Burned Area Emergency Response Assessment
Watershed Summary
Oak Fire, CA (CA-MMU-016149)

Mariposa County

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Objectives & Introduction

This report contains a summary of post-fire watershed responses that are expected after the Oak fire. Included here are modeled results of increased stream flows, surface erosion, and debris flow potential. Post-fire stream sedimentation and bulking is also addressed. USDA Forest Service Burned Area Emergency Response (BAER) teams use these data, paired with field observations of burned conditions to assess threats to critical values on Forest Service Land, although all products produced by the BAER Team provide data for the whole fire footprint (including lands on and off Federal lands). The purpose of this report is to compile the relevant modeling data and summarize the post-fire watershed responses that are possible for the entire Oak fire area.

The following are the primary duties and objectives of the Soil, Hydrology, and Geology Assessment.

- The "Soil" function on a BAER team is to determine the soil burn severity (SBS) caused by the fire and evaluate the resulting threat of increased post-fire erosion and sedimentation.
- The "Hydrology" function on a BAER team is to assess watershed changes caused by the fire, evaluate possible post-fire hydrologic threats, including post-fire flooding, slope instability, and bulking of flows from sediment and debris.
- The "Geology" function on a BAER team is to identify the geologic conditions and geomorphic processes that have helped shape and alter the watersheds and landscapes and assess the impacts from the fire on those conditions and processes that potentially could affect downstream critical values or values at risk (VAR's).

The Soils, Hydrology and Geology resource areas work together to develop a cohesive picture of post-fire watershed response. A range of storm event sizes and corresponding watershed responses are given by each resource area, but it should be noted that BAER is a rapid assessment. The data gathering and analysis occurred over approximately one week. Thus, these data should be used for informing relative risk within and downstream of the fire, but they may not be appropriate for predicting specific effects to property or resources downstream.

Resource Setting

General

The Oak Fire occurred on the west slope of the Central Sierra Nevada Mountain range. The physiography of the burned area is dominated generally by gentle to moderate slopes (0-40%) with some steeper slopes of 40+ percent. Relatively small areas of the fire occupy very steep slopes of 60+ percent and are mostly located in the northeast area of the fire, on the slopes above Skelton and Owl Creeks.

This region is characterized by dissected ridge lines and drainages. The major (HUC 14) drainages in the fire area include: Skelton Creek, Plumbar Creek, and Sweetwater Creek; all flowing north into the Merced River, and Snow Creek, and Jones Creek, both flowing south into the West Fork Chowchilla River, that eventually ends up in Eastman Lake. Elevations in the burned area range from about 2,500 feet above sea level (Where Snow Creeks flows out of the burn area) to 4,615 feet above sea level at Sweetwater Point.

Geology

Bedrock within the boundaries of the Oak Fire consists of four primary geological units:
Rhyolitic dikes unit - rhyolite (Trh); Bass Lake Tonalite pluton - tonalite (Kbl); Sullivan Creek phyllites terrane, Briceburg formation - phyllite (JTrsb); and Sullivan Creek metavolcanics terrane, Bullion Mountain formation – greenstone (JTrsbm). Three other geological units that are exposed in limited areas in the burn area include: An unnamed pluton - diorite (KJdg); Calaveras terrane, Hite Cove unit – limestone (Trhls); and Calaveras terrane - argillite (cmp).

Slope instability features such as recent pre-fire debris slides, rock-falls and surface erosion features are for the most case absent in the burned area, a fact which is related to the nature/properties of the geological units and parent materials in the burn area. Field observations showed that the majority of slopes and drainages in the burn area have large amounts of fine sediments but are lacking larger rocky materials. Relatively very few channels in the burn area have rocky materials stored ready to be mobilized by flooding events and debris flows. This means large landslides were not a primary force that shaped the current landscape of the Oak fire; instead, fluvial erosion processes have shaped the gentler valleys and ridges, forming a relatively smooth landscape, devoid of instability features.

Resource Condition Assessment

Soil Burn Severity

The Soil Burn Severity product is used as an input for all the methods presented in this report; it is thus the basis for determining the severity of post-fire watershed response. Combined, Moderate (45%) and High (21%) soil burn severity cover most of the fire. Burn severity percentages by ownership are shown in Table 1, and a map of burn severity is in Appendix Map 1. In this fire, from a distance the high and moderate burn severities look very similar. In all vegetation types burned at moderate SBS, there is little or no intact canopy, no live vegetation remaining, and no potential for needlecast to act as a ground cover; only 10% of the sampled locations (2 of 20 in moderate and high SBS) had any potential for effective needlecast. The high SBS differs from moderate by having deeper soil heating and consumption of roots, and a thicker, deeper hydrophobic layer. Finally, in the reburn areas, particularly in the Carstens fire, there is very deep soil heating and structure loss underneath burned logs that were laying on the surface before the Oak fire (Figure 1A). In contrast (as usual), low SBS will have good ground cover or needlecast potential, some live vegetation cover, and lower expected erosion and runoff response. Low SBS was mapped in all vegetation types but is most extensive in oak woodland with a grass understory, and in parts of the Ferguson fire reburn that did not have large accumulations of fuel buildup, or where fire behavior was minimal.

Table 1- Soil Burn Severity

Soil Burn Severity	NFS	BLM	Private	Total	Percent
Unburned	547	2	849	4,003	7
Low	1,763	13	3,503	8,800	27
Moderate	4,570	17	4,213	5,279	45
High	2,324	23	1,656	1,397	21
Total	9,204	55	10,221	19,480	100

