Hydrology Resource Assessment
Route Complex

Humboldt and Trinity Counties, California

Six Rivers and Shasta-Trinity National Forests

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September 15, 2015

1. Objectives

The objective of this assessment is to evaluate the effects of the Route Complex Fire on watershed hydrologic processes and function including changes in runoff, soil conditions and watershed response to precipitation events. This assessment focuses on fire-induced changes in hydrologic processes and functions that pose a significant threat to human life and safety, property, and critical natural and cultural resources on National Forest System Lands. Values at risk are identified and a determination of the probability of damage or loss and the magnitude of consequences has been made for each value. Treatments recommendations have been developed for resources where critical resources at risk have been identified exist.

2. Burned Area Characterization

Hydrologic Setting
The Route Complex began on July 30th, when a large storm system produced numerous lightening strikes in Trinity, Shasta and Humbolt Counties causing over 150 fires. The Route Complex consists of numerious fires that were combined into the Buck Fire and the Johnson Fire. Total complex area on the Six Rivers National Forest is 18,446 acres and the total complex area on the Shasta-Trinity National Forest is 17,094 acres. Additionally, within the Route Complex, there are 134 acres of "Other" lands outside National Forest boundaries. The two fires totaled approximately 35,675 acres (approximately 56 square miles). The fires burned in watersheds tributary to the South Fork Trinity River, Mad River and Eel River. The burned areas included numerous tributaries to perennial fish bearing streams. Many of these perennial fish bearing streams downstream of the fire perimeter are anadromous.

Geologic Setting
The Route Fire Complex is located within the Klamath Mountains. The area is largely composed of metasediments, limestone, ultramaphic rocks, metavolcanics, basic intrusives and granitic intrusives.

Climate
The climate of the fire area is typified by warm, dry summers and cool wet winters. Substantial variation in temperature and precipitation occurs with elevation. The average maximum and minimum temperatures in the summer are 95 and 50 degrees Fahrenheit, respectively. Winter temperatures range from lows in the 20s to highs around 50 degrees F. Annual precipitation in the fire areas range from 45 - 100 inches with more precipitation occurring in high elevation areas. The majority of winter precipitation falls as snow at higher elevations. Almost all of the precipitation occurs between October and May.

Hydrology
Hydrologic features found within the Route Complex include the South Fork Trinity River, Mad River, Van Duzan River and it tributary streams. Elevations within the area of the Johnson Fire ranges from 1,378 feet down near the South Fork Trinity River to over 5,871 feet at Blake Mountain. Elevations within the area of the Buck Fire ranges from 2,927 feet down near the Van Duzen River to over 5,146 feet at Tierney Peak. The burn area in the Route Complex contains approximately 112 miles of ephemeral streams, 56 miles of intermittent streams and 70 miles of perennial streams. The drainage density for the Route Complex burn area is 4.3 miles of stream channel per square mile[1]. The Trinity

River, Mad River and Eel River are currently listed for for water quality impairment (303d list) by the Environmental Protection Agency for sediment impairment. All of the streams within and downstream of the fire perimeter drain into these listed streams.

3. Hydrology Resource Assessment

Reconnaissance of the burn area was conducted using a rapid approach described as a burned area emergency assessment. The burned area emergency assessment is an immediate and rapid assessment of the burned area that is conducted in order to identify post-fire threats, critical values at risk, and need for emergency stabilization measures. The burned area emergency assessment is not a comprehensive evaluation of all fire damage or long-term rehabilitation or restoration needs (FSM 2500, 2004).

Reconnaissance of the burned area was conducted by helicopter overviews, driving roads, hiking on trails and cross-country through the burn and interviewing people familiar with the burned area. Specialists that the hydrologists worked with and/or consulted during the field assessments included soil scientists, fisheries biologist, geologist, botanist, archaeologist, GIS specialists and roads engineers.

The Route Complex burned a total of 35,675 acres within portions of 15 Hydrologic Unit Codes (HUC) 7 drainages (Figure 1). BAER soil scientists' determined the burn severity for the fire based on burn intensity information from the BARC and field surveys of the burned area (see Table 1 for definitions).

Term	Definition
Burn Intensity	The intensity of the fire's effect on the watershed vegetation. Low severity indicates ground fire only with only small areas of canopy burned. Moderate severity indicates hot ground fire with frequent scorching of canopy. Tree mortality is high but needles and leaves are not consumed. High severity indicates ground and canopy fire with complete consumption of the forest canopy. Burn intensity is determined based on imagery of the burned area reflectance classification (BARC) as refined by ground surveys.
Burn Severity	Rating of fire impacts on soil hydrologic function (e.g. infiltration capacity, erodability, etc.). Burn severity is determined by refining the burn intensity information from the BARC with additional field surveys. Classes of burn severity are high, moderate, low, and very low/ unburned.
Watershed Response	A qualitative degree and/or modeled measure of how a watershed will respond to precipitation. Parameters include pre-existing soil moisture; amount of soil cover; amount and distribution of impermeable surfaces (rock outcrop, hydrophobic soils), amount, duration, and intensity of rainfall; watershed area and slope, and lag time between initiation of storm and peak flow runoff. Response is generally measured as peak-flow discharge and sediment yield. Changes in the characteristics of watershed brought about by a fire will increase the efficiency with which waters runs off, thus increasing peak flows and decreasing lag times.

Table 1: Severity and response definitions.

[1] Drainage densities based on the Six Rivers National Forest NHD streams layer clipped to the fire perimeters.

