BAER Hydrology Report: Coffee Fire
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The purpose of this report is to provide hydrology input for planning and implementation of burn area emergency response (BAER) activities for the Coffee Fire. A rapid assessment approach was used for the collection of information and the preparation of the BAER report. In order to facilitate the preparation of the BAER report this document is limited to the following topics:

- Calculation of hydrologic design factors for Burned-Area Report (FS-2500-8) and pre-fire and post-fire modeling. The methods and rationale used to develop and calculate hydrologic design factors and other hydrology data needs for the FS-2500-8 are discussed.

- Summary of fire effects on discharge at pour points of interest. Potential treatments and the rationale for no treatments are discussed where applicable.

<u>Fire Location and Pour Point Watershed Characteristics</u>
The fire occurred on the Shasta-Trinity National Forest within both the North Fork Coffee Creek and Lower Coffee Creek HUC 6 Watersheds, and the Granite Creek, Lick Creek-North Fork Coffee Creek, East Fork Coffee Creek, and the Sugar Pine Creek-Coffee Creek HUC 7 subwatersheds (Figure 1). This area falls within the jurisdiction of the North Coast Regional Water Quality Control Board. The fire perimeter closely parallels both the North Fork Coffee Creek and East Fork Coffee Creek beginning at their confluence with Coffee Creek.

Pour points used for analysis were the confluence of both the North Fork and South Fork Coffee Creek with the main channel of Coffee Creek, Coffee Creek just above one of the bridges, Coffee Creek approximately 5 miles downstream of the fire adjacent to residences, and the entrance to two culverts (referred to as Kickapoo Falls Culvert and Culvert 2 in this report) along county road 104, which borders a section of the fire. Characteristics of the drainages, and the information necessary for discharge calculations for these pour points, were calculated using the USGS StreamStats program and are presented in Table 1.