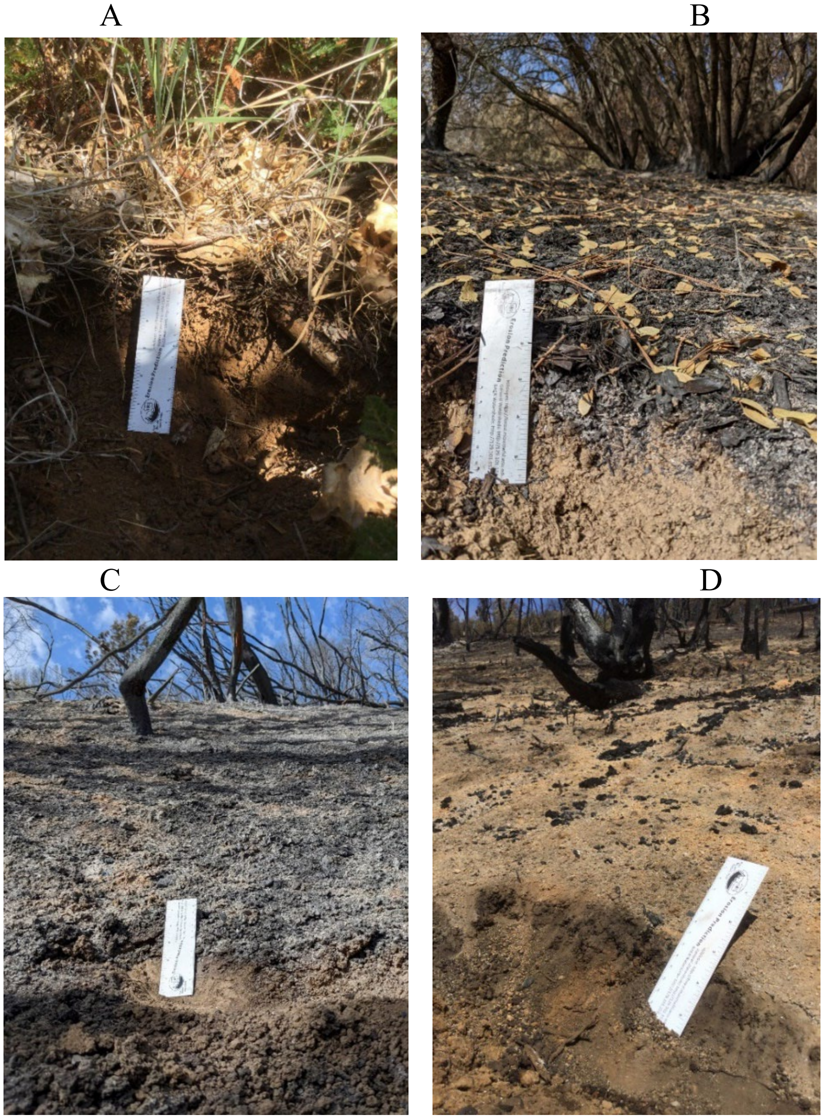
Figure 1- Reburn areas

A) Carstens reburn, deep soil heating under heavy surface woody debris loading, and **B)** Ferguson reburn area, with more widely spaced burned down logs, and no ground cover remaining.

A

B

Figure 2- Soil Burn Severity Examples
A) Unburned example, forest floor under oak canopy, **B)** Example Low soil burn severity showing partially intact litter layer, under oak, **C)** Moderate SBS, Oak, with 1cm thick ash layer, charred fine roots, and little ground cover, and **D)** High SBS example, Oak, with thicker ash layer, soil color change from heating, and destroyed structure.



Erosion Response

The Erosion Risk Management Tool (ERMiT) was used to model erosion and sediment potential within the entire fire perimeter. ERMiT is a storm-based erosion potential model and 2-year (50 percent probability) and 5-year (20 percent probability) runoff events were modeled. Pre fire erosion rates average less than 2 ton/acre across the fire area, but a few very steep hillslopes above Devil Gulch exceed 10 tons/acre pre-fire. The post-fire erosion rates for a 2-year storm event ranged from 1 to 43 tons per acre, and in a 5-year runoff event, erosion rates range from 1 to 90 tons/acre. Rates for 3 storm size events are compared pre and post fire in Table 3 below. These rates and ranges are typical given the varied terrain and burn conditions within the Oak fire. Most of the soils are not naturally highly erosive, but on steeper terrain where ground cover is lost, substantially elevated erosion rates are expected. Erosion rates are highest on the southwest-facing slopes below Buckingham Mountain, and above Devil Gulch and Skelton Creek in the NE corner of the fire. See the soils report for modeling assumptions used in ERMiT. The erosion rate maps in Appendix A (maps 2 and 3) can be used to show relative risk of erosion across the fire for different storm events.

Table 2- ERMiT Hillslope Erosion Potential, averaged fire-wide

	2-year Runoff Event (tons/acre)	5-year Runoff Event (tons/acre)	10-year Runoff Event (tons/acre)
Burned (Post-fire)	7.7	16.3	22.2
Unburned (Pre-fire)	1.9	5.4	9.0

Water repellent soil was somewhat common in the Oak fire, but its distribution was highly variable. In high soil burn severity, it was present at all sampled locations, but the strength varied from weak to very strong. In moderate burn severity, water repellency was present at 2/3 of sampled locations, but was rarely strong or very thick. Generally, the hydrophobic layer was close to the surface in moderate and low (rarely found) burn severity, but in high burn severity it was often thick, and found deep in the profile, between 3 and 6 cm below the soil surface. Thus, hydrophobic soils are likely to have a substantial impact on erosion rates and sediment potential for drainages below high SBS, but its effect will be less pronounced in moderate burn severity.

Hydrologic Response

Hydrologic modeling for post-fire discharge was completed for burned watersheds for design storms of 2, 5, 10, 25-, 50-, 100- and 200-year peak flows (results for all design storms are available in the BAER hydrology report). Because increased watershed response conditions tend to occur during the first five years post-fire, the 2-year (Q2) and 5-year (Q5) peak flow events are of particular concern. Percent increases in Q2 are shown in Table 3 below, and additional detail and flow numbers are shown in Appendix Table A. Based on results of hydrologic modeling, the watersheds predicted to have the highest post fire watershed response (up to 200 to 300 and above percent flow increases) are within the Plumbar Creek, Snow Creek and Jones Creek watersheds and tributaries and high watershed response is likely. Post-fire runoff and sediment during storm events are likely to be substantial enough to create impacts to Forest Road and trail infrastructure. Forest roads and trails are the main critical values that increased watershed response will affect. Threats to Human Life and Safety on Forest lands are not as likely because of the lack of populated areas and infrastructure within the watersheds. Visitors on Forest roads and trails may encounter hazardous watershed conditions if present during large storm events or if present within drainages with high watershed response.