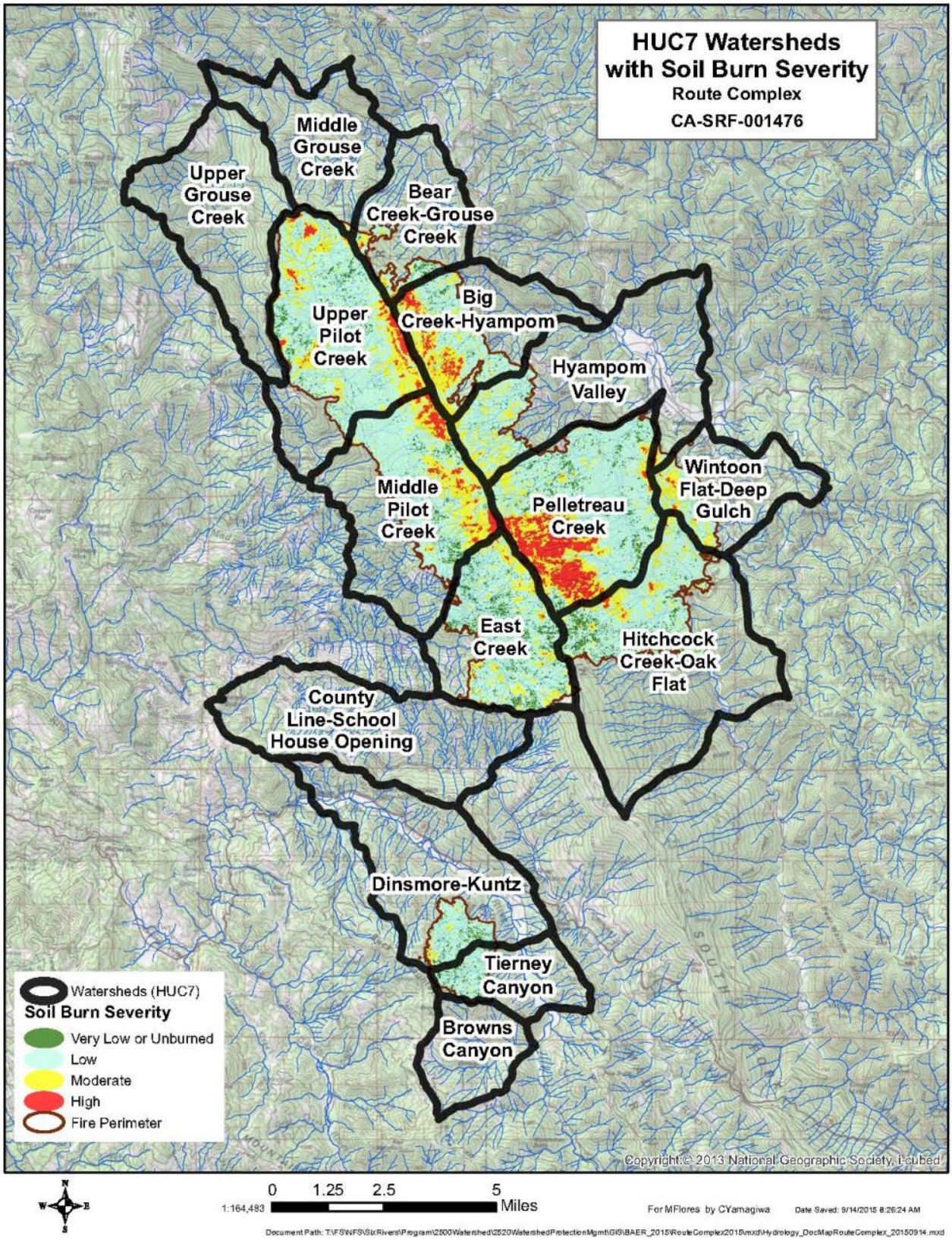

Figure 1. Map of the Route Complex fire severity and HUC 7 watershed locations.

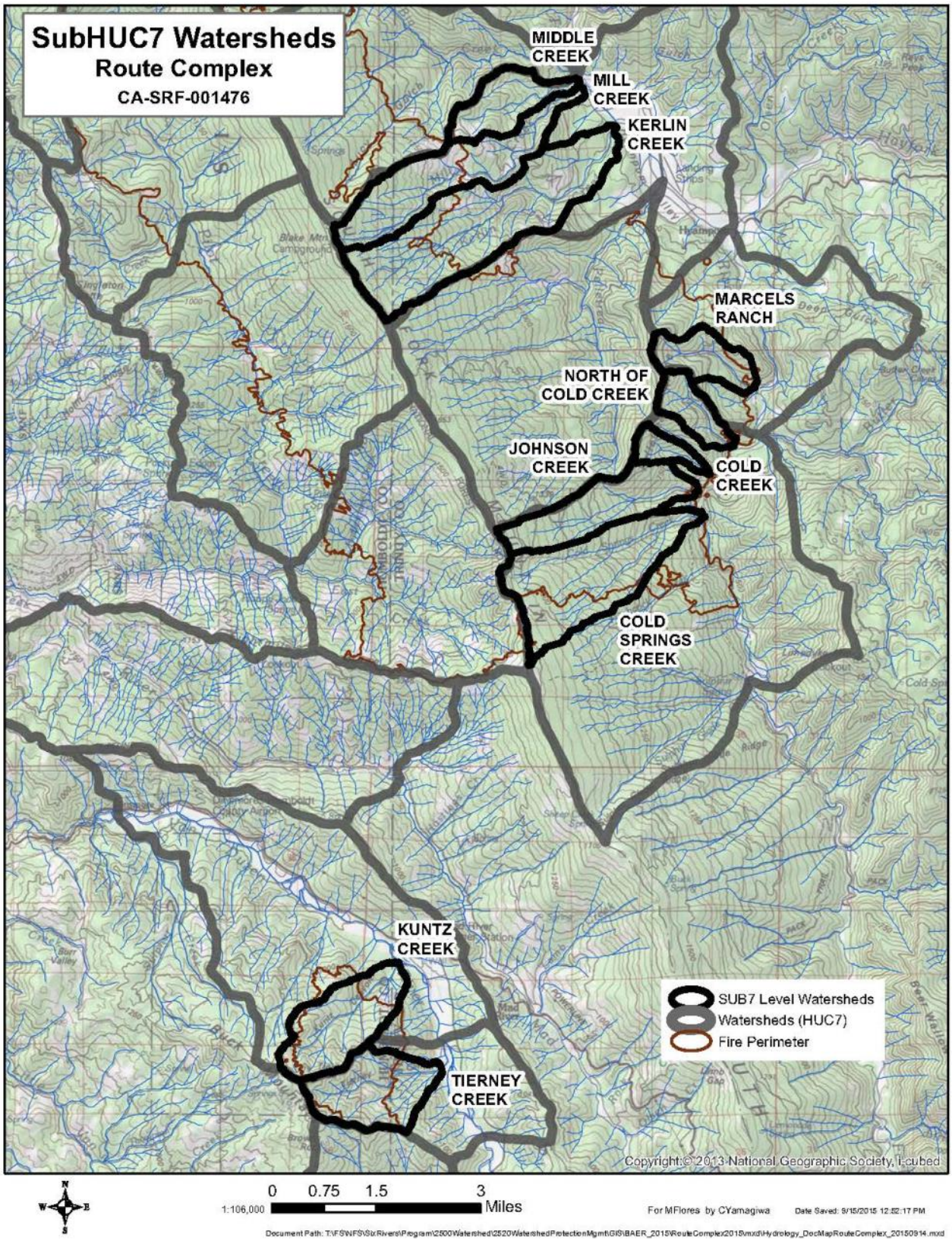

Figure 2. Map of the Route Complex Sub HUC 7 watershed locations.

