BURNED AREA EMERGENCY RESPONSE

MENDOCINO COMPLEX FIRE

WATERSHED MODELING REPORT

I. OBJECTIVES

- Identify and inventory values at risk.
- Identify potential threats to human life, property, and critical natural and cultural resources in relation to potential flooding, debris flows, erosion, and sediment deposition.
- Inspect hillslope conditions, channel morphology, and riparian conditions.
- Identify potential flood and erosion source areas as well as sediment deposition areas.
- Assess changes in soil and watershed conditions caused by the fire.
- Evaluate soil burn severity and watershed response in order to identify potential flood and erosion source areas as well as debris flow hazards.
- Determine needs for emergency stabilization and design treatment recommendations.

II. ISSUES

- Risk of habitat loss within the Lost Valley Meadow ACEC due to gulley erosion headcutting.
- Risk of erosion from and sediment transport to the 8-Mile Meadow Restoration Project.
- Risk of sediment transport to downstream T&E fisheries in the Russian River.
- Risk of increased sediment transport downstream to Clear Lake, a 303(d) list waterbody with a current nutrient TMDL.
- Risk to road infrastructure including roads, stream crossings.
- Risk to trail infrastructure.
- Risk to cultural sites.
- Risk of flooding and sediment delivery to areas and communities downstream of drainages which experienced moderate to severe soil burn severity.

III. OBSERVATIONS

A. Background

The purpose of the Burned Area Emergency Response Team watershed assessment is to determine if the 2018 River and Ranch Fires caused emergency watershed conditions and to determine if identified values at risk are likely to be affected by these conditions.

Identification of values at risk occurs through consultation with individuals, Tribal, state, and federal agencies as well as through field investigations. Values at risk include threats to life, property, and significant cultural and natural resources located within or downstream of the fire that may be subject to damage from flooding, debris flows, or hillslope erosion. If emergency watershed conditions are found to be present and values at risk are confirmed to be susceptible to post-wildfire impacts, then treatment specifications are developed to reduce the threat to the identified values at risk.

The most significant factor leading to emergency watershed conditions is loss of effective ground cover, which leads to erosion and changes in hydrologic function in the form of decreased infiltration, increased rates of soil erosion, and increased surface runoff. Such conditions lead to increased flooding, debris flows, sedimentation and further deterioration of soil conditions.

B. Field Reconnaissance Methodology

Field assessments of watershed conditions were conducted from August 16-19, 2018. Soil burn severity was evaluated following the protocol presented in the Field Guide for Mapping Post-Fire Soil Burn Severity (Parson et al., 2010) in order to analyze potential post-wildfire hydrologic effects. Specialists considered soil conditions on variety of landscape conditions such as varying slopes, aspects, pre-burn vegetation communities, and apparent soil burn severities. In validating/mapping soil burn severity the watershed team evaluated field-observable parameters such as the amount and condition of surface litter and duff remaining, ash color and depth, soil aggregate stability, amount and condition of fine and very fine roots remaining, and surface infiltration rate (water repellency). Soil water repellency was measured in situ utilizing the water drop penetration time (WDPT) test - a method considered one of the most indicative of the hydrological consequences of water repellency (Doerr, 1998; Leelamanie, Karube, and Yoshia, 2008). Field measurements of burn severity and soil water repellency were collected at multiple sites representing an array of field conditions including slope, aspect, and BARC classifications (i.e. unburned, low, moderate, and high severity).

C. Soil Burn Severity

Burned Area Reflectance Classification (BARC) is a satellite-derived data layer of post-fire vegetation condition. BARC data were acquired for the Mendocino Complex Fire. Data generated from field measurements are utilized to modify the BARC data as necessary to produce a map of soil burn severity.

The Mendocino Complex Fire occurred on US Bureau of Lands Management (BLM) lands, Bureau of Indian Affairs (BIA) lands, Forest Service lands, State of California lands, and private land. As of August 21, 2018, the total area within the Mendocino Complex Fire perimeter was 366,749 acres. The validated Soil Burn Severity map indicates 50,158 acres of unburned land, 77,736 acres of low burn severity, 227,416 acres of moderate burn severity, and 11,438 acres of high burn severity within the fire area (Table 1).

Table 1. Mendocino Complex River Fire as of August 21, 2018 – SBS by Class (All Lands).

