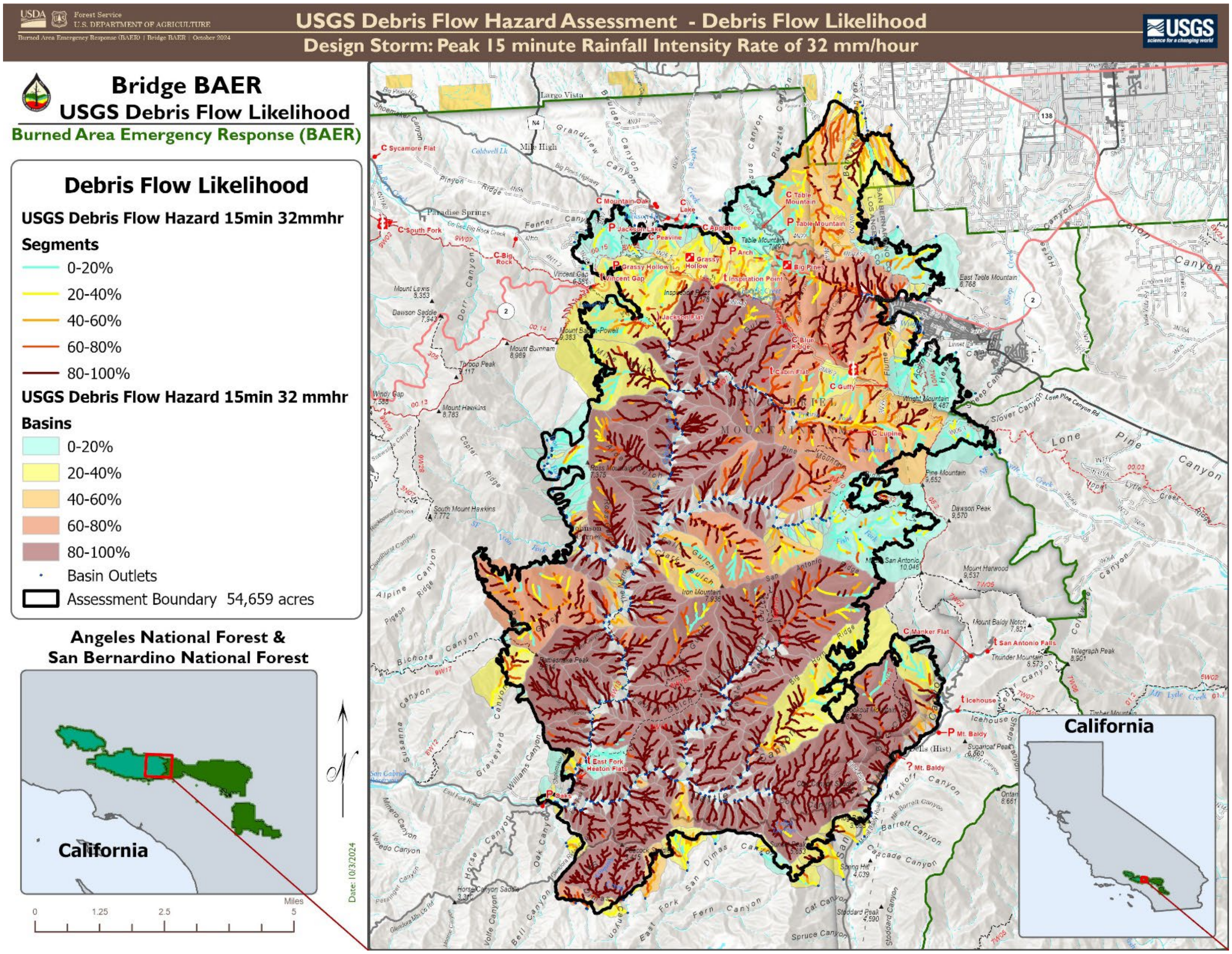



Soil Erosion Rate
(Tons/Ac)
Post-Fire 2 Year Event
0 - 2
3 - 6
7 - 9
10 - 15
16 - 19
20 - 24
25 - 29
30 - 49
50 - 74
75 - 141
Paradise Springs
Mount Lewis
Mount Baden-Powell
Mount Hawkins
South Mount Hawkins
Smith Mountain
Wrightwood
Mount San Antonio
Ontario Peak
Silver Mountain
San Gabriel Reservoir
Grandview Canyon
County of Los Angeles, California State Parks, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA, USFWS



Forest Service
U.S. DEPARTMENT OF AGRICULTURE
Bridge BAER - Modeled Catchments with Soil Burn Severity
Angeles National Forest & San Bernardino National Forest
Bridge BAER
Modeled Catchments
Burned Area Emergency Response (BAER)
Large Modeled Catchments # 2 and 9
Small Modeled Catchments
Soil Burn Severity
Acres
% Burned
High
3,743
7%
Moderate
27,806
51%
Low
17,140
31 %
Unburned
5,970
11%
Assessment Boundary 54,659 acres
California
Angeles National Forest &
San Bernardino National Forest
California
Miles
0
1.25
2.5
5
14
13
4
18
19
12
5
10
11
17
1
9
2
6
7


USDA Forest Service U.S. DEPARTMENT OF AGRICULTURE
Bridge BAER - Modeled Catchment Response
Post-Fire Flow Increase – 50% Probability Flood (multiples of pre-fire flow)
Bridge BAER
Modeled Catchment Response
Burned Area Emergency Response (BAER)
Large Modeled Basins
Magnitude increase
4-6
>6
Small Modeled Catchments
Magnitude increase
< 2
2 - 4
4 - 6
> 6
Assessment Boundary 54,659 acres
Pour Points
California
Angeles National Forest &
San Bernardino National Forest
California
0 1.25 2.5 5 Miles
Date: 10/5/2024
14
13
4
18
19
12
5
10
11
17
1
9
2
6
7


USDA Forest Service U.S. DEPARTMENT OF AGRICULTURE
USGS Debris Flow Hazard Assessment - Debris Flow Likelihood
Design Storm: Peak 15 minute Rainfall Intensity Rate of 32 mm/hour
USGS
Bridge BAER
USGS Debris Flow Likelihood
Burned Area Emergency Response (BAER)
Debris Flow Likelihood
USGS Debris Flow Hazard 15min 32mmhr
Segments
0-20%
20-40%
40-60%
60-80%
80-100%
USGS Debris Flow Hazard 15min 32 mmhr
Basins
0-20%
20-40%
40-60%
60-80%
80-100%
Basin Outlets
Assessment Boundary 54,659 acres
Angeles National Forest &
San Bernardino National Forest
California
0
1.25
2.5
5
Miles
Date: 10/3/2024
California