Watershed Steamflow Analysis

Fire effects on runoff were determined by modeling pre-fire and post-fire discharges for all HUC 5, 6, 7 watersheds affected by the Route Complex (Table 2). Increases in runoff were assumed to be due to hydrophobic soils and the loss of vegetation and ground cover (i.e. interception, evapotranspiration, ground cover storage). Elevated streamflows can be expected to occur in the burned watersheds, with greater flow increases in those drainages having higher percentages of high burn severity. The percentage of each HUC 5, 6, and 7 burned at high, moderate, low and very low/ unburned burn severity is also shown in Table 2.

Estimated pre-and post-fire peak flows were modeled for HUC 5, 6 and 7 level watersheds using the United States Geological Survey (USGS) Regional Flood Frequency method (Gotvald, et. al., 2012), utilizing a GIS-based approach developed on the Shasta-Trinity National Forest (Lotkeff, 2009). The average annual precipitation was calculated from the current PRISM climate dataset covering the period 1981-2010 (PRISM Climate Group, 2015). The Peak flow equations were calculated in relation to regional hydrologic characteristics (Gotvald, et. al., 2012). Pre-fire peak flows were calculated for the full range of recurrence intervals defined in the regional equations, between 2 and 25 years, for all watershed scales between 5th- and 7th-field Hydrologic Unit Codes (HUCs) that intersect the burned area. Post-fire peak flows for all complete watersheds intersecting the burned area were calculated for the recurrence intervals, between 2 and 25 years. Pre- and post-fire peak flows for the burned area were calculated for 7th-field HUCs, in order to characterize the design flow increase from the burned area. The 5th-field HUCs and 6th-field HUCs are shown to assist in evaluating the cumlative effect of the burned area contributions to the major streams and rivers. The post-fire peak flow increase estimates are based on a factor of three (300%) increase in flow from areas of high burn severity, a factor of 1.5 (50%) increase from areas of moderate burn severity, and factor of 1.1 (10%) increase from areas of low burn severity. These factors were adopted from ratios used for similar areas in Southern California where intense rainstorms are the most likely type of damaging storm. It should be noted that the regional flood frequency estimates describe linear post-fire increases in peak flow magnitude with increased recurrence intervals. Field studies in Southern California have demonstrated that as recurrence interval increases, the effects of fire or other vegetation losses on peak flows is reduced (Rowe, Countryman and Storey, 1949). Therefore, estimates for longer recurrence interval post-fire peak flows were not calculated. Additionally, a sediment/ debris bulking factor was added to the high severity burn acreages following the the methods outlines in Gusman, 2011.

Because high and moderate burn severity areas were widely scattered and relatively isolated thoughout the fire the burn severity was further stratified by smaller subwatersheds/drainages of interest to more closely examine impacts to water resources and values at risk. These smaller subwatersheds/drainages were identified as being at risk to fire induced impacts based on values at risk. As shown in Figure 2, these subwatersheds were dilineated utilizing the USGS StreamStats Program (http://water.usgs.gov/osw/streamstats/california.html). Projected flow increases resulting from increases in runoff from the burn areas are shown in Tables 2 and 3.