	River Fire		**Ranch Fire**		**Mendocino Complex**	
Soil Burn Severity (SBS) Class	Area (Acres)	% of Area	Area (Acres)	% of Area	Area (Acres)	% of Area
High	3,771	8	7,668	2	11,438	3
Moderate	33,230	68	194,186	61	227,416	62
Low	8,577	18	69,160	22	77,736	21
Unburned	3,304	7	46,854	15	50,158	14
Total Area	48,881	--------	317,868	--------	366,749	--------

This assessment focuses on identifying values at risk and assessing lands managed by the BLM. As of the time of this assessment 60,062 acres of BLM lands were within the Mendocino Complex Fire perimeter (29,795 on River and 30,217 on Ranch; Figure 2). Table 2 presents a refined analysis of soil burn severity by class within the fire perimeter of the River Fire and the Ranch Fire, as well as the totals for the entire Mendocino Complex Fire.

Table 2. Mendocino Complex Fire as of August 21, 2018 – SBS by Class (BLM Lands)

	River Fire		Ranch Fire		Mendocino Complex	
Soil Burn Severity (SBS) Class	Area (Acres)	% of Area	Area (Acres)	% of Area	Area (Acres)	% of Area
High	3,311	11	314	1	3,645	6
Moderate	21,230	71	22,069	73	42,3299	72
Low	3,686	13	4,296	14	7,982	13
Unburned	1,548	5	3,538	12	5,086	9
Total Area	29,795	--------	30,217	--------	61,012	--------

Soil burn severity is an important factor in the post-fire hydrological response of individual watersheds within the fire. The watersheds of concern within the Mendocino Complex mostly experienced low to moderate soil burn severity. Table 3 illustrates the soil burn severity classes for the individual watersheds that were modeled with AGWA as discussed in the following section.

Table 3. Areas of soil burn severity by class for individual watersheds of concern. Unburned acres include watershed area outside of the fire perimeter.

Watershed	Watershed Acres	Soil Burn Severity	Area (acres)	Percent of Area in Classification
Morrison Creek	5,957	High	589	10 %
		Moderate	3,411	57 %
		Low	620	11 %
		Unburned	1,337	22 %
Scotts Creek	47,045	High	3,048	7 %
		Moderate	22,969	49 %
		Low	4,818	10 %
		Unburned	16,210	34 %
Wolf Creek	11,948	High	711	6 %
		Moderate	7,236	61 %
		Low	732	6 %
		Unburned	3,270	27 %

D. Hydrologic Modeling and Results

Watershed modeling is commonly used by BAER teams to estimate post-fire runoff response and to identify treatment locations and inform design of treatments designed to estimate risk to life, infrastructure, and natural and cultural resources.

Post-fire watershed response was calculated using the Automated Geospatial Watershed Assessment Tool (AGWA) – a GIS-based hydrologic modeling tool developed by the USDA-ARS Southwest Watershed Research Center and the U.S. EPA Office of Research and Development Landscape Ecology Branch. AGWA uses a Digital Elevation Model (DEM) to discretize the watershed and then intersects with soil, land-use/cover, and precipitation (uniform or distributed) to derive the requisite model input parameters (Goodrich et al., 2005). AGWA is designed to provide quantitative estimates of runoff and erosion changes as a result of landscape change. One limitation of the AGWA model is that the software is subject to the assumptions and limitations of its component models (Goodrich et al., 2005); therefore, detailed field observations were utilized to calibrate the model input parameters in order to maximize the accuracy of the predicted changes to runoff and erosion.

Three watersheds were chosen for watershed modeling efforts: Morrison Creek, Scotts Creek, and Wolf Creek. These watersheds were chosen due to their large contributing areas and the presence of identified downstream values-at-risk. Watersheds were modeled individually to more fully evaluate potential threats to the values-at-risk.

Watershed response was modeled for the three watersheds of concern by applying a 2-hour, 25-year recurrence interval storm that distributed a watershed-specific depth of precipitation uniformly over each watershed (Table 4 and Table 5). Design storms of 1, 2, and 3 hour durations were considered with recurrence intervals of 5, 10, and 25 years (annual exceedance probabilities of 20%, 10%, and 4%, respectively). Based on local precipitation data and input from watershed and modeling specialists, the 2-hour, 25-year storm was chosen as the design storm which would best represent a high-intensity storm with the potential to initiate hillslope overland flow and sediment delivery to downstream values-at-risk. This design storm was developed utilizing the procedures defined in NOAA ATLAS 14 Precipitation-Frequency Atlas of the Western United States - Volume 6 Version 2.3: California (Perica et al., 2014). This approach follows precedent from similar analyses of rainfall events and their effects on wildfire burn areas (Nickless, Boldt, and Neesvig, 2002).