Table 3- Pourpoint Watersheds assessed in the Oak fire

Pour Point (PP) Watershed and Location	Post-Fire Q2 Percent Increase
Owl Creek @ Devils Gulch	38
Road 5s524 drainage crossing	64
Pegleg Creek below Fire Boundary	80
Skelton Creek @ Devils Gulch	148

Pour Point (PP) Watershed and Location	Post-Fire Q2 Percent Increase
Plumbar Creek @ Highway 140 Bridge	160
West Fork Chowchilla River @ Darrah Road Bridge	168
Sweetwater Creek @ Fire Boundary	184
Jones Creek @ Snow Creek confluence	209
Snow Creek Tributary @ Snow Creek Confluence	225
Snow Creek @ Triangle Road Bridge	251
Plumbar Creek @ Reservoir	282
Skelton Creek Tributary Basin	285
Unnamed Basin below Triangle Road Culvert	295
Upper Snow Creek Tributary	313
Plumbar Creek Tributary above Reservoir	350
Plumbar Creek @ Tributary to Plumbar Creek	689
Jones Creek @ Deer Creek Road culvert	786

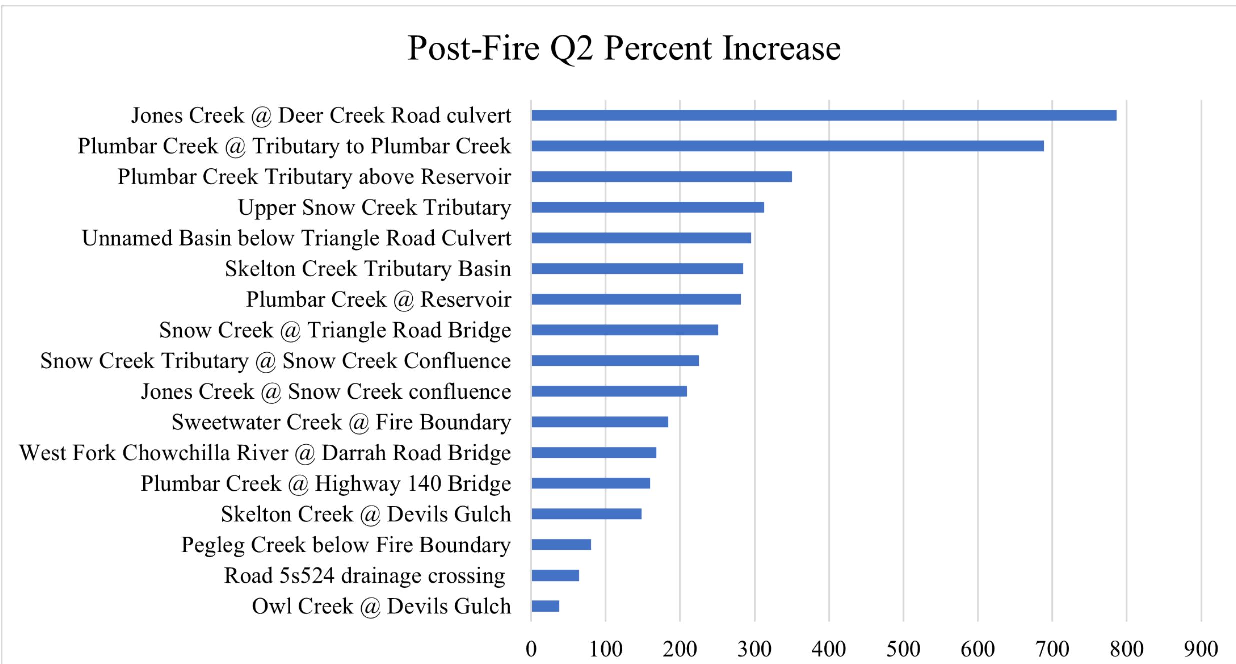


Figure 3- Modeled percent increase of a 2-year return interval peak flow (Q2, bulked)

Debris Flow Potential

Based on USGS debris flow modeling it appears that under conditions of a peak 15-minute rainfall intensity storm of 24 millimeters per hour (0.95 inches/hour), quite a few channels in the burn area present high probabilities (60-80% & 80-100%) of initiation of debris flows. The majority of these channels are located at the headwaters of Plumbar Creek, Jones Creek, channels flowing to the south and west of Buckingham Mountain, and some channels flowing west of Footman Ridge.