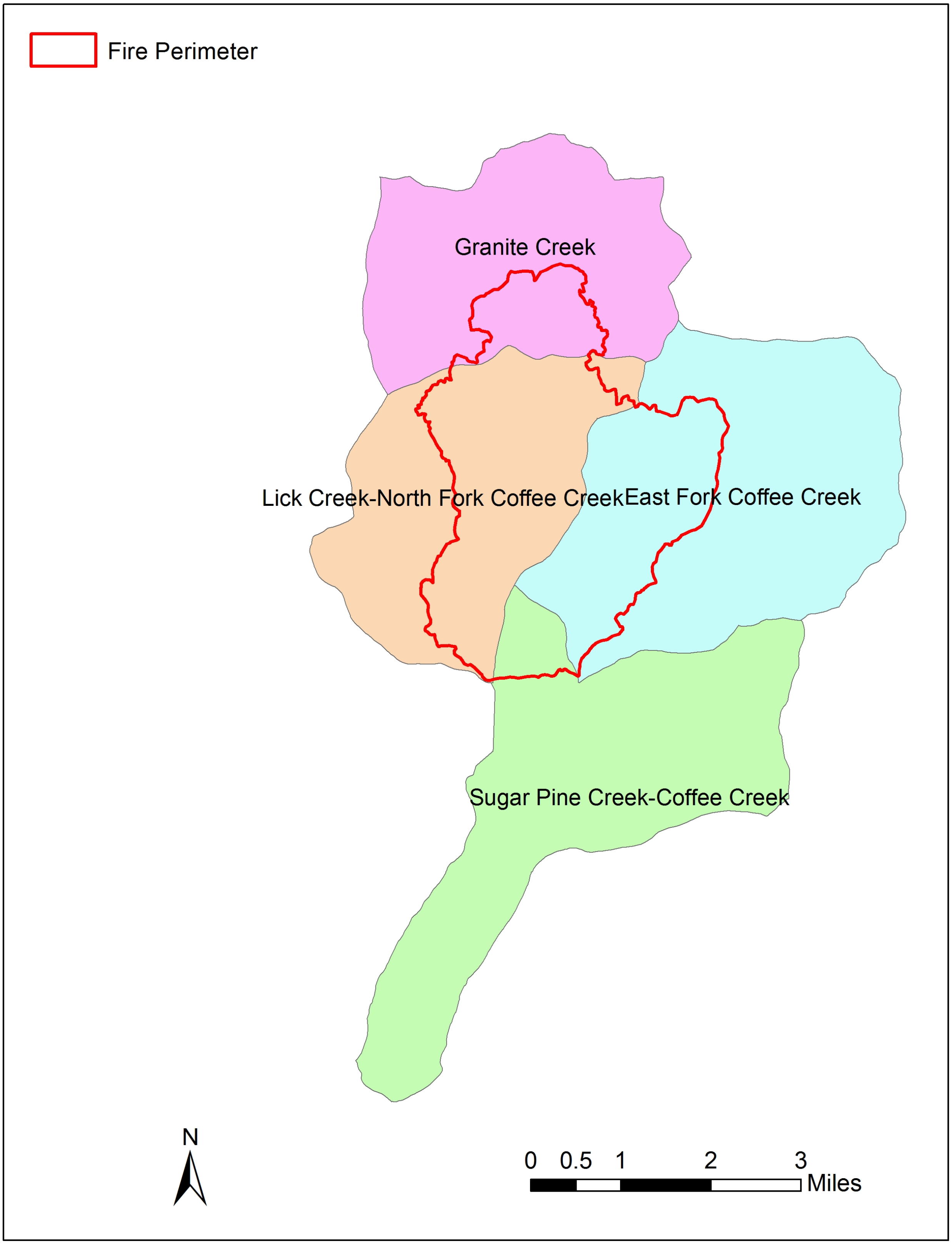

Figure 1. HUC7 subwatersheds impacted by the Coffee Fire.

Table 1. Watershed characteristics for pour points of interest.

Parameter	Coffee Creek (residences)	Coffee Creek (bridge)	North Fork Coffee Creek	East Fork Coffee Creek	Kickapoo Falls Culvert	Culvert 2
Drainage Area (miles^2)	82.7	70.6	24.4	11.2	0.2	0.1
Elevation Range (ft)	3182 - 8051	3344 - 8051	3581 - 7772	3329 - 7656	3467 - 5801	3563 - 6244
Altitude Index (ft)	4.9	4.93	5.0	4.8	3.79	4.13
Mean Annual Precip (in)	64.1	62.9	58.2	71.9	59.8	58.7
Mean Basin Slope (%)	41.6	41.8	40.8	39.7	50.9	54.9

Coffee Creek flows into the Upper Trinity River approximately 8 miles downstream of the fire perimeter. The beneficial uses of water, as defined in the Water Quality Plan for the North Coast Region of California (California, 2011), are presented in Table 2. Trinity Reservoir is approximately 2 miles downstream of the confluence of Coffee Creek with Upper Trinity River, and is currently on the 2010 303(d) list of impaired water with respect to elevated mercury levels (EPA, 2010). Two water rights for irrigation and stock watering are present in Coffee Creek approximately 1.5 and 5 miles downstream of the fire perimeter.

Table 2. Beneficial uses of water for the Upper Trinity River.

Beneficial Uses	Upper Trinity River
Municipal and Domestic Supply	E
Agricultural Supply	E
Industrial Service Supply	P
Industrial Process Supply	P
Groundwater Recharge	E
Freshwater Replenishment	E
Navigation	E
Hydropower Generation	P
Water Contact Recreation	E
Non-Contact Water Recreation	E
Commercial and Sport Fishing	E
Cold Freshwater Habitat	E
Wildlife Habitat	E
Rare, Threatened, or Endangered Species	E
Migration of Aquatic Organisms	E
Spawning, Reproduction, and/or Early Development	E
Aquaculture	E