Table 4. NOAA PDS-based point precipitation frequency estimates (90% CI) for Lakeport, CA (39.1011°, -123.0136°). Values represent high end of calculated range. The 2-hour 25-year storm event was used for modeling events from the Morrison Creek and Scotts Creek. Modeled value of 36.83mm (1.45 inches) shown in bold.

Scotts Creek and Morrison Creek Watersheds	5 Year Event Precipitation (mm)	10 Year Event Precipitation (mm)	25 Year Event Precipitation (mm)
1 Hour Event	17.88	20.98	25.40
2 Hour Event	26.92	30.99	**36.83**
3 Hour Event	38.61	44.96	54.86

Table 5. NOAA PDS-based point precipitation frequency estimates (90% CI) for Upper Lake, CA (39.1322°, -122.6270°). Values represent median of calculated range. The 2-hour 25-year storm event was used for modeling events from the Wolf Creek Watershed. Modeled value of 41.66mm (1.64 inches) shown in bold.

Wolf Creek Watershed	5 Year Event Precipitation (mm)	10 Year Event Precipitation (mm)	25 Year Event Precipitation (mm)
1 Hour Event	19.81	23.11	28.45
2 Hour Event	29.72	34.54	**41.66**
3 Hour Event	38.1	44.2	52.83

E. Hydrologic Modeling and Results

The AGWA tool was used to model post-fire watershed response to the design storm. Model outputs provide quantitative estimates of post-fire runoff and erosion increases as a result of temporary vegetation loss and reduced soil infiltration rates.

Model outputs provide data on calculated discharge increases for each individual stream reach within the modeled area as well as calculations of increase sediment yield from each individual hillslope plane within the burned area; however, for the purposes of assessing watershed-scale impacts from vegetation and soil changes due to the fires, results are presented here for values calculated at the outlet – or most downstream extent – of each watershed. Table 6 shows model results for the chosen design storms applied to the entire watershed areas.

Data from Morrison Creek (5,957 acres) show that strong discharge and sediment inputs are likely from the upper reaches of the watershed towards the ridgeline that carries the Mendo-Lake road. Slopes towards the lower extents of the watershed contribute less runoff and sediment, and as a result the predicted stormflow and sediment flow values at the watershed outlet are less severe than the local effects modeled towards the ridgelines. Model runs suggest that a 25-year storm event delivering 37mm (1.5 inches) of precipitation in two hours would result in a 74% increase in peak flows and a 240% increase in background sediment yield due to vegation cover and soil changes caused as a result of the fire (Table 6; Figure 3).

Scotts Creek, the largest of the three watersheds modeled (47,045 acres), drains the majority of the burned area within the River Fire. Areas with high soil burn severity towards the geographic center of the Scotts Creek drainage are predicted to be the highest source areas of increased runoff and sediment yield. Due to the large size of the watershed, combined with the large contributing areas of high runoff and sediment yield, modeled runoff increases are significantly higher from Scotts Creek than the other two modeled drainages; model results suggest 126% peak flow increases and a 690% increase above background sediment yield as a result of the first 25-year storm event of 37mm (1.5 inches) of precipitation at this location (Table 6; Figure 4).

Wolf Creek (11,948 acres) is located on the southeastern edge of the Ranch Fire. The areas of greatest surface runoff and sediment contributions are from the northeastern aspect hillslopes which were affected by the greatest magnitude of vegetation loss and soil burn severity. Model results suggest 36% peak flow increases in surface runoff and 167% increases above background sediment yield as a result of the 2-hour 25-year event which would deliver 42mm (1.6 inches) of precipitation uniformly over the watershed area (Table 6; Figure 5).

Table 6. Modeled results for peak flow and storm sediment increases for watersheds of concern.

	Morrison Creek		**Scotts Creek**		**Wolf Creek**	
	Peak Flow % Increase	Storm Sediment % Increase	Peak Flow % Increase	Storm Sediment % Increase	Peak Flow % Increase	Storm Sediment % Increase
% Change	74%	240%	126	690%	36%	167
Magnitude Change	2	3	2	8	1	3

F. Post-fire Watershed Conditions and Watershed Response

Generally, across the River and Ranch Fires, the following observations were made regarding watershed conditions:

- The majority of the lands (62%) within the fire perimeter were in the moderate soil burn severity class.
- Surface roughness (micro-depressions, rocks and rock fragments, unburned areas, unburned litter) are present and will help catch and detain rainfall – this will aid infiltration and mitigate potential increases in erosion and runoff.
- The primary watershed responses from the effects of the River and Ranch Fires are expected to include increased runoff and an initial flush of ash as a result of normal precipitation.
- Flooding and debris flows may be initiated by moderate and high intensity precipitation events.
- Gully and rill erosion may occur on steep slopes in drainages with moderate soil burn severity.
- High intensity precipitation events may initiate debris flows. Sediment deposition may occur where stream gradients flatten and/or at tributary mouths.
- Increases in storm runoff should be expected during the first several years after the fire.

