SOILS REPORT FOR THE SOUTH COMPLEX
Shasta-Trinity NF
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I. Resource Condition Assessment

A. Objectives

Surveyed and analyzed the burned area for:

- Threats of loss of soil productivity
- Accelerated soil erosion
- Degradation of water quality, riparian, and fisheries habitat
- Increased risk for flood and debris flow
- Threats to life, property, and natural resources that may result from these above

B. Methods

Characterize Burned Area Soils: Used existing soil survey information to map and describe soils burned area soils. Conducted field surveys to verify soil properties and describe soil resource condition.

Review Burned Area Reflectance Classification Satellite Image: Utilized the BARC to produce an accurate soil burn severity map in a short timeframe. The BAER Team acquired and merged 2 BARC images which covered most of the burned area. Minor adjustments, following field review, were made. Details on adjustments and development of the final soil burn severity map are available in the project file.

Conduct Soil Burn Severity Survey: The soil burn severity survey was conducted by aerial and ground based reconnaissance of the River Complex burned areas. Soil burn severity was interpreted according to the definitions in the Field Guide for Mapping Soil Burn Severity (http://www.fs.fed.us/rm/pubs/rmrs_gtr243.pdf). Soil burn severity indicators include depth, color and character of ash; size and amount of live fuels consumed; amount of litter consumed; condition of plant root crowns; loss of soil structure; development of water repellency; and soil crusting. In areas where pre-fire vegetation was primarily conifer forest, live needle consumption and consumption of forest floor litter/duff provide the most useful indicators of burn severity.

General Burn Severity Criteria

Burn Severity	Ash Color	Canopy Consumed	Size of Material Consumed
High	white/red	More than 80%	More than 3/4 inch
Moderate	black/gray/white	40-80%	1/4-3/4 inch
Low	black/gray	Less than 40%	0-1/4 inch

Map Unit Concepts: Low soil burn severity was mapped where site factors indicated low or moderate severity on the entire area. Moderate severity areas were mapped where some site factors with high or low burn severity occurred on less than 40% of the area. Conversely, high severity areas were mapped where units contained patches of low or moderate burn intensity comprising up to 40% of the map unit.

Determine Hydrophobic Soil Conditions: Collected field data to determine the degree and extent of fire induced water repellent (hydrophobic) conditions for comparison with background (natural) hydrophobicity.

Predict Potential Rates of Soil Erosion and Determined Erosion Hazard Ratings for the Burned Area: Calculated pre-fire/post-fire potential soil erosion with the ERMiT model (http://forest.moscowfsl.wsu.edu/cgi-bin/fswepp/ermit/ermit.pl). Existing information from the Shasta-Trinity National Forest Soil Survey to describe pre-fire soil erosion hazard ratings was used for this report.

C. Summary of Findings

Soil Map Units within the Lake Burned Area (from Shasta-Trinity NF Soil Survey) and Project Soils Report generated from the Web Soil Survey

Soil Name	Taxonomic Subgroup	Particle Size Class.	Max. EHR	Susceptibility to Damage from Fire	Percent Area
Neuns Family	Dystric Xerochrepts	Loamy-skeletal	H	H	22
Deadwood Family	Dystric Xerochrepts	Loamy-skeletal	H	H	14
Holland Family, deep	Ultic Haploxeralfs	Fine-loamy	L	L	11
Goulding Family	Lithic Xerochrepts	Loamy-skeletal	H	H	8
Hohmann Family	Typic Xerochrepts	Fine-loamy	H	M	7
Chaix Family	Dystric Xerochrepts	Coarse-loamy	VH	H	6
Rock Outcrop			H	H	4
Hugo Family	Dystric Xerochrepts	Fine-loamy	L	L	4
Dunsmuir Family	Ultic Haploxeralfs	Fine-loamy	L	M	4
Beaughton Family	Lithic Argixerolls	Clayey-skeletal	H	H	4
Marpa Family	Ultic Haploxeralfs	Loamy-skeletal	M	L	2
Holland Family	Ultic Haploxeralfs	Fine-loamy	H	L	2
Typic Xerorthents	Typic Xerothents	Loamy-skeletal	H	H	2
Huntmount Family	Typic Haploxerolfs	Fine-loamy	M	M	2
Hugo Family, moderately deep	Dystric Xerochrepts	Fine-loamy	H	M	2
Dubakella Family	Mollic Haploxeralfs	Clayey-skeletal	L	H	1
Chawanakee Family	Dystric Xerochrepts	Loamy	VH	H	1
Weitchpec Family	Typic Xerochrept	Loamy-skeletal	L	H	1
Neuns Family, deep	Dystic Xerochrepts	Loamy-skeletal	L	L	1