Watershed Names			HUC	Water-shed Area	Mean Annual Precip.	Pre-Fire Peak Flow (@ Watershed Outlet, CFS)				Burn Severity (acres)			Post-Fire Peak Flow (@ Watershed Outlet, CFS)				Post-Fire/Pre-Fire Ratio (@ Watershed Outlet) (CFS)		
HUC 5	HUC 6	HUC 7 and smaller	(#)	(acres)	(inches)	Qp2	Qp5	Qp10	Qp25	Severe	Moderate	Low	Qp2	Qp5	Qp10	Qp25	Qp2	Qp5	Qp10
Lower South Fork Trinity River			1801021205	129109.7	68.8	14123	23549	30021	38314	1550.7	2839.5	7702.8	15084	25151	32063	40920	1.07	1.07	1.07
	Grouse Creek		180102120502	36244.2	88.0	5705	9228	11650	14733	19.2	144.1	440.6	5736	9279	11713	14813	1.01	1.01	1.01
		Bear Creek-Grouse Creek	18010212050206	4296.1	81.3	768	1309	1688	2174	19.6	135.8	392.6	802	1367	1763	2270	1.04	1.04	1.04
		Middle Grouse Creek	18010212050205	5236.4	78.2	884	1515	1955	2522	0.0	10.6	43.7	885	1517	1959	2527	1.00	1.00	1.00
		Upper Grouse Creek	18010212050201	7231.2	98.7	1487	2414	3055	3870	0.0	0.2	5.7	1488	2414	3055	3871	1.00	1.00	1.00
	Pelletreau Creek-South Fork Trinity River		180102120503	36669.4	61.4	4047	7062	9162	11873	1531.5	2695.4	7262.2	4995	8715	11306	14651	1.23	1.23	1.23
		Big Creek-Hyampom	18010212050303	5292.0	83.8	955	1613	2071	2658	275.3	911.8	1478.3	1275	2153	2765	3549	1.34	1.34	1.34
		Hyampom Valley	18010212050302	9174.9	61.3	1155	2064	2704	3534	23.7	498.2	1335.4	1216	2173	2846	3720	1.05	1.05	1.05
		Kerlin Creek - Sub HUC 7	18010212050302s	2521.4	65.6	384	692	910	1192	2.9	268.5	594.4	415	748	984	1290	1.08	1.08	1.08
		Middle Creek - Sub HUC 7	18010212050302s	647.3	54.6	94	180	242	324	0.0	0.0	9.4	94	180	242	324	1.00	1.00	1.00
		Mill Creek - Sub HUC 7	18010212050302s	1480.7	68.1	246	444	584	767	2.3	155.6	679.8	272	491	646	847	1.10	1.10	1.10
		Pelletreau Creek	18010212050301	7577.1	71.3	1127	1957	2538	3287	1227.9	1284.5	4462.7	2065	3586	4651	6023	1.83	1.83	1.83
Middle South Fork Trinity River			1801021204	145690.2	62.1	14244	24220	31091	39927	88.6	889.4	3486.0	14358	24414	31341	40248	1.01	1.01	1.01
	Sulphur Glade Creek-South Fork Trinity River		180102120406	22704.9	58.1	2485	4423	5782	7543	88.6	889.4	3486.0	2613	4651	6080	7931	1.05	1.05	1.05
		Hitchcock Creek-Oak Flat	18010212040602	11792.9	63.0	1489	2634	3437	4477	59.5	507.2	2847.2	1588	2810	3668	4777	1.07	1.07	1.07
		Cold Creek - Sub HUC 7	18010212040602s	222.2	52.8	35	68	92	125	0.0	23.6	192.4	39	77	105	142	1.14	1.14	1.14
		Cold Springs Creek - Sub HUC 7	18010212040602s	1790.0	74.4	319	562	734	957	2.2	65.2	997.7	344	607	793	1032	1.08	1.08	1.08
		Johnson Creek - Sub HUC 7	18010212040602s	1049.6	68.0	180	327	431	567	42.2	245.7	661.1	243	441	583	766	1.35	1.35	1.35
		North of Cold Creek - Sub HUC 7	18010212040602s	391.8	49.6	54	107	145	197	3.8	73.9	294.9	66	129	176	238	1.21	1.21	1.21
		Wintoon Flat-Deep Gulch	18010212040603	4033.2	48.2	434	827	1110	1481	33.4	375.9	618.9	476	907	1218	1625	1.10	1.10	1.10
		Mercels Ranch - Sub HUC 7	18010212040603s	537.6	49.7	72	142	192	259	20.2	151.6	299.9	98	192	261	352	1.36	1.36	1.36
Middle Mad River			1801010203	56462.3	74.1	7193	11974	15267	19483	753.0	3039.5	11280.5	7938	13214	16849	21501	1.10	1.10	1.10
	Pilot Creek		180101020301	25429.5	83.8	3947	6490	8243	10482	753.0	3039.3	11276.4	4855	7982	10139	12892	1.23	1.23	1.23
		East Creek	18010102030103	5778.9	77.4	956	1640	2117	2731	44.9	660.9	3355.3	1098	1883	2431	3136	1.15	1.15	1.15
		Middle Pilot Creek	18010102030102	8491.2	82.3	1439	2419	3101	3973	363.8	1092.7	3019.4	1844	3101	3975	5094	1.28	1.28	1.28
		Upper Pilot Creek	18010102030101	8498.4	98.8	1723	2788	3524	4460	342.7	1281.1	4897.8	2247	3636	4596	5817	1.30	1.30	1.30
	Bear Creek-Mad River		180101020302	31032.7	65.9	3731	6432	8309	10727	0.0	0.1	4.1	3731	6432	8310	10727	1.00	1.00	1.00
		County Line-School House Opening	18010102030204	8266.9	64.1	1098	1948	2545	3318	0.0	0.1	3.9	1098	1948	2545	3318	1.00	1.00	1.00
Lower Van Duzen River_Buck Fire			1801010509	131791.2	64.7	13545	22872	29290	37532	0.1	1.6	0.6	13545	22872	29290	37532	1.00	1.00	1.00
	Little Van Duzen River		180101050902	26374.9	74.4	3629	6115	7836	10042	0.1	1.6	0.6	3629	6115	7836	10043	1.00	1.00	1.00
Upper Van Duzen River_Buck Fire			1801010507	54645.9	69.3	6538	11046	14159	18154	2.2	96.2	1347.9	6562	11085	14209	18218	1.00	1.00	1.00
	Mill Creek-Van Duzen River		180101050703	16288.3	66.4	2099	3652	4737	6136	2.2	95.6	1340.3	2124	3695	4793	6208	1.01	1.01	1.01
		Dinsmore-Kuntz	18010105070302	8124.5	64.7	1091	1932	2523	3287	1.3	67.5	752.0	1106	1959	2558	3333	1.01	1.01	1.01
		Kuntz Creek - Sub HUC 7	18010105070302s	1080.3	75.0	204	362	474	618	1.3	66.0	608.2	222	395	517	675	1.09	1.09	1.09
		Tierney Canyon	18010105070301	2747.6	67.4	426	762	1000	1307	0.9	28.1	588.7	438	783	1028	1344	1.03	1.03	1.03
		Tierney Creek - Sub HUC 7	18010105070301s	1021.4	73.9	191	340	446	583	1.0	27.3	543.2	204	364	478	625	1.07	1.07	1.07
	Shanty Creek-Van Duzen River		180101050702	23142.9	68.5	2973	5109	6594	8505	0.0	0.6	7.6	2973	5109	6594	8506	1.00	1.00	1.00
		Browns Canyon	18010105070204	2890.1	70.6	467	826	1079	1407	0.0	0.6	7.3	467	826	1080	1407	1.00	1.00	1.00

Table 2: Pre-fire runoff and post-fire predicted flows for HUC 5, 6, and 7 watersheds in the Route Fire Complex.