Elevated soil erosion, sedimentation, runoff, and stream flows are expected to decrease rapidly after the first year and return to the natural hydrological watershed function within several years after the fire.

Vegetation recovery will contribute to the restoration of surface soil-hydrologic function and processes.

Data from assessments of field conditions as well as the results from this watershed modeling report were utilized by Burned Area Emergency Response team members to inform the need for, and design of, individual treatment specifications which will be implemented to reduce threats to human life and safety, as well as critical cultural and natural resources. Individual treatment specifications are included in the 2018 BLM Mendocino Complex Fire Emergency Stabilization and Burned Area Rehabilitation Plan.

IV. FIGURES

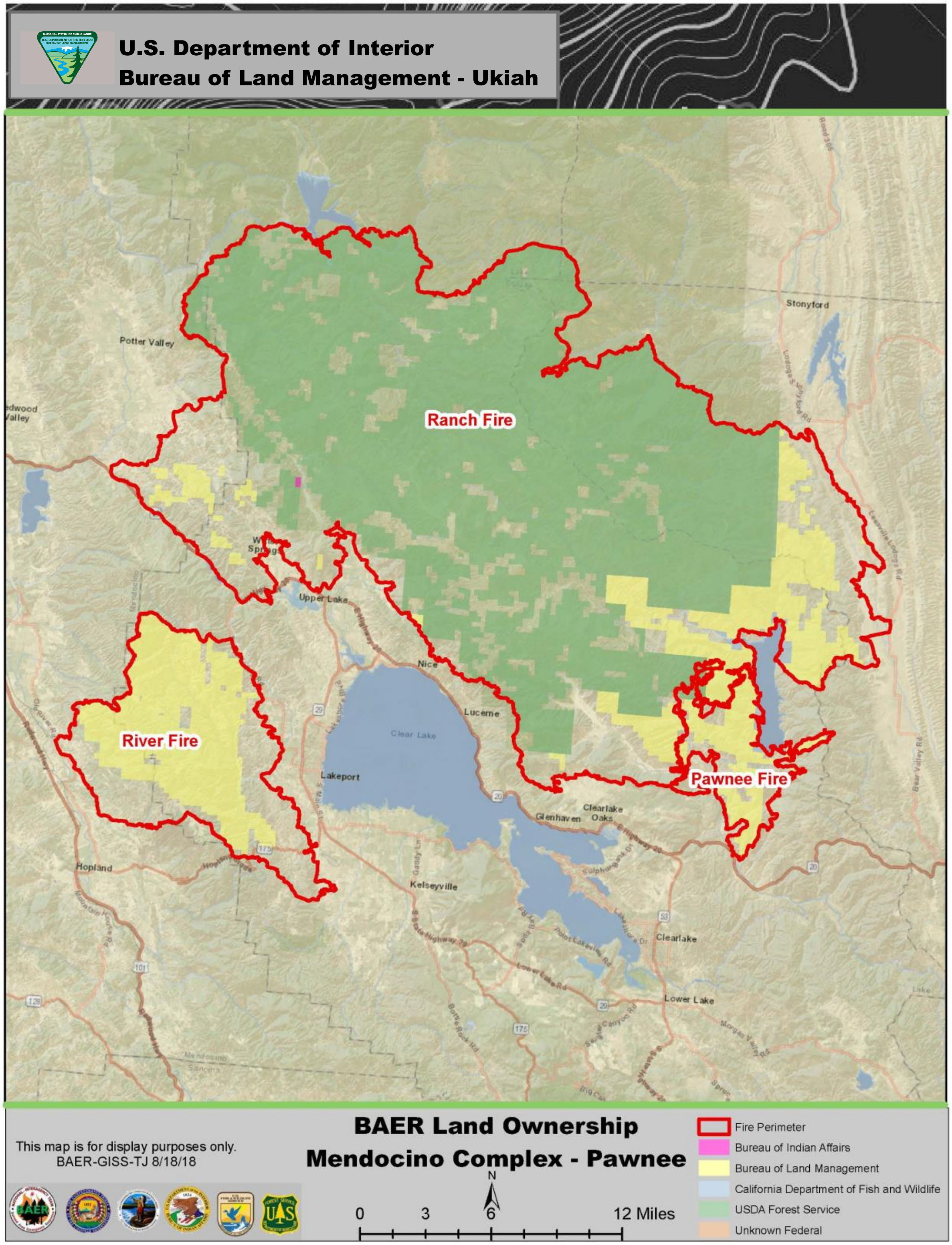

Figure 1. Map of land ownership within the fire perimeter for the Mendocino Complex and Pawnee Fires.