Soil productivity and hydrologic function can be impacted by fire. Sensitivity of soil to impacts from fire is influenced by soil properties such as depth of surface layer, overall soil depth, rock content and texture. As shown in the preceding table, over 60% of the area has soils which have high susceptibility to the effects of fire. Soil productivity is likely impacted where heavy surface fuels were consumed but these areas are not extensive. Ground cover removal in moderate and high burn soil severity areas was extensive and high rates of erosion are expected in these areas. Pulse erosion following fire is a natural process.

Potential Physical, Chemical and Biological Fire Effects on Soil Resources: Fire effects on soil productivity range from beneficial to damaging, depending on fire severity, soil type, and site history. Adverse fire effects increase as burn severity increases and the effects are often proportional to the amount of surface litter and soil organic matter consumed.

Physical Effects:

- Loss of litter layer, soil and soil organic matter
- Loss of soil structure
- Hydrophobicity (formation of water repellent layer)
- In extreme cases, destruction of clay minerals

Chemical Effects:

- Increase in pH
- Loss of cation exchange capacity
- Loss of nutrients by volatilization, in fly ash, or by leaching
- Increase plant available N (ammonia) under low severity burns
- Oxidation reactions from extremely severe burning can discolor the surface soil
- Potential for increased release of heavy metals in contaminated soils

Biological Effects:

- Direct mortality of soil organisms and loss of their habitat with soil heating

Severe Burning of Duff, Litter, and Soils:

Severe Burning of the litter, duff, and soil effects soil cover, infiltration, organisms, and nutrients:

- Loss of effective ground cover leaves soil susceptible to erosion
- Debris movement and dry ravel may increase when small organic debris dams are burned out
- Increased water repellent (hydrophobic) soil limits water infiltration. Surface hydrophobicity may protect the soil from erosion but significantly increase channel scour caused by accelerated runoff. Additionally, when a hydrophobic layer forms below a

surface layer, the risk of the surface layer "slicking off" is increased. Stronger (more water repellent) and deeper hydrophobic layers occur in sandy soils.

- Mortality of some soil organisms and combustion of surface soil organic matter
- Volatilization or release and increased mobility of some soil nutrients

The following soil burn severity tables show burn severity for the whole burned area and sub-watersheds.