E = Existing; P = Potential

Fisheries

The fishes of the general Coffee Creek area are represented by the 'Inland Coldwater Sportfish' assemblage as identified in the Shasta-Trinity National Forest Land and Resource Management Plan. Common rainbow trout are essentially an indicator species typical of that assemblage and are present within Coffee Creek. There are no ESA-listed anadromous fish that can access Coffee Creek or the portion of the Trinity River at the confluence. There are also no USFS Sensitive fish species that inhabit Coffee Creek. *This information was provided by Bill Brock, Fisheries and Aquatics Program Manager for the Shasta-Trinity National Forest.*

Fire Severity Assessment

The BAER team received a Burned Area Reflectance Classification (BARC) satellite imagery map of the Coffee Fire from the Remote Sensing Applications Center (RSAC) in Salt Lake City, Utah. The BAER Team adjusted the preliminary BARC map based on both on-the-ground and aerial reconnaissance from August 16-19, 2014 (see Soils Specialist Report for more detail), with a focus on at-risk resources and accompanying pour points, as identified by the BAER team. Soil burn severity across each HUC 7 subwatershed is presented in Table 3, and percentage soil burn severity at each pour point of interest is presented in Table 4.

Table 3. Soil burn severity for each HUC 7 subwatershed in which the fire occurred.

HUC 7	Total Acres	Severity	Acres Within Perimeter	Acres Outside Perimeter	Percentage of Total HUC
Granite Creek	4705.69	Very Low/Unburned	305	3967	91%
		Low	252		5%
		Moderate	144		3%
		High	38		1%
		Total	**738**		**100%**
Lick Creek/ North Fork Coffee Creek	5044.56	Very Low/Unburned	320	2123	48%
		Low	695		14%
		Moderate	1362		27%
		High	545		11%
		Total	**2922**		**100%**
East Fork Coffee Creek	7143.14	Very Low/Unburned	120	4971	71%
		Low	661		9%
		Moderate	840		12%
		High	551		8%
		Total	**2172**		**100%**
Sugar Pine Creek/ Coffee Creek	6426.81	Very Low/Unburned	17	6037	94%
		Low	111		2%
		Moderate	260		4%
		High	2		0%
		Total	**390**		**100%**

Table 4. Soil burn severity at watersheds for the pour points of interest.

		Soil Burn Severity Acres					
Watershed Pour Points	Total Acres	High	%	Moderate	%	Low/Unburned	%
Coffee Creek Residences	94139	1137	1.2	2607	2.8	90395	96.0
Coffee Creek	45205	586	1.3	1767	3.9	42852	94.8
North Fork Coffee Creek	15595	584	3.7	1510	9.7	13501	86.6
East Fork Coffee Creek	7153	551	7.7	841	11.8	5761	80.5
Kickapoo Falls Culvert	123	0.22	0.2	84	68.1	39	31.7
Culvert2	65	0.22	0.3	54	83.1	11	16.5

Potential Watershed Response

The potential watershed responses of the Coffee Fire are: 1) an initial flush of ash, 2) rill and gully erosion in drainages and on moderate and steep slopes within the burned area, 3) increased peak flows, and 4) sediment deposition in streams within and downstream of the fire. These responses are expected to be greatest within initial storm events. The likelihood of these disturbances occurring will decrease over time as vegetation is reestablished (which would provide ground cover and increase surface roughness) and soil hydrophobicity decreases (which would increase the infiltration capacity of the soils).