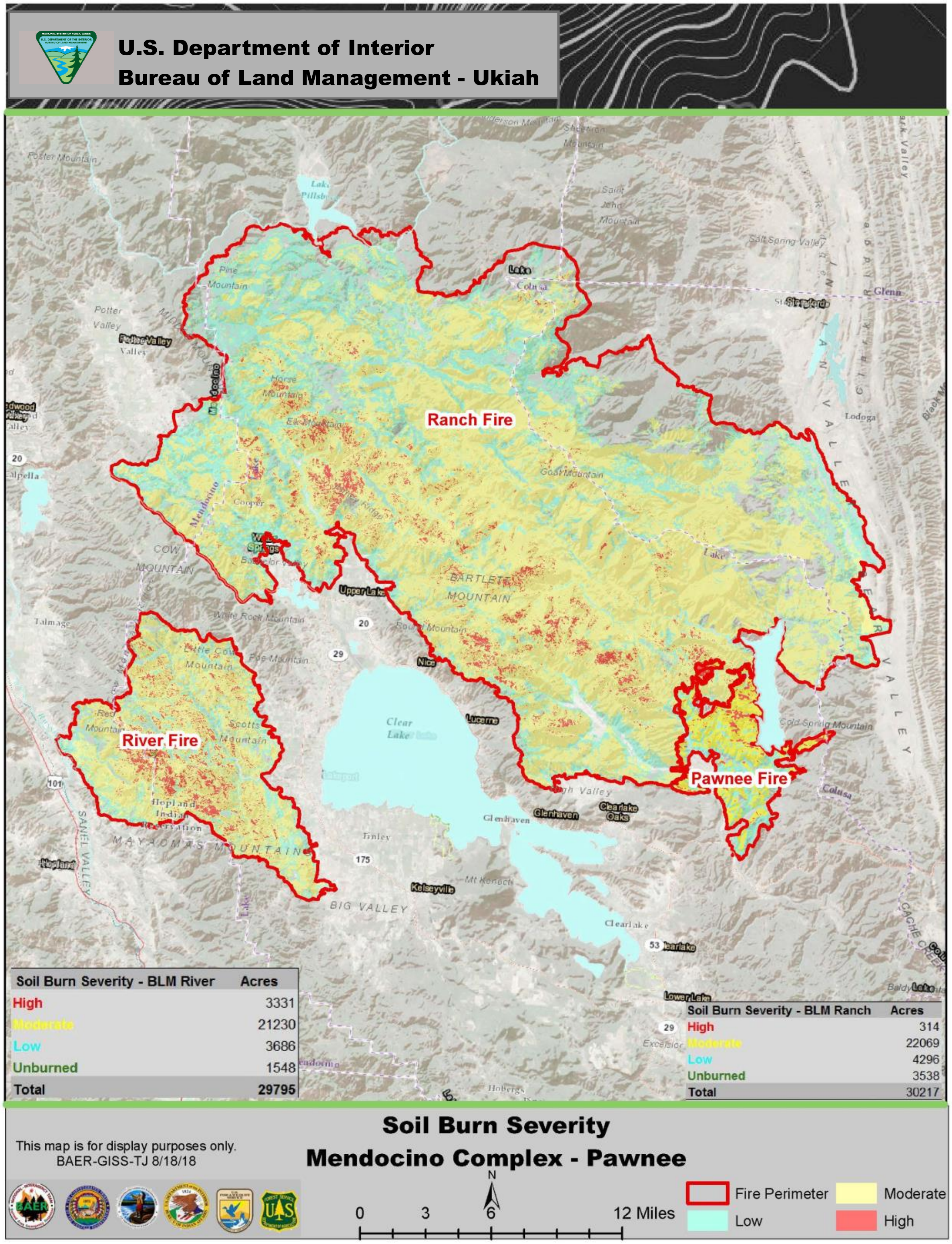

Figure 2. Soil Burn Severity Map for River, Ranch, and Pawnee Fires. Acres of BLM land included for River and Ranch Fires.