Projected Pre-Fire/Post-Fire ratio increases for a 2-year recurrence interval storm within the HUC 5 and HUC 6 analysis ranged from a low ratio of 1.0 to a moderate ratio of 1.23 in the Pilot Creek watershed and Pelletreau Creek-South Fork Trinity River watershed (Table 2). The results show minimal to low increases in flows at these watershed levels. This is likely due to the patchy, lower severity burn and a high percentage of the watersheds being unburned. The analysis of the HUC 7 and smaller subwatersheds with higher percentages of moderate and high burn severity resulted in higher ranges with the maximum factor of 1.83 in the Pelletreau Creek watershed. Other areas with moderate ratios included much of the headwater creeks draining directly into the South Fork of the Trinity River and Pilot Creek which drains into the Mad River. (Figure 3)

Watershed Names			HUC	Water-shed Area	Mean Annual Precip.	Burn Severity (acres)			Post-Fire/Pre-Fire Ratio (@ Watershed Outlet) (CFS)		
HUC 5	HUC 6	HUC 7 and smaller	(#)	(acres)	(inches)	Severe	Moderate	Low	Qp2	Qp5	Qp10
Lower South Fork Trinity River			1801021205	129109.7	68.8						
	Pelletreau Creek-South Fork Trinity River		180102120503	36669.4	61.4	1531.5	2695.4	7262.2	1.23	1.23	1.23
		Big Creek-Hyampom	18010212050303	5292.0	83.8	275.3	911.8	1478.3	1.34	1.34	1.34
		Pelletreau Creek	18010212050301	7577.1	71.3	1227.9	1284.5	4462.7	1.83	1.83	1.83
Middle South Fork Trinity River			1801021204	145690.2	62.1						
	Sulphur Glade Creek-South Fork Trinity River		180102120406	22704.9	58.1						
		Cold Creek - Sub HUC 7	18010212040602s	222.2	52.8	0.0	23.6	192.4	1.14	1.14	1.14
		Johnson Creek - Sub HUC 7	18010212040602s	1049.6	68.0	42.2	245.7	661.1	1.35	1.35	1.35
		North of Cold Creek - Sub HUC 7	18010212040602s	391.8	49.6	3.8	73.9	294.9	1.21	1.21	1.21
		Mercels Ranch - Sub HUC 7	18010212040603s	537.6	49.7	20.2	151.6	299.9	1.36	1.36	1.36
Middle Mad River			1801010203	56462.3	74.1						
	Pilot Creek		180101020301	25429.5	83.8	753.0	3039.3	11276.4	1.23	1.23	1.23
		East Creek	18010102030103	5778.9	77.4	44.9	660.9	3355.3	1.15	1.15	1.15
		Middle Pilot Creek	18010102030102	8491.2	82.3	363.8	1092.7	3019.4	1.28	1.28	1.28
		Upper Pilot Creek	18010102030101	8498.4	98.8	342.7	1281.1	4897.8	1.30	1.30	1.30

Table 3: Selected drainages in the Route Complex Fire area for further analysis.

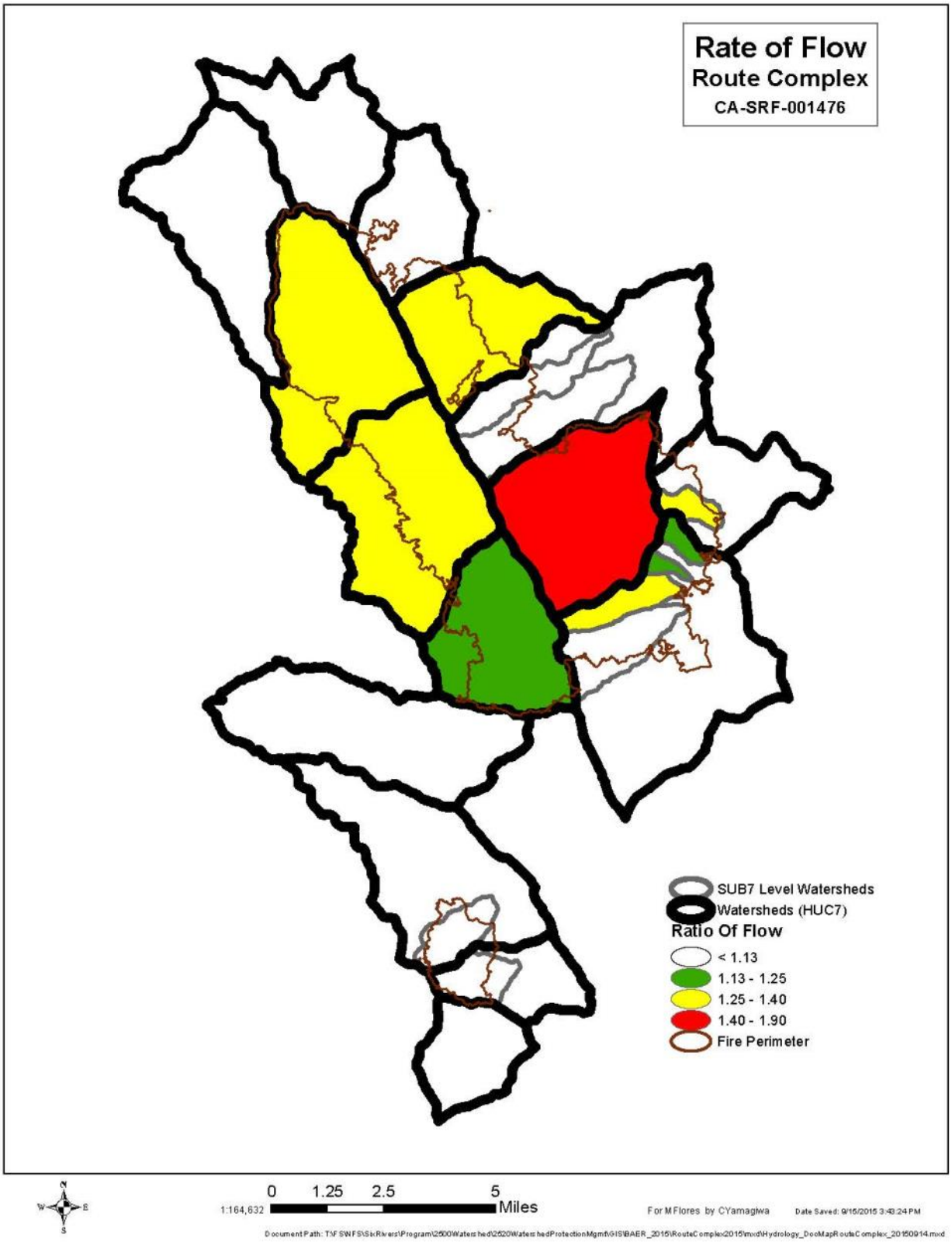

Figure 3. Map of the HUC 7 Watersheds and Sub HUC 7 Watersheds Pre-Fire/Post-Fire predicted Streamflow Ratio Increases.