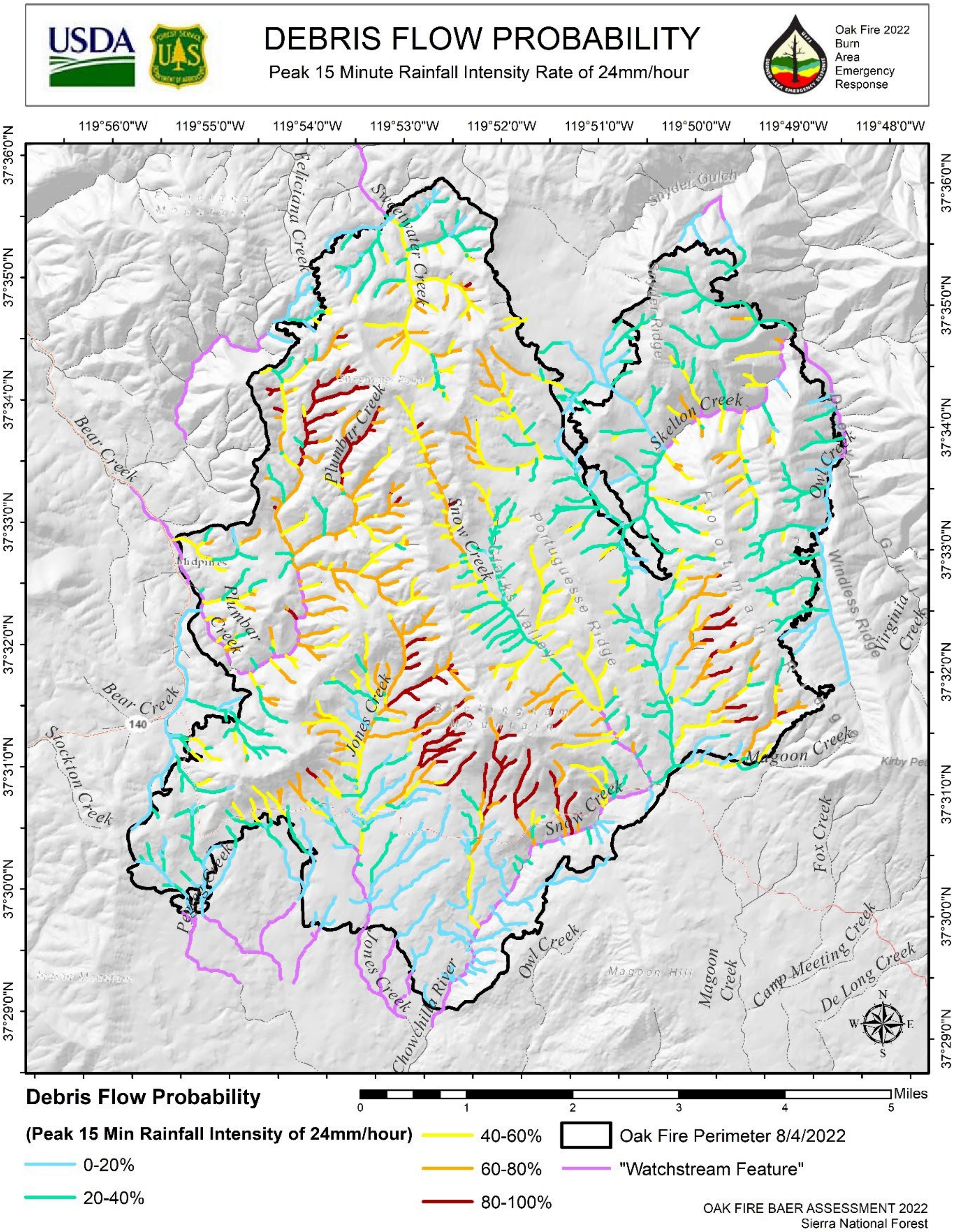
Based on the model, debris flows are likely in many of the drainages above Triangle Road south of Buckingham Mountain. Most of the assessed burn area requires rainfall rates less than 32 mm/h to exceed a 50% likelihood of debris-flow occurrence. High hazard areas require modest rainfall rates between 16 and 28 mm/h to exceed a 50% likelihood of debris flow occurrence.

Based on ground surveys and a flight recon, it is our opinion that even though the USGS debris flow model predicts a relatively high response of the burn landscape to initiations of post-fire debris flows, the widespread lack of surface rocky materials associated with the parent material / geological units in the burn area present limited conditions for true destructive post-fire debris flow events. Rather than post-fire debris flows, it is our view that the majority of the area impacted by the Oak Fire has high potential to initiate hyper-concentrated flows, sediment-laden flows and other flooding events. These types of flooding events can be extremely hazardous to life and safety and in addition can cause substantial damage to roads, trails, and other Critical Values, but lack the extreme destructive nature of post-fire debris flows.

These conditions leading potentially for the geological hazards described above will stay in affect till vegetation in the burned watersheds re-establishes itself, which depending on rain conditions, could take 2-5 years after the fire.

Methodologies
Each specialist report contains additional information about the models and methods used to derive the information above. These reports will be made available on request, after the BAER assessment process is complete.

Figure 4- Channel segment debris flow probability



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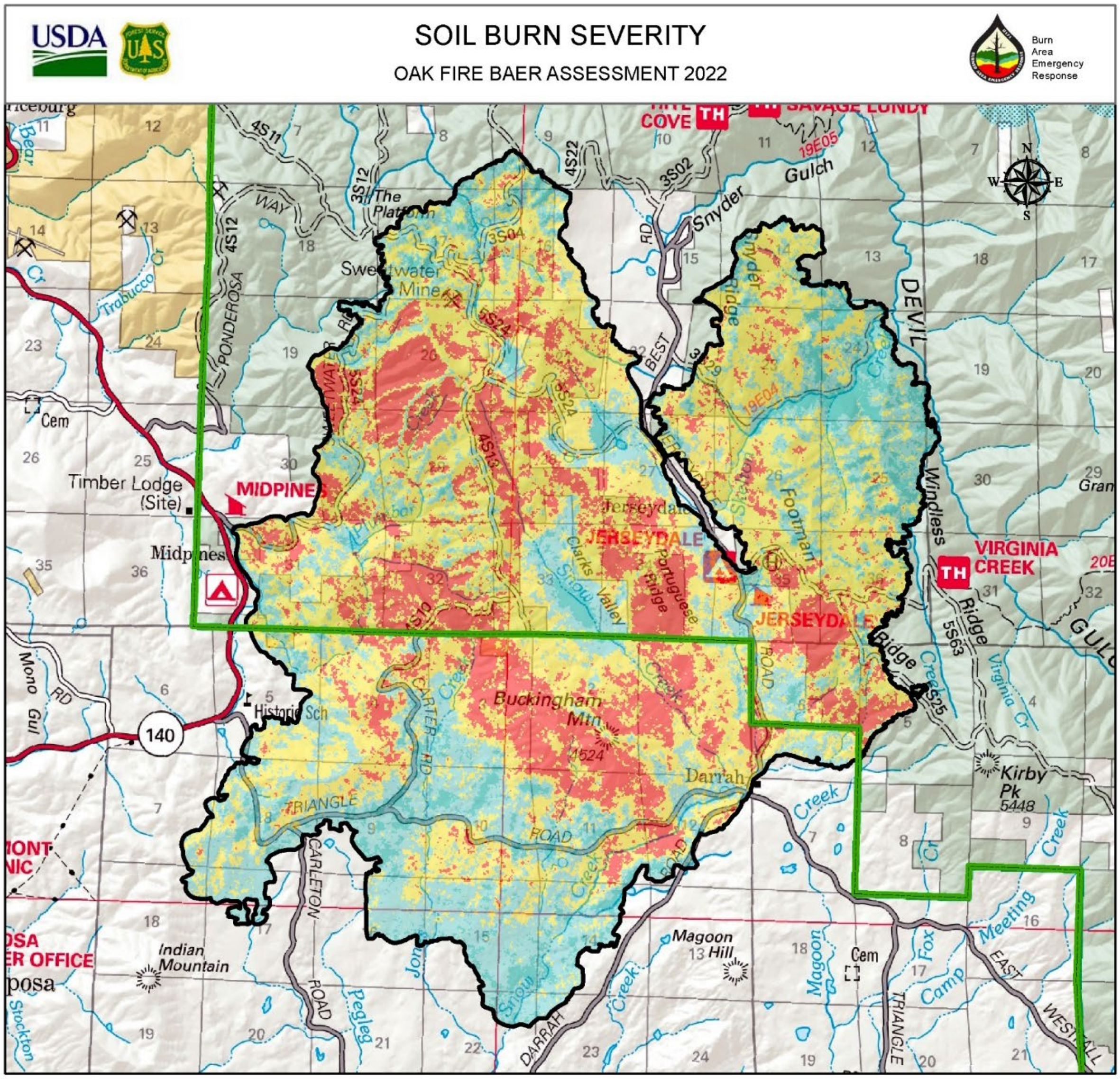
Staley D.M., Negri JA, Kean J.W., Laber JL, Tillery AC, Youberg AM (2017) Prediction ofspatially explicit rainfall intensity–duration thresholds for post-fire debris-flow generationin the Western United States. Geomorphology 278:149–162