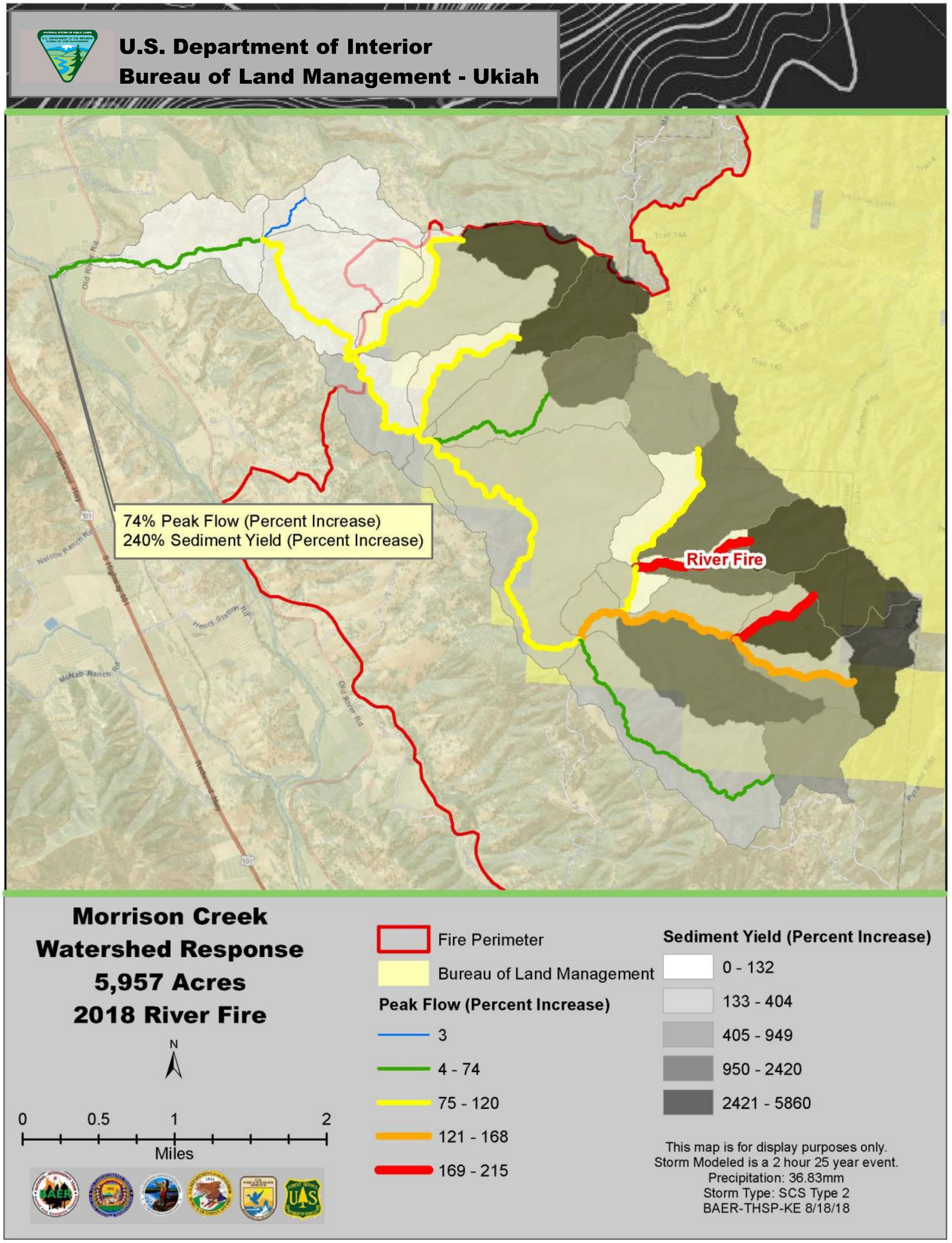

Figure 3. Map of Morrison Creek Watershed – Modeled watershed response to 25-year 2-hour 37mm (1.5 inch) storm event.