4. Values at Risk and Threats

The Burn Area Emeregency Response (BAER) team identified several categories of issues, threats and resource concerns for the Route Complex. Threats to human life and safety, downstream effects to water quality and aquatic habitat, erosion of transportation facilities (roads), and water supplies are the principal values at risk related to hydrologic effects of the Route Complex. Values at risk for water quality, fisheries and water supplies are presented below. Refer to the Route Complex 2500-8 for a complete summary of all values at risk.

Values at Risk and Threats by HUC 7 Watersheds

Pelletreau Creek– Jackson Fire (tributary to South Fork Trinity River) Headwaters burned hot with high to moderate soil burn severity and streamflow analysis indicate the post-fire watershed will have an 83% increase the design flow over the prefire conditions. This watershed has a low to moderate erosion rating and could erode significantly due to the increases in runoff response to Qp2 to Qp25 storm events. The fire activity may produce accelerated surface erosion, debris flow activity, loss of soil productivity and increased runoff. All of these threats may affect the following values at risk:

- Midslope road segments of road 3N14 and 3N10 – These roads may be susceptible to increased flows and debris flows.Streamflow analysis indicate that the headwaters of Pelletreau Creek will have a 83% increase in stream flow comparable to a Q10 event. Undersized, plugged or damaged culverts on these roads have a likely risk failure (Refer to the Engineers report).
- The South Fork of the Trinity River water quality and aquatic habitat – Pelletreau Creek is a tributary into the South Fork of the Trinity River. The river has critical coho habitat. Pelletreau Creek is likely to experience high erosion rates and transport large quantities of sediment to the South Fork Trinity River.
- Trinity Count Road 311, Pelletreau Creek crossing. This concrete bridge will be likely to pass the increase runoff . Cleaning storm debris from the channel immediately upstream of the bridge is recommended.
- The vast majority of the watershed is in private ownership. Slope treatments to reduce erosion and protect soil productivity on Federal Lands should be coordinated with the private landowner(s) if treatments are intiated on the private land.

Hyampom Valley – Jackson Fire (tributary to South Fork Trinity River) The upper third of the headwaters western slope burned with moderate to low soil burn severity and streamflow analysis, of the HUC 7 watershed, indicate the post-fire watershed will have an 5% increase the design flow over the prefire conditions. Three Sub HUC 7 watersheds are in the burned area and are tributary to South Fork Trinity River. Streamflow analysis, Kerlin Creek, Middle, and Mills Creek, indicate the post-fire watershed will have an 8%, <0.1%, and 10%, respectfully, increase the design flow over the prefire conditions . This watershed has a low to moderate erosion rating and could erode at low to moderate rates due to the increases in runoff response to Qp2 to Qp25 storm events. The fire activity may produce accelerated surface erosion, debris flow activity, loss of soil productivity and increased runoff. All of these threats may affect the following values at risk:

- Midslope road segment of road 3N14 – This road may be susceptible to increased flows and debris flows. Undersized, plugged or damaged culverts on this road have a likely risk failure (Refer to the Engineers report).
- The South Fork of the Trinity River water quality and aquatic habitat – Kerlin, Middle, and Mills

Creek are tributary into the South Fork of the Trinity River. The river has critical coho habitat. Kerlin, Middle, and Mills Creek are likely to experience low to moderate erosion rates and transport moderate quantities of sediment to the South Fork Trinity River.

- Trinity Count Road 311, Kerlin, Middle, and Mills Creek crossings. These stream crossings will be likely to pass the low increase runoff . Cleaning storm debris from the channel immediately upstream of the crossings is recommended.

Big Creek-Hyampom – Jackson Fire (tributary to South Fork Trinity River) The upper third of the headwaters western slope burned with high to moderate soil burn severity and streamflow analysis, of the HUC 7 watershed, indicate the post-fire watershed will have an 38% increase the design flow over the prefire conditions. This watershed has a low to moderate erosion rating and could erode at moderate to high rates due to the increases in runoff response to Qp2 to Qp25 storm events. The fire activity may produce accelerated surface erosion, debris flow activity, loss of soil productivity and increased runoff. All of these threats may affect the following values at risk:

- Midslope road segment of road 3N14 – This road may be susceptible to increased flows and debris flows. Undersized, plugged or damaged culverts on this road have a likely risk failure (Refer to the Engineers report).
- The South Fork of the Trinity River water quality and aquatic habitat – Big Creek is a tributary into the South Fork of the Trinity River. The river has critical coho habitat. Big Creek is likely to experience moderate erosion rates and transport moderate quantities of sediment to the South Fork Trinity River.
- Trinity Count Road 311, Big Creek Bridge. This stream crossing will be likely to pass the increase runoff . Cleaning storm debris from the channel immediately upstream of the crossings is recommended.
- The Big Creek 7-R Power Project in Trinity County CA is located on the lower third of Big Creek. The inlet is on Federal Land and the Hydro plant is on private land. Efforts to locate the owner or operator of the power plant have been unsuccessful.

Bear Creek-Grouse Creek – Jackson Fire (tributary to South Fork Trinity River) A small portion of the headwaters western slope burned with moderate to low soil burn severity and streamflow analysis, of the HUC 7 watershed, indicate the post-fire watershed will have an 4% increase the design flow over the prefire conditions. This watershed has a high erosion rating and could erode at high rates due to the increases in runoff response to Qp2 to Qp25 storm events. The fire activity may produce accelerated surface erosion, debris flow activity, loss of soil productivity and increased runoff. All of these threats may affect the following values at risk:

- Midslope road segment of road 3N14 – This road may be susceptible to increased flows and debris flows. Undersized, plugged or damaged culverts on this road have a likely risk failure (Refer to the Engineers report).
- The South Fork of the Trinity River water quality and aquatic habitat – This HUC 7 watershed feeds into the Huc Huc 6 Grouse Creek watershed which in turn is a tributary into the South Fork of the Trinity River. The river has critical coho habitat.No increases of sediment above prefire conditions are likely to reach the South Fork Trinity River.