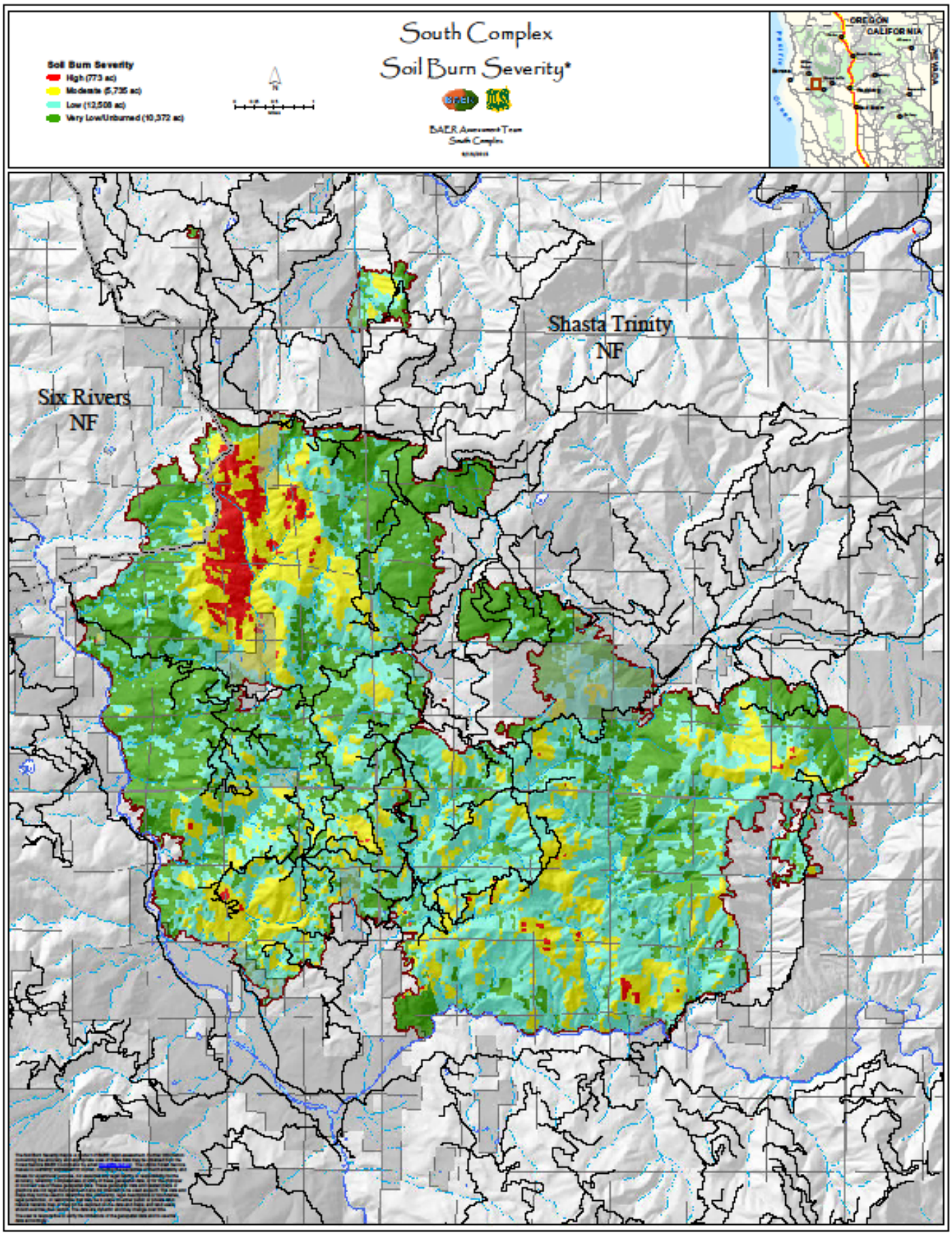
Soil Burn Severity for the South Complex Fire

Severity	Acres Burned	Percent
Very Low/Unburned	10,372	35
Low	12,508	42
Moderate	5,735	20
High	773	3
	29,388	**100**

Vegetation in the burned area is generally conifer forest/woodland, hardwood forest/woodland, and mixed conifer and hardwood forest woodland. Small areas of shrub cover also occur. Vegetation size and density are variable throughout the burned area.

Watershed Soil Burn Severity Acres

HU 12 Watersheds	High	Moderate	Low	Very Low / Unburned	Total Inside Perimeter	Outside Perimeter	Total
Corral Creek	14	1,077	3,964	2,710	7,765	15,391	23,156
Eltapom Creek	617	2,125	3,022	3,845	9,609	2,939	12,548
McDonald Creek-Trinity River	1	66	143	204	415	19,422	19,838
Olsen Creek-Hayfork Creek	52	1,306	3,788	877	6,023	28,914	34,937
Pelletreau Creek-South Fork Trinity River	89	1,160	1,591	2,735	5,575	31,094	36,669
Total	**773**	**5,735**	**12,508**	**10,372**	**29,388**	**97,760**	**127,148**


South Complex
Soil Burn Severity*
Soil Burn Severity
High (773 ac)
Moderate (5,735 ac)
Low (12,508 ac)
Very Low/Unburned (10,372 ac)
BAER Assessment Team
South Complex
OREGON
CALIFORNIA
Shasta Trinity
NF
Six Rivers
NF

The vast majority of the burned area has a mosaic pattern of unburned, very low and low soil burn severity. Notable areas of large blocks of high and moderate soil burn severity occur in the upper reaches of Buckhorn Creek and Young Gulch.

Erosion Hazard Rating:
Pre-fire erosion hazard for burned area soils was obtained from existing soil erosion hazard rating information in the Shasta Trinity NF Soil Survey. The EHR interpretation is based on soil properties such as soil texture, slope, aggregate stability, infiltration rate, subsoil permeability, depth to restrictive layers, and soil rock content. The rating is the maximum EHR for the soil map units. Actual pre and post fire erosion potential is better reflected by the ERMiT modeling runs for this project.