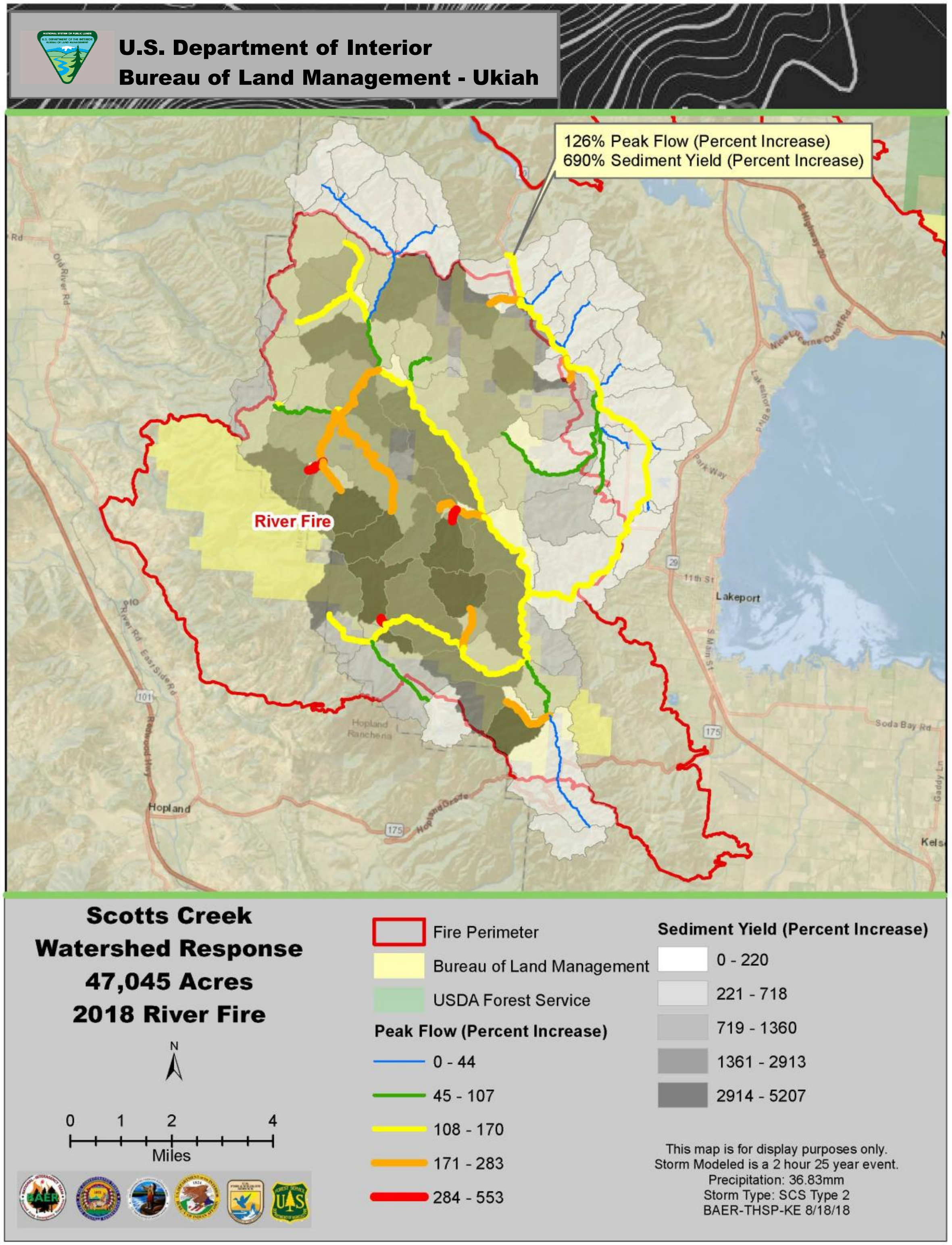

Figure 4. Map of Scotts Creek Watershed – Modeled watershed response to the 25-year 2-hour 37mm (1.5 inch) storm event.