Upper Grouse Creek and Middle Grouse Creek – Jackson Fire (tributary to South Fork Trinity River) A very small portion of the headwaters western slope burned with moderate to low soil burn severity and streamflow analysis, of the two HUC 7 watersheds, indicate each post-fire watershed will have an

<0.1% increase the design flow over the prefire conditions. These watersheds has a high erosion rating however there should be no increase in runoff due to the fire. No threats are foreseen that may affect the following value at risk:

- The South Fork of the Trinity River water quality and aquatic habitat – These two HUC 7 watersheds feed into the HUC 6 Grouse Creek watershed which in turn is a tributary into the South Fork of the Trinity River. The river has critical coho habitat.No increases of sediment above prefire conditions are likely to reach the South Fork Trinity River.

Wintoon Flat-Deep Gulch – Jackson Fire (tributary to South Fork Trinity River) The headwaters western slope burned with high to moderate soil burn severity and streamflow analysis, of the HUC 7 watershed, indicate the post-fire watershed will have an 10% increase the design flow over the prefire conditions. One Sub HUC 7 watershed is in the burned area and is tributary to South Fork Trinity River. Streamflow analysis, Mercels Ranch (unnamed stream), indicate the post-fire watershed will have an 36% increase the design flow over the prefire conditions . This watershed has a high erosion rating and could erode at moderate rates due to the increases in runoff response to Qp2 to Qp25 storm events. The fire activity may produce significant accelerated surface erosion, debris flow activity, loss of soil productivity and increased runoff. All of these threats may affect the following values at risk:

- The South Fork of the Trinity River water quality and aquatic habitat – Mercels Ranch (unnamed stream) is a tributary into the South Fork of the Trinity River. The river has critical coho habitat. Kerlin and Mills Creek are likely to experience moderate erosion rates and transport low quantities of sediment, due to small contribution areas, to the South Fork Trinity River.

Hitchcock Creek-Oak Flat – Jackson Fire (tributary to South Fork Trinity River) The headwaters north-western slope burned with high to moderate soil burn severity and streamflow analysis, of the HUC 7 watershed, indicate the post-fire watershed will have an 7% increase the design flow over the prefire conditions. Four Sub HUC 7 watersheds are in the burned area and are tributary to South Fork Trinity River. Streamflow analysis; North of Cold Creek (unnamed stream), Cold Creek, Johnson Creek, and Cold Springs Creek; indicate the post-fire watersheds will have an 21%, 14%, 35%, and 8%, respectfully, increase the design flow over the prefire conditions . This watershed has a high to moderate erosion rating and could erode at high rates due to the increases in runoff response to Qp2 to Qp25 storm events. The fire activity may produce accelerated surface erosion, debris flow activity, loss of soil productivity and increased runoff. All of these threats may affect the following values at risk:

- The South Fork of the Trinity River water quality and aquatic habitat – North of Cold Creek (unnamed stream), Cold Creek, Johnson Creek, and Cold Springs Creek are tributary into the South Fork of the Trinity River. The river has critical coho habitat. Cold Creek, Johnson Creek, and Cold Springs Creek are likely to experience high erosion rates and transport moderate quantities of sediment, due to small contribution areas, to the South Fork Trinity River.

County Line-School House Opening – Jackson Fire (tributary to Mad River) A very small portion of the headwaters western slope burned with moderate to low soil burn severity and streamflow analysis, of the HUC 7 watershed, indicate the post-fire watershed will have an <0.1% increase the design flow over the prefire conditions. This watershed has a high erosion rating however there should be no increase in runoff due to the fire. No threats are foreseen that may affect the following value at risk:

- The Mad River water quality and aquatic habitat – This HUC 7 watershed is a tributary into the Mad River. No increases of sediment above prefire conditions are likely to reach the Mad River.

Upper Pilot Creek– Jackson Fire (tributary to Mad River) Headwaters burned hot with high to moderate soil burn severity on the upper slopes and streamflow analysis indicate the post-fire watershed will have an 30% increase the design flow over the prefire conditions. This watershed has a high erosion rating and could erode at high rates due to the increases in runoff response to Qp2 to Qp25 storm events. The fire activity may produce accelerated surface erosion, debris flow activity, loss of soil productivity and increased runoff. All of these threats may affect the following values at risk:

- The Mad River water quality and aquatic habitat – Pilot Creek is a tributary to the Mad River. The Pilot Creek has critical steelhead habitat. Pilot Creek is likely to experience high erosion rates and transport moderate quantities of sediment to Pilot Creek and transport low quantities of sediment to the Mad River.

Middle Pilot Creek– Jackson Fire (tributary to Mad River) Headwaters burned hot with moderate soil burn severity on the upper eastern slopes and streamflow analysis indicate the post-fire watershed will have an 28% increase the design flow over the prefire conditions. This watershed has a high erosion rating and could erode at high rates due to the increases in runoff response to Qp2 to Qp25 storm events. The fire activity may produce accelerated surface erosion, debris flow activity, loss of soil productivity and increased runoff. All of these threats may affect the following values at risk:

- The Mad River water quality and aquatic habitat – Pilot Creek is a tributary to the Mad River. The Pilot Creek has critical steelhead habitat. Pilot Creek is likely to experience high erosion rates and transport moderate quantities of sediment to Pilot Creek and transport low quantities of sediment to the Mad River.

East Creek 1.15 Middle Pilot Creek– Jackson Fire (tributary to Mad River) Headwaters burned moderately hot with moderate soil burn severity on the upper eastern slopes and streamflow analysis indicate the post-fire watershed will have an 15% increase the design flow over the prefire conditions. This watershed has a high erosion rating and could erode at high rates due to the increases in runoff response to Qp2 to Qp25 storm events. The fire activity may produce accelerated surface erosion, debris flow activity, loss of soil productivity and increased runoff. All of these threats may affect the following values at risk:

- The Mad River water quality and aquatic habitat – East Creek is a tributary to the Pilot Creek. The Pilot Creek has critical steelhead habitat. East Creek is likely to experience moderate erosion rates and transport moderate quantities of sediment to Pilot Creek and transport low quantities of sediment to the Mad River.