<u>Appendix A</u>
Soil Information
<u>Map 1- Soil Burn Severity</u>



0	1	2	3	4	5	6	7	8	9 Miles

Oak Fire Soil Burn Severity :

Soil Burn Severity	%	Total Acres (Approx.)	Acres of Soil Burn Severity by Land Ownership		
			USDA Forest Service	Bureau of Land Management	Private
High	21	4,003.41	2,324.07	23.46	1,655.88
Moderate	45	8,800.17	4,569.92	17.05	4,213.19
Low	27	5,279.29	1,763.29	12.50	3,503.50
Unburned	7	1,397.42	546.97	1.83	848.62
Grand Total	100	*19,480.29	9,204.26	54.84	10,221.20

*Total size of fire is different than that reported by the Incident because the BAER assessment perimeter includes several unburned islands (totaling approx. 240 acres) within the perimeter of the fire.

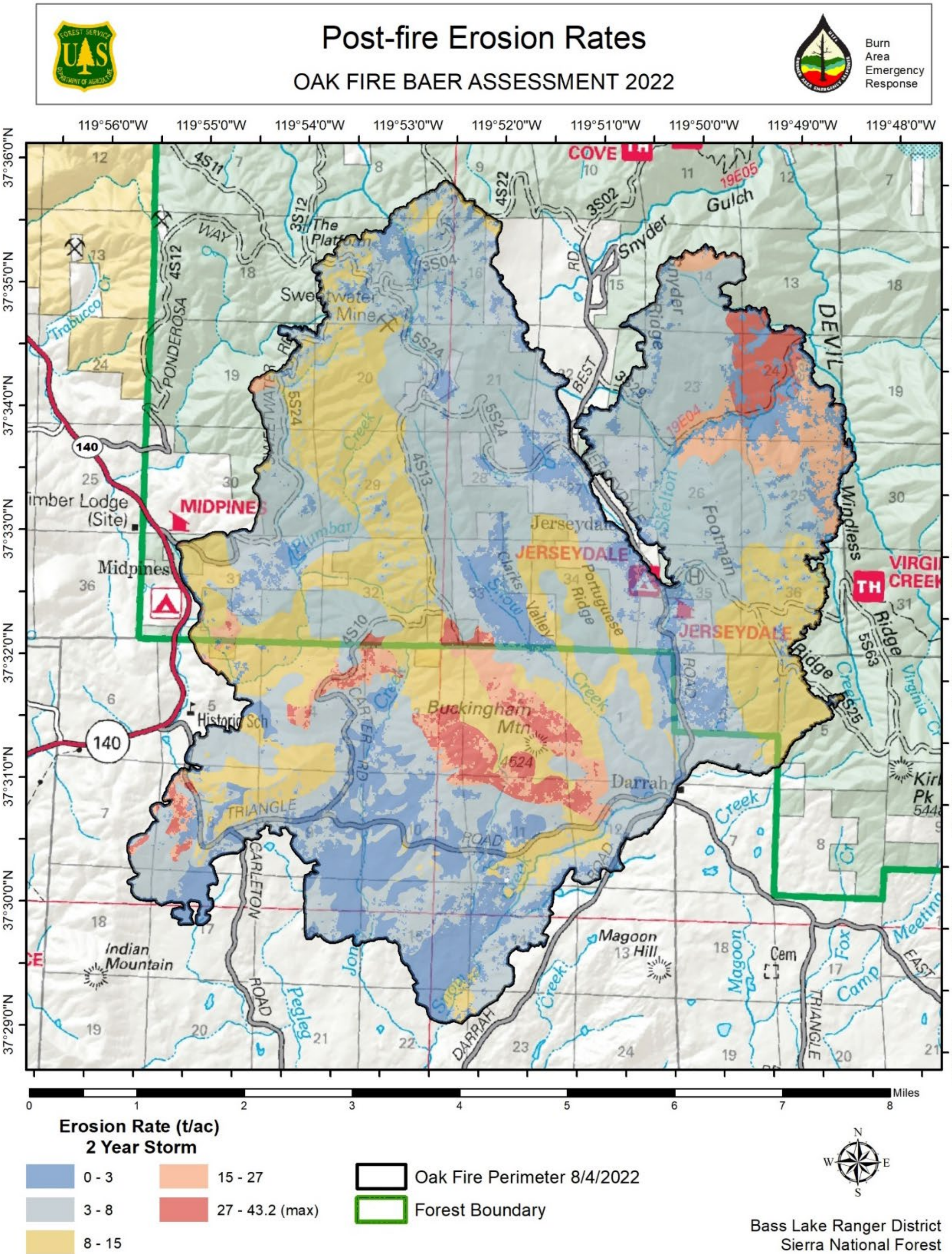
Bass Lake Ranger District, Sierra National Forest, Region 5

- Oak Fire Perimeter 8/4/2022
- Sierra National Forest Boundary
- Bureau of Land Management Land
- Private Land
- National Forest Land