Design Storm and Discharge Equations

A 2-year, 6-hour design storm of 2.19 inches (range of 1.89 – 2.57 inches) was used for hydrologic analysis, which was calculated using the National Weather Service Precipitation Frequency Tool. Runoff-response regression equations developed by Waananen and Crippen (1977) for the California North Coast Region were used to determine pre-fire and post-fire runoff. The regression equations were developed from peak-discharge records from 5 to 85 years at more than 700 gaging stations throughout the state. To determine post-fire runoff associated with a 2-year, 6-hour design storm, area-weighted runoff response calculations used the 2-year recurrence discharge equation for unburned and low severity areas, the 5-year recurrance discharge calculation for moderate severity areas, and the 10-year recurrence discharge calculation for high severity areas (as discussed in Kaplan-Henry, 2007). The regression equations are as follows:

$$Q_2 = 3.52\ A^{0.90}\ P^{0.89}\ H^{-0.47}$$

$$Q_5 = 5.04\ A^{0.89}\ P^{0.91}\ H^{-0.35}$$

$$Q_{10} = 6.21\ A^{0.88}\ P^{0.93}\ H^{-0.27}$$

where Q = discharge (cfs), A = drainage area (miles^2), P = mean precipitation (inches), and H = altitude index (feet), as calculated by USGS StreamStats.

Hydrologic Design Factors Necessary for Form 2500-8.

A. Estimated Vegetative Recovery Period: A recovery period of approximately **5 years** was selected for areas burned at high and moderate intensity. This value represents the number of years of vegetative recovery that is necessary before early seral stage plant communities become effective in reducing hillslope erosion in areas that burned at moderate and high intensity.

B. Design Chance of Success: The design chance of success ranges from **75-90%**. Treatments such as stream crossing upgrades and trail erosion control should have a very high probability of success (90%). The 75% probability is associated with the risk of a precipitation event that could occur soon after the fire.

C. Equivalent Design Recurrence Interval: **2-year** recurrance interval.

D. Design Storm Duration: A design storm duration of **2 hours** was chosen for watersheds affected by the Coffee Fire. This value was chosen as late summer and fall thunderstorms are likely in the area and could have the potential to cause erosion and sediment delivery to streams (note that a storm of this duration occurred during the fire). A large snowpack generally accumulates in the area and winter rain storms are unlikely.

E. Design Storm Magnitude: The 2-year, 6-hour rainfall event was determined to be **2.19 inches**. The value was estimated with the National Weather Service Precipitation Frequency Tool.

F. Design Flow: The pre-event design flow was calculated for each watershed according to methodology developed by Waananen and Crippen, 1977. The parameters of watershed area, mean annual rainfall, and altitude index needed for the calculations are shown in Table 1 for each watershed. Estimated runoff for a two year recurrence interval is shown in Table 5. The total average pre-fire runoff from a 2-year recurrence interval storm was calculated to be **47.7 cfs/mile^2**. The pre-fire flows calculations for the 2 culverts were not included when calculating average flows due to their small watershed relative to the other pour points of interest (Table 4).

G. Estimated Reduction in Infiltration: The reduction in infiltration was estimated to be **15 percent** for areas of high and moderate burn severities. Moderate severity burn areas were included in this estimate because hydrophobic soils were observed during field reconnaisance in moderate burn areas.

H. Adjusted Design Flow: The total post-fire runoff response to a 2-year recurrence interval storm was calculated to be **59.1 cfs/mile^2**. The adjusted design flow was calculated based on the reduction in infiltration from both high and moderate intensity burn areas.

<u>Pre-Fire and Post-Fire Flows and Associated Impacts</u>

Pre-fire and post-fire flow events were calculated for a 2-year recurrence interval storm at each pour point of interst (Table 5), the results of which are presented in Figure 2.

Table 5. Pre-fire and post-fire flows calculations at each pour point of interest following a 2-year, 6-hour design storm.