Browns Canyon – Buck Fire (tributary to Eel River) A very small portion of the headwaters northern slope burned with low soil burn severity and streamflow analysis, of the HUC 7 watershed, indicate the post-fire watershed will have an <0.1% increase the design flow over the prefire conditions. This watershed has a high erosion rating however there should be no increase in runoff due to the fire. No threats are foreseen that may affect the following value at risk:

- The Eel River water quality and aquatic habitat – This HUC 7 watershed is a tributary into the Van Duzen River. No increases of sediment above prefire conditions are likely to reach the Eel River.

Dinsmore-Kuntz – Buck Fire (tributary to Eel River) A small portion of the headwaters southern slope burned with moderate to low soil burn severity and streamflow analysis, of the HUC 7 watershed,

indicate the post-fire watershed will have an 1% increase the design flow over the prefire conditions. One Sub HUC 7 watershed is in the burned area and is tributary to Van Duzen River. Streamflow analysis, Kuntz_Creek, indicate the post-fire watershed will have an 8% increase the design flow over the prefire conditions . This watershed has a high and moderate erosion rating and could erode at low rates due to the increases in runoff response to Qp2 to Qp25 storm events. The fire activity may produce low accelerated surface erosion, debris flow activity, loss of soil productivity and increased runoff. All of these threats may affect the following values at risk:

- Midslope road segment of road 31N13 – This road may be susceptible to increased flows and debris flows. Undersized, plugged or damaged culverts on this road have a likely risk failure (Refer to the Engineers report).

Tierney Canyon – Buck Fire (tributary to Eel River The upper half of the headwaters western slope burned with moderate to low soil burn severity and streamflow analysis, of the HUC 7 watershed, indicate the post-fire watershed will have an 3% increase the design flow over the prefire conditions. One Sub HUC 7 watershed is in the burned area and is tributary to Van Duzen River. Streamflow analysis, Tierney Creek, indicate the post-fire watershed will have an 8% increase the design flow over the prefire conditions . This watershed has a moderate and low erosion rating and could erode at low rates due to the increases in runoff response to Qp2 to Qp25 storm events. The fire activity may produce low accelerated surface erosion, debris flow activity, loss of soil productivity and increased runoff. All of these threats may affect the following values at risk:

- Midslope road segment of road 31N13 – This road may be susceptible to increased flows and debris flows. Undersized, plugged or damaged culverts on this road have a likely risk failure (Refer to the Engineers report).

5. Assessment of Values at Risk

The assessment of values at risk utilized a 2 year equivalent design recurrence interval storm for determining calculated risk for the Route Complex. This design storm was chosen because it is likely that this event will occur within six months of the fire. Both design storm durations of 12 and 24 hours were evaluated for watersheds affected by the fire. The most common type of flood generating storms are long-duration winter rainfall events caused by Pacific Ocean frontal systems (Levitan, et. al., 2015). Occassional rain-on-snow events produce the highest peak flows and pose the greatest erosion risk. The design storm magnitude for the 2 year, 12 hour rainfall event was determined to be 3.62 inches and the 2 year, 24 hour rainfall event was determined to be 5.36 inches. These values was derived from National Oceanic Atmospheric Association's National Weather Service Meteorological Design Studies Center, Precipitation Frequency Data Center, accessed September 14. The pre-event design flow was calculated for each HUC 7 watershed according to methodology developed by Gotvald, et. al., 2012. The total pre-fire runoff from a 2 year recurrence interval storm was calculated to be 101 cubic feet per second per square mile. The adjusted design flow was calculated based on the reduction of infiltration from both high and moderate intensity burn areas. Increases in runoff were generally low due to the small amount of total watershed acreage affected by high and moderate severity burns. The total post-fire runoff in response to a 2 year recurrence interval storm was calculated to be 116 cubic feet per second. This value shows an overall increase in total runoff of by 15 cfs or a 15.2% as a result of the fire. More localized high severity burn areas (HUC7 or smaller watersheds) did show increases up to 83% in a specific location (Table 3 and Figure 3).

Value Catagory	Value at Risk	Description of Threat	BAER Critical Value	Probability	Magnitude	Risk
Property	Hydropower water diversion on Forest Service Lands	Threats to water system located on NFS lands that supply water to 5 MGW hydropower plant from flooding, erosion, sedimentation and debris flows.	N			
Property	Trinity County Road 311	Threats to road infrastructure for each stream crossing from Pelletreau Creek to Big Creekat the Forest Glen bridge across Glen Creek from flooding and debris flows.	N			
Property	Forest Roads	Threats to undersized culverts from flooding and debris flows are expected to plug or overtop and severly damage road infrastructure with loss NFS investment. Areas of concern include the 3N10, 3N14, and 31N13 roads (Refer to Engineers report).	Y	Very Likely	Moderate	Very High
Natural Resource	Water Quality	Threats to 303d – listed streams from increased sediment delivery. Impacts to watershed proccesses and functions that regulate erosion, large wood recruitment and sediment delivery in areas that burned at moderate and high severity. Threats to water quality can potentially impact beneficial uses such as habitat for ESA-listed aquatic species, domestic water supply systems, and capacity and productivity of hydropower facilities.	Y	Likely	Moderate	High

6. Response Actions Recommended to Mitigate the Risk

Road Treatments

Replace plugged and damaged culverts with functional culverts. Replace undersized culverts or add rolling dips to improve road drainage for roads located within or below high severity burn areas (Refer to Engineers report for locations of undersized crossings and treatment recommendations). These areas will likely experience increased runoff as a result of the fire. Please refer to Table 3 for more detailed flood flow ratio increases. Use storm patrols; remove storm debris; clean sediment from culvert inlets on level 3 and 4 roads located in or have drainage from moderate and high severity burn areas and access can occur safely.

Administrative Closures

It is recommended that administrative closures be considered on all level 2 roads during the wet season of November through May for a minimum of 1 year and up to 3 years after the fire until natural vegetation has been established. This will prevent vechical traffic from damaging critical water control facilities incorporated in to these roads.

7. Consultations

It is recommended that USFS consult with the following:

California Water board, Humboldt Bay Municipal Water District for water quality concerns,
Trinity County Roads department for county roads below the burned area, and
NRCS for mitigating risk to private property values at risk.
Special Use Permit holder for the Big Creek R-7 Hydro power diversion facility for potential changes in flow and water quality due to upstream fire effects.

8. References

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