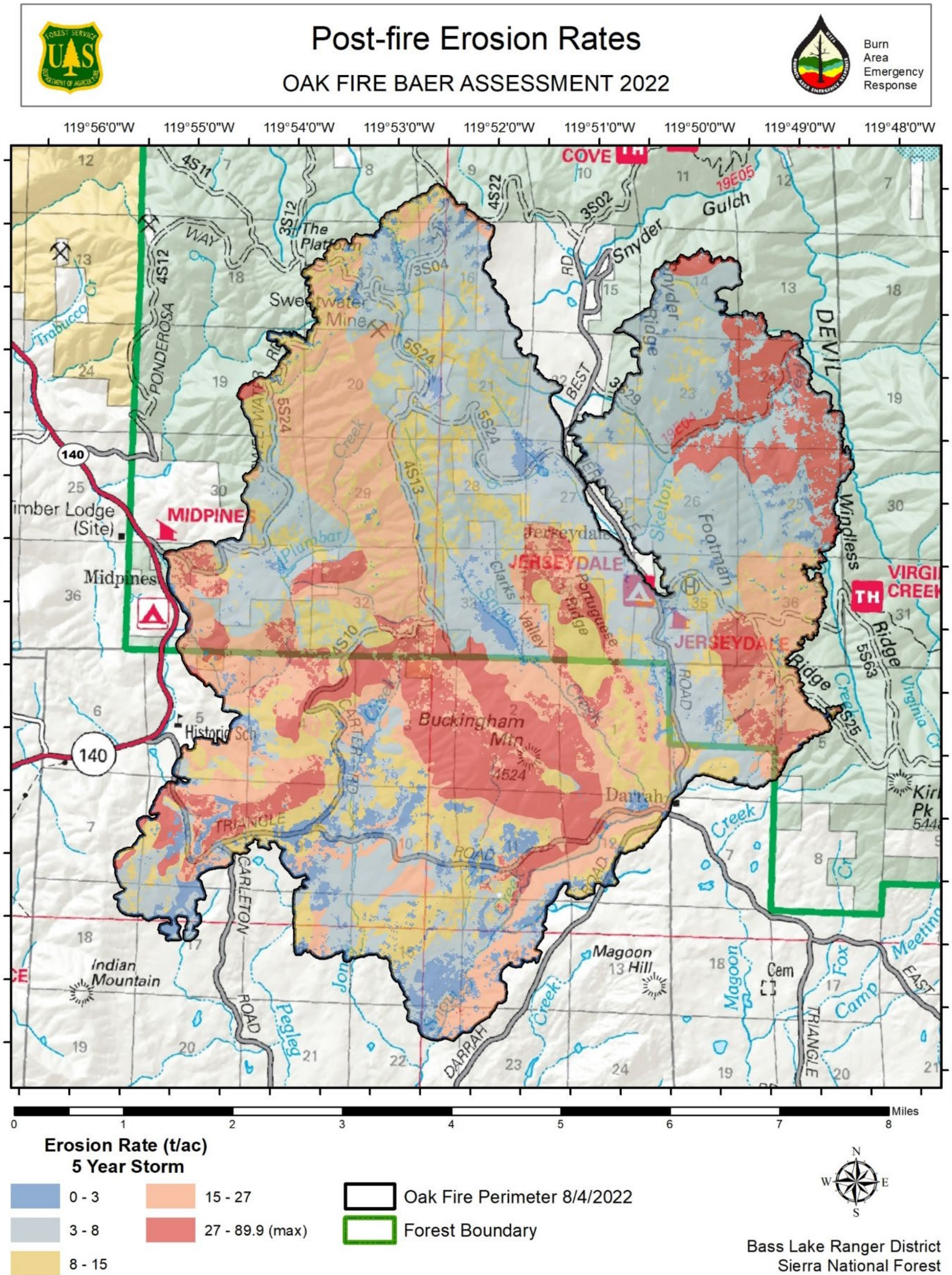
This map is a product of a Burned Area Emergency Response (BAER) Team rapid assessment. This product is reproduced from geospatial information prepared by the USDA Forest Service. Geospatial information and GIS product accuracy may vary. Using GIS products for purposes other than those for which they were created may yield inaccurate or misleading results. USDA Forest Service reserves the right to correct, update, modify or replace GIS products without notification. Oak Fire soil burn severity derived from 8/14/2022 Landsat 8

Maps 2 & 3 below show predicted erosion rates. The highest erosion rates are shown in red and tan colors, but note the erosion scale in the legend is different for the last category on the 2 maps (higher max erosion rate).