Pour Point	Pre-Fire 2-Year Flow (cfs)	Post-Fire 2-Year Flow (cfs)	Factor Increase
Coffee Creek Residences	3598	4134	1.15
Coffee Creek	3061	3401	1.11
North Fork	1089	1367	1.26
East Fork	664	918	1.38
Kickapoo Falls Culvert	16	27	1.68
Culvert 2	9	16	1.82

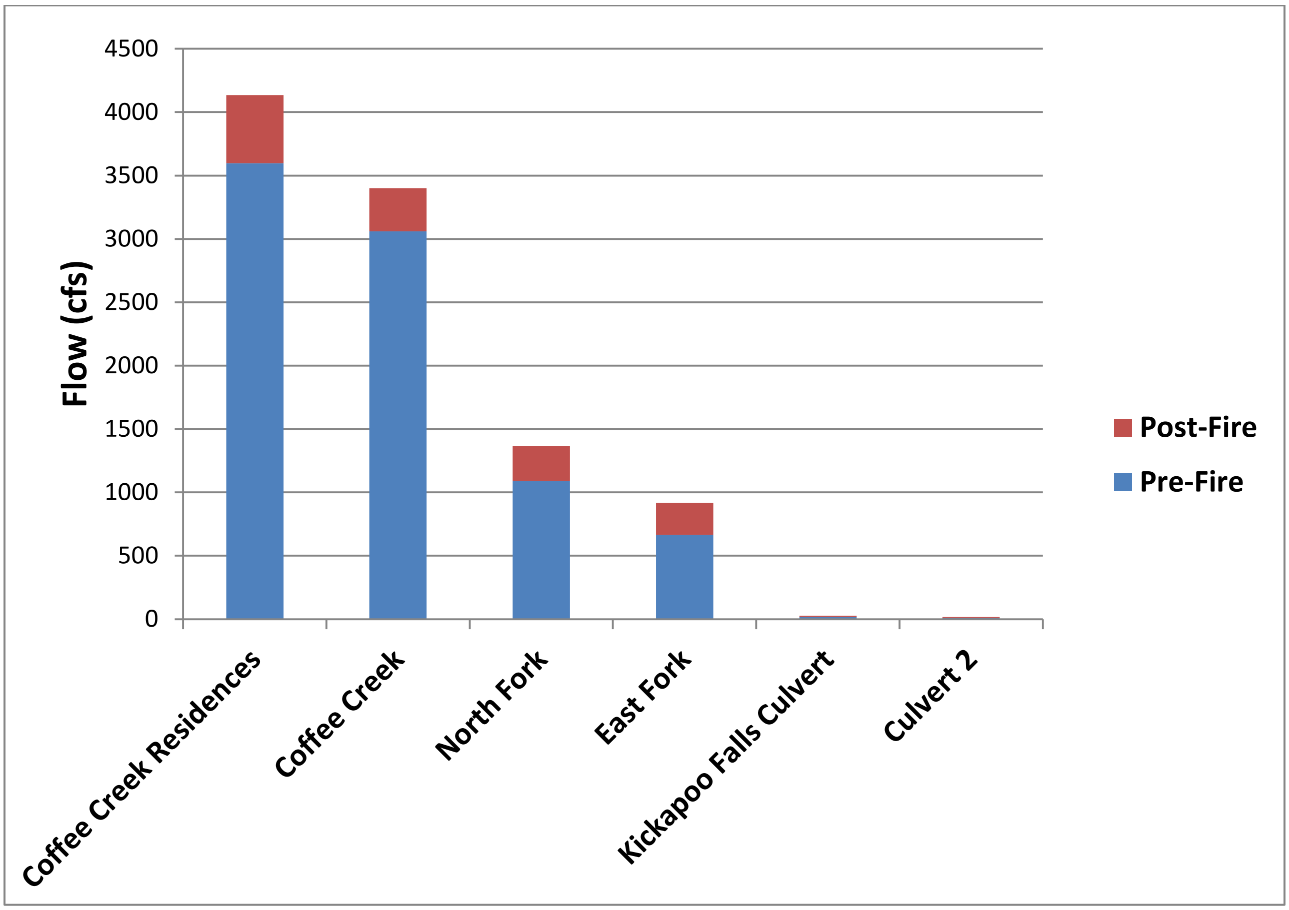

Figure 2. Modeled pre-fire and post-fire 2 year (Q_2) recurrence interval runoff response following a 2-year 6-hour storm.