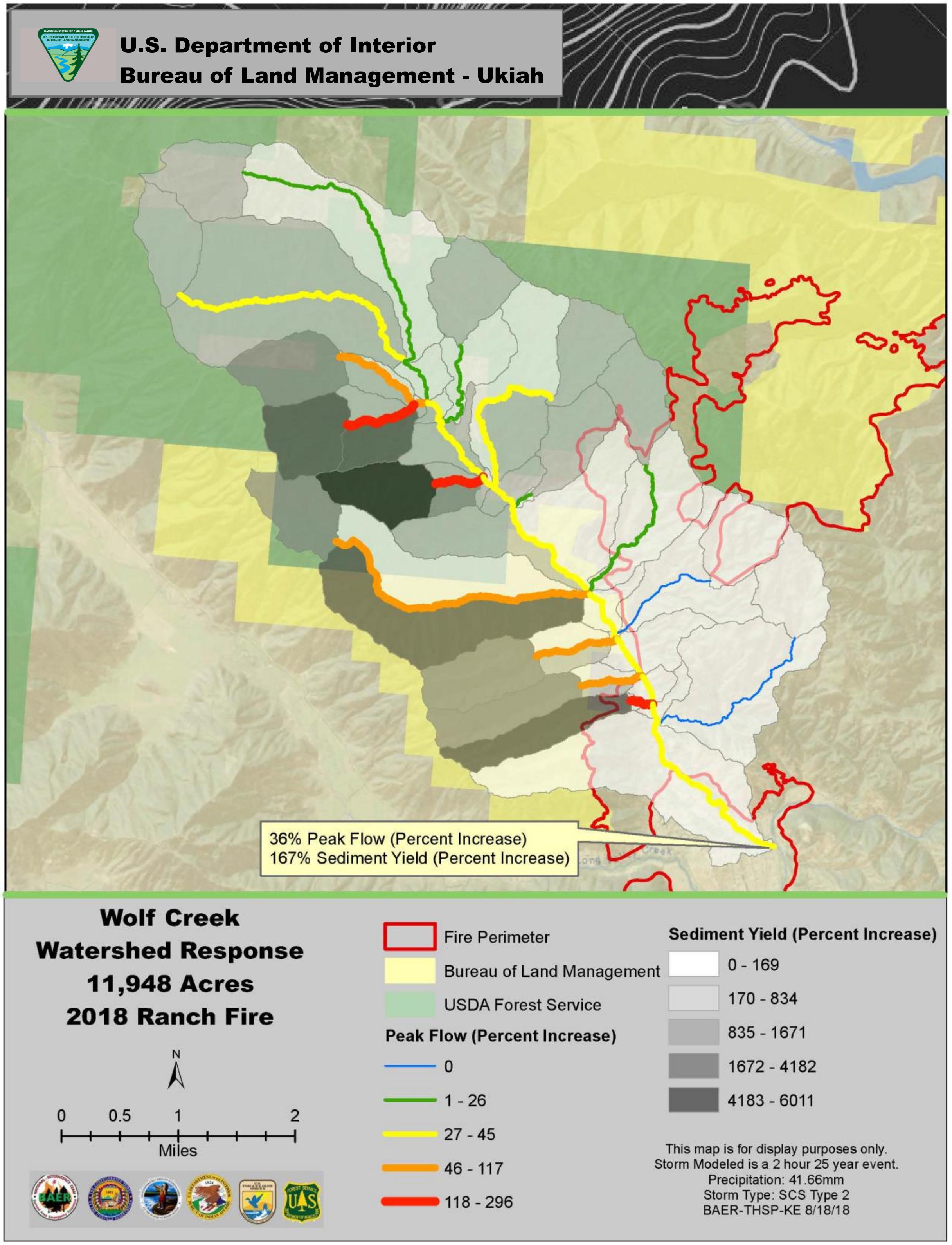

Figure 5. Map of Wolf Creek Watershed – Modeled watershed response to the 25-year 2-hour 42mm (1.6 inch) storm event.

V. REFERENCES

Doerr, S.H. 1998. On standardizing the ‘water drop penetration time’ and the ‘molarity of an ethanol droplet’ techniques to classify soil hydrophobicity: A case study using medium textured soils. Earth Surf. Processes Landforms, 23, 663– 668.

Nickless, R., Boldt, E., and Neesvig, C. 2002. Rainfall Events and Their Effect on Severely Burned Areas of Western Montana Following the Forest Fires of 2000. National Weather Service. Western Reg. Tech.

Leelamanie, D. A. L., Karube, J., and Yoshida, A. 2008. Characterizing water repellency indices: Contact angle and water drop penetration time of hydrophobized sand. Soil Science & Plant Nutrition, 54(2), 179-187.

Parson, A., Robichaud, P. R., Lewis, S. A., Napper, C., Clark, J. T. 2010. Field Guide for Mapping Post-Fire Soil Burn Severity. Gen. Tech. Rep. RMRS-GTR-243. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 49 p.

Perica, P., Dietz, S., Heim, S., Hiner, L., Maitaria, K., Martin, D., Pavlovic, S., Roy, I., Trypaluk, C., Unruh, D., Yan, F., Yekta, M., Zhao, T., Bonnin, G., Brewer, D., Chen., L, Parzybok, T., Yarchoan, J. 2014. NOAA Atlas 14 Volume 6, Version 2.3, *Precipitation-Frequency Atlas of the United States, California*. NOAA, National Weather Service, Silver Spring, MD.

Phillips, J.V. and Tadayon, S. 2006. Selection of Manning's roughness coefficient for natural and constructed vegetated and non-vegetated channels, and vegetation maintenance plan guidelines for vegetated channels in Central Arizona. US Department of the Interior, US Geological Survey.

Casey E. Ryan, Confederated Salish & Kootenai Tribes, Hydrologist Pablo, MT 406.531.7883