Map 2- Erosion from a 2-year runoff event



Map 3- Erosion from 5 year runoff event



Hydrology
Map 4- Pourpoint Watersheds

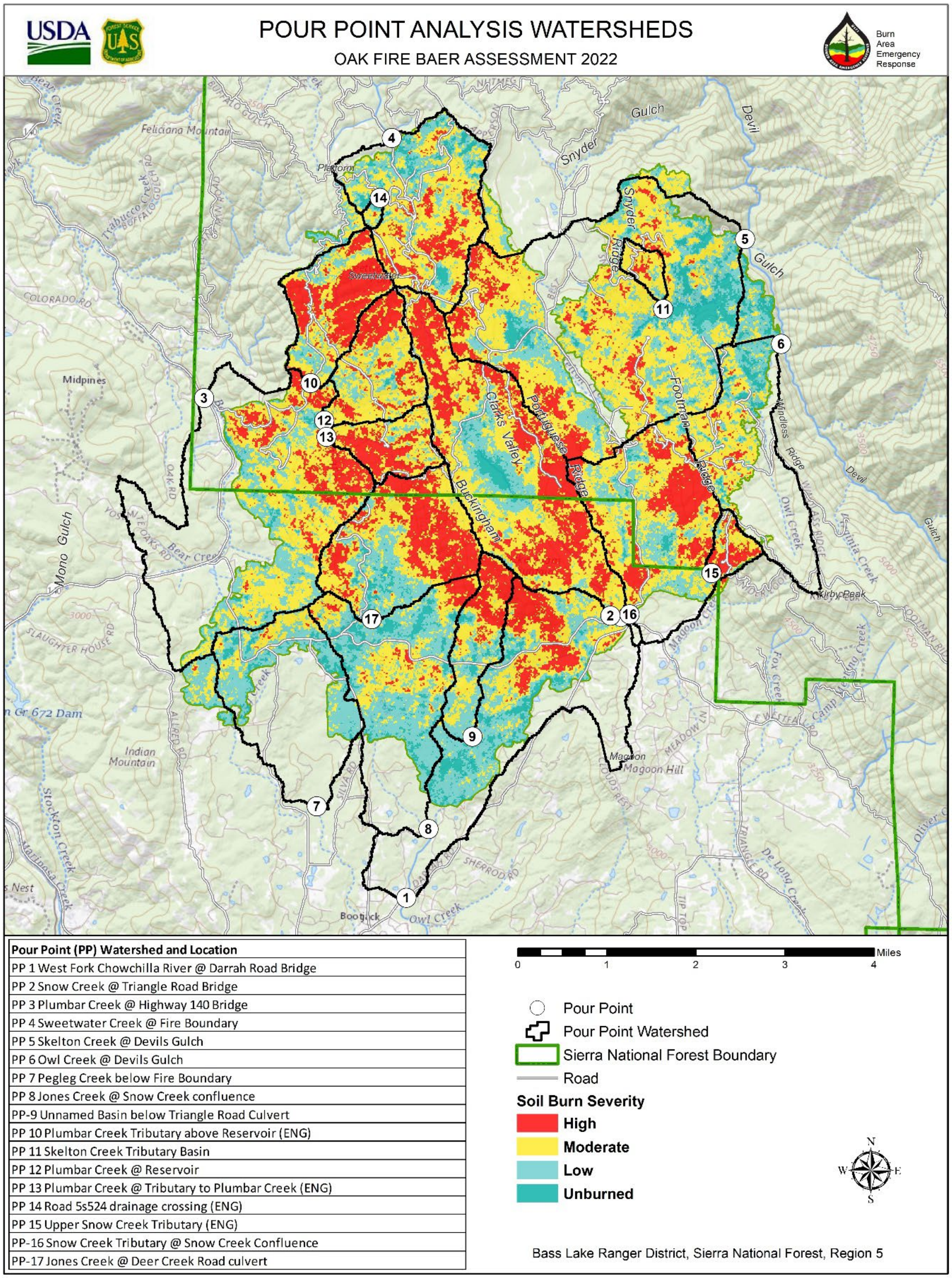
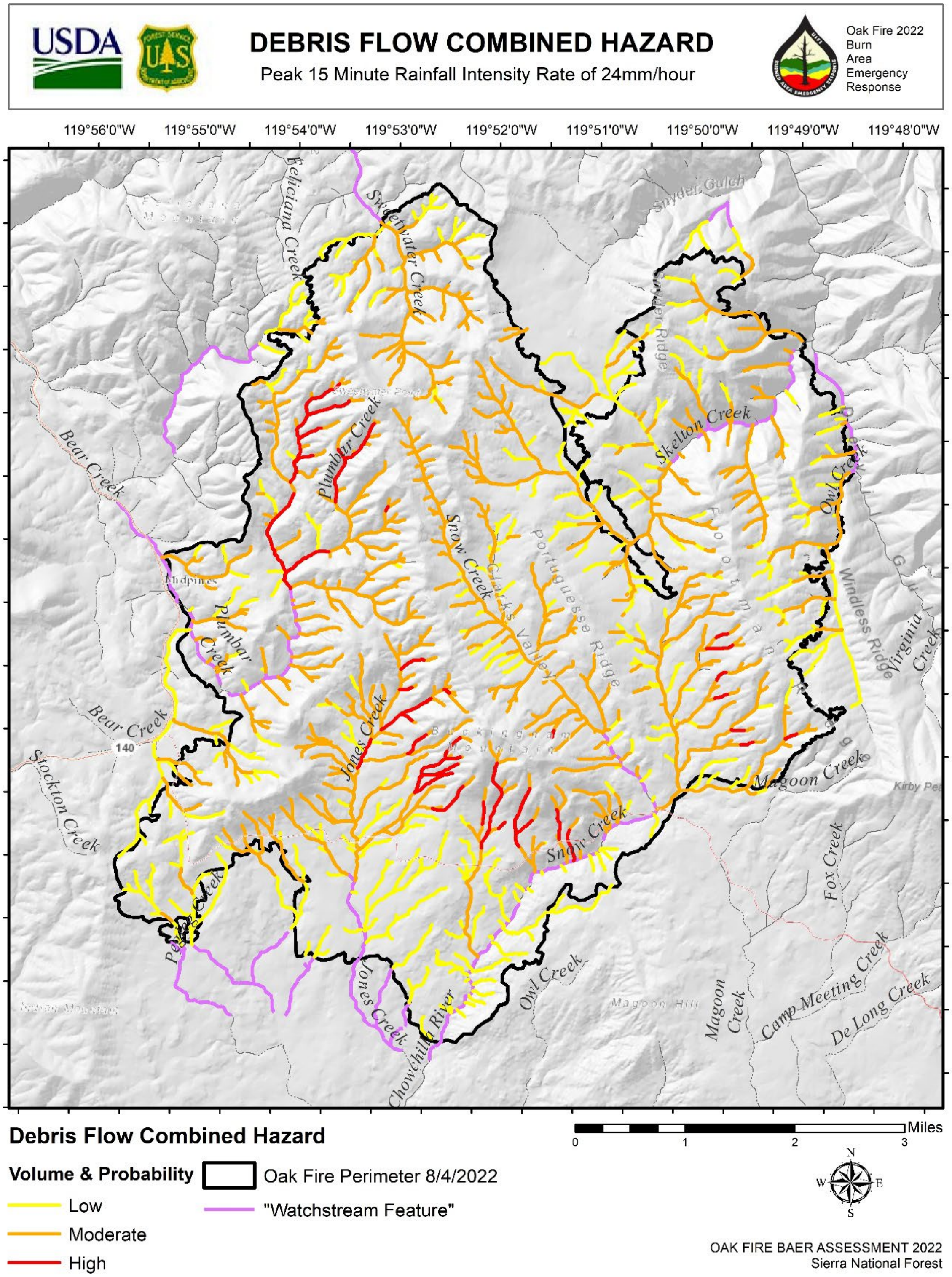