Based upon calculations of expected pre-fire and post-fire Q_2 runoff response resulting from a 2-year, 6-hour storm, large increases in post-fire flow are not expected. At the pour points with drainage areas greater than 7,000 acres (Coffee Creek residences, Coffee Creek near the bridges, and the confluences of Coffee Creek with both the North and East Forks of Coffee Creek), post-fire runoff increased by an average factor of 1.2. Increased flows of this size would likely not impact the bridges across Coffee Creek or pose a danger to the downstream residences adjacent to Coffee Creek. Two water rights exist downstream of the fire for irrigation and stock watering, which will not be negatively impacted. Potential for increased flows and sediment delivery would not impact the Trinity Dam or its 303(d) status with respect to elevated mercury levels. Increased flow or sediment delivery does not pose a threat to any threatened, endangered, or sensitive fish species or habitat.

At the two culvert locations along County Road 104, the modeled post-fire flows increased by an average factor of 1.75. The higher increase at these locations is due to the small drainage areas and the fact that nearly all of the drainage areas are within the fire perimeter. Even with the increased post-fire flows, these culverts are sized appropriately to handle the design storm (see engineering report). Further, field surveys found high rock content in the soil above these drainages, which greatly reduces the potential for sheet, rill, and gully erosion.

The North Fork and East Fork Coffee Creek hiking trails parallel the fire perimeter and are susceptible to trail damage. This is particularly true of the East Fork trail, in which a rain storm of approximately 0.5 inches that fell during the fire caused significant damage and destroyed the trail at 2 creek crossings. If further storms occur more damage is likely, especially at creek crossings.

It is also important to note that potential for negative impacts related to the fire will decrease over time due to decreased soil hydrophobicity and increased over- and understory vegetation, root growth, and water infiltration into soils.

Treatment Options and Recommendations

A variety of treatment options exist with respect to hydrologic resources. Applying mulch to hillslopes with a helicopter can be effective in reducing raindrop impact, improving infiltration rates, and trapping sediment, but is generally not appropriate for use in the wilderness. Contour falling of trees across hillslopes can reduce sediment movement across hillslopes, but if logs are not perfectly aligned along the contour or are not in complete contact with the ground, fallen logs can make erosion worse by concentrating otherwise dispersed flow. Straw wattles can reduce the movement of sediment towards streams, but suffer from limited sediment storage capacity and are not appropriate for use in wilderness. Grade control structures in streams (check dams, straw bales, etc.) can be initially effective in trapping instream sediment, but become ineffective if not cleaned regularly and can turn a short-term sediment pulse into a chronic sediment source with large negative downstream impacts.

Due to the relatively small post-fire runoff response and the fact that the fire occurred in wilderness, treatment other than trail work, particularly at stream crossings, is not recommended with respect to potential hydrologic impacts. It does not appear that elevated peak flows and erosion rates will be large enough to adversely affect life, property, critical habitat, or beneficial uses of water.

References

California State Water Quality Control Board. October, 2011. Water Quality Control Plan for the North Coast Region.

EPA. 2010. 303(d) List of Impaired Waters. Last accessed on August 21, 2014.

Kaplan-Henry, T.A. 2007. McNally post-fire discharge and the relationship of Sierra Nevada-wide flood frequency curves and local Kern River discharge curves. In: Furniss, M., Clifton, C., and Ronnenberg, K., eds., 2007. *Advancing the Fundamental Sciences: Proceedings of the Forest Service National Earth Sciences Conference, San Diego, CA, 18-22 October 2004*. PNW-GTR-689, Portland, Oregon: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Waananen, A. O. & Crippen, J. R. (1977) Magnitude and frequency of floods in California. *Water Resources Investigations Report 77-21.* US Geological Survey. Water Resource Division, California USA.