Table A- Hydrologic Model results
For a 2 Year Return Interval Peak Flow (Q2), and Peak Bulked Flows (Q2)

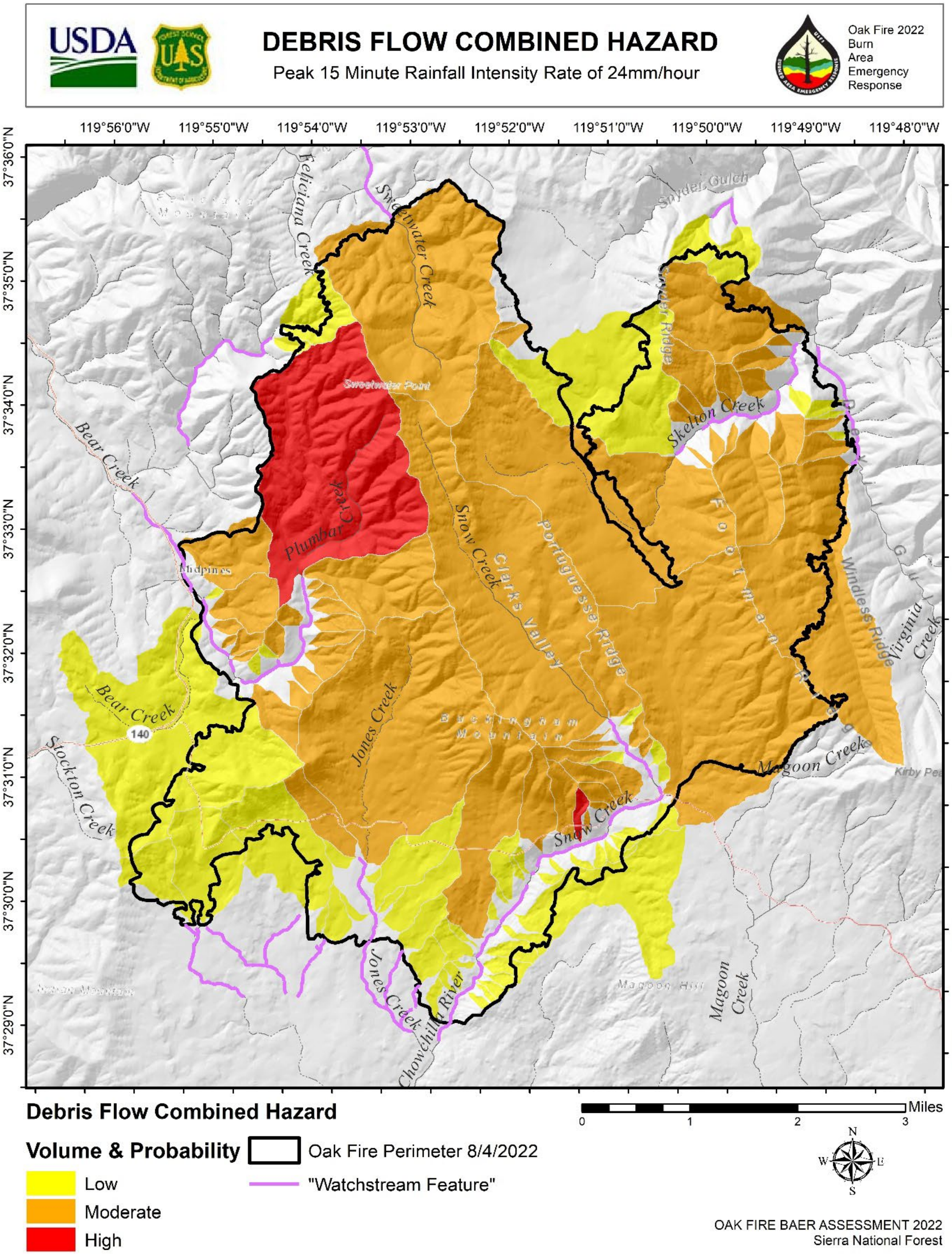
Pour Point (PP) Watershed and Location	Affected WS Area (mi2)	Pre-Fire Q2 Discharge in CFS	Post-Fire Q2 Discharge in CFS	Post-Fire Q2 Discharge in CFS (bulked)	Post-Fire Q2 Discharge (cfs/mi2)	Percent Increase Discharge (bulked)
PP 1 West Fork Chowchilla River @ Darrah Road Bridge	15.90	303	564	811	36	168
PP 2 Snow Creek @ Triangle Road Bridge	6.60	143	335	502	51	251
PP 3 Plumbar Creek @ Highway 140 Bridge	8.40	171	323	444	38	160
PP 4 Sweetwater Creek @ Fire Boundary	2.40	57	114	160	47	184
PP 5 Skelton Creek @ Devils Gulch	6.80	141	249	350	37	148
PP 6 Owl Creek @ Devils Gulch	2.1	45	45	62	22	38
PP 7 Pegleg Creek below Fire Boundary	2.40	48	64	87	27	80
PP 8 Jones Creek @ Snow Creek confluence	4.80	96	247	298	52	209
PP-9 Unnamed Basin below Triangle Road Culvert	0.90	20.5	68	81	75	295
PP 10 Plumbar Creek Tributary above Reservoir **(ENG)**	1.20	29	81.23	125	67	329
PP 11 Skelton Creek Tributary Basin	.20	5	13	20	66	285
PP 12 Plumbar Creek @ Reservoir	1.10	27	70	104	63	282
PP 13 Plumbar Creek @ Tributary to Plumbar Creek **(ENG)**	.70	18	87	140	124	689
PP 14 Road 5s524 drainage crossing **(ENG)**	.10	2.89	3.52	4.7	35	64
PP 15 Upper Snow Creek Tributary **(ENG)**	.30	8	22	34	73	313
PP-16 Snow Creek Tributary @ Snow Creek Confluence	2.9	68	149	221	51	225
PP-17 Jones Creek @ Deer Creek Road culvert	2.0	47	255	404	128	786

Geology

Map 5- Debris Flow Combined Hazard by stream segment



Map 6- Debris Flow Combined Hazard by basin



Map 7- Debris Flow Precipitation Threshold Triggers by basin