Erosion Hazard Ratings

EHR	Low	Moderate	High or Very High
Acres	6024	9,786	13,602

Soil heating affected aggregate stability, canopy cover, ground cover, and infiltration rate. Before the fire, most of the area had protective vegetative ground cover in the form of litter, duff, or ground vegetation. In the high burn severity areas, little or no vegetative ground cover remains and the potential for re-establishment of ground cover within the first year following the fire is low.

Erosion Potential:
Erosion response is heavily influenced by soil burn severity and hill slope. The burn affected soil aggregate stability, canopy cover, ground cover, and infiltration rates. Before the fire, most of the forested areas had protective ground cover in the form of litter, duff, or ground vegetation. In high and moderate soil burn severity areas, it is highly likely that increased rates of soil erosion and sediment delivery to stream channels will occur, in the first and second year following the fire, particularly on steep slopes.

ERMIT Erosion Model Outputs for the First 2 years Following the Fire

Average Erosion Potential (tons/acre)

	10 Year Storm	5 Year Storm	2 Year Storm
Year 1	20.4	11.2	7.0
Year 2	15.4	7.7	4.3
24 month total	35.8	18.9	11.3

Using a 2 year storm event (50% chance of exceedance) erosion rates ranged from 0 tons/acre to 24 tons/acre one year after the fire. By year two erosion rates are predicted to drop to the range of 0 tons/acre to 19 tons/acre. After five years the average erosion rate is predicted to be 2 tons/acre. Erosion in a mature forest under normal conditions is said to be 2 tons/acre/year.

ERMiT allows users to predict the probability of a given amount of sediment delivery to the base of a hillslope following variable burns on forest, rangeland, and chaparral conditions in each of five years following wildfire. The ERMiT model can be accessed at http://forest.moscowfsl.wsu.edu/fswepp/.

ERMiT Model Assumptions and Inputs:
- Custom slope lengths were created for ERMiT runs
- Soil surface textures were variable but loam and clay loams were common
- Soil Rock Content ranged from 5-50 %/Volume

The majority of the high soil burn severity in the South Complex occurred on the east slope of Underwood Mountain and the adjacent slope to the east. This area is in the Buckhorn Creek drainage which is a tributary to Eltapom Creek. Buckhorn Creek is a drinking water source to residents at Skunk Ranch. This area of the Buckhorn Creek drainage is comprised of 1427 acres of mostly high and moderate soil burn severity. ERMiT modeling of this area with no treatment produced an erosion potential of 27.1 tons/acre after the first year and 18.5 tons/acre the second year using a 20% chance of exceedance (equivalent to a 5 year storm event). By five years after the fire the erosion potential is expected to drop to 2.4 tons/acre, which is almost back to background erosion rates for an unburned forest.

Average Sediment Potential (tons/acre)

	10 Year Storm	5 Year Storm	2 Year Storm
Year 1	12.2	6.7	4.2
Year 2	9.2	4.6	2.6
24 month total	21.5	11.3	6.8

ERMiT estimates and accounts for hillslope re-deposition with sediment production numbers are delivery to the bottom of the hillslope. Many modeled hillslopes in this fire have streams at the base of the slope and sediment is deposited into ephemeral and intermittent streams. Therefore it is roughly estimated that 60% of sediment estimates above would be delivered to the fluvial system.

Water Repellent Soils and Increased Runoff:
Water-Repellent Soils: The degree and extent of water repellent soils is largely unknown due to limited collection of field data. The extent of water repellent soils is estimated to be 4,525 acres or 70% of the moderate and high burn severity areas. However, observations indicated strong repellency at the surface over several vegetation types and moderate to high burn severities. Water repellent soils were also observed in unburned areas. The pattern of water repellent soils is likely to be patchy and mosaic.

Repellency will be largely responsible for moderate soil burn severity expected to have a watershed runoff response similar to high. Repellency also occurred naturally in unburned areas. Without repellency, these soils have rapid infiltration rates and surface runoff and erosion would normally be localized to shallow soil areas and/or steep slopes.

Increased runoff due to hydrophobic conditions is reflected in the peak flow analysis contained in the Hydrology Report. Increased overland flow due to the hydrophobic conditions may increase hill-slope rill and sheet erosion. Hydrophobic layers will usually take six months to two years to break down. Plant root development, soil microbial activity, and freeze-thaw cycling all contribute to the degradation of hydrophobic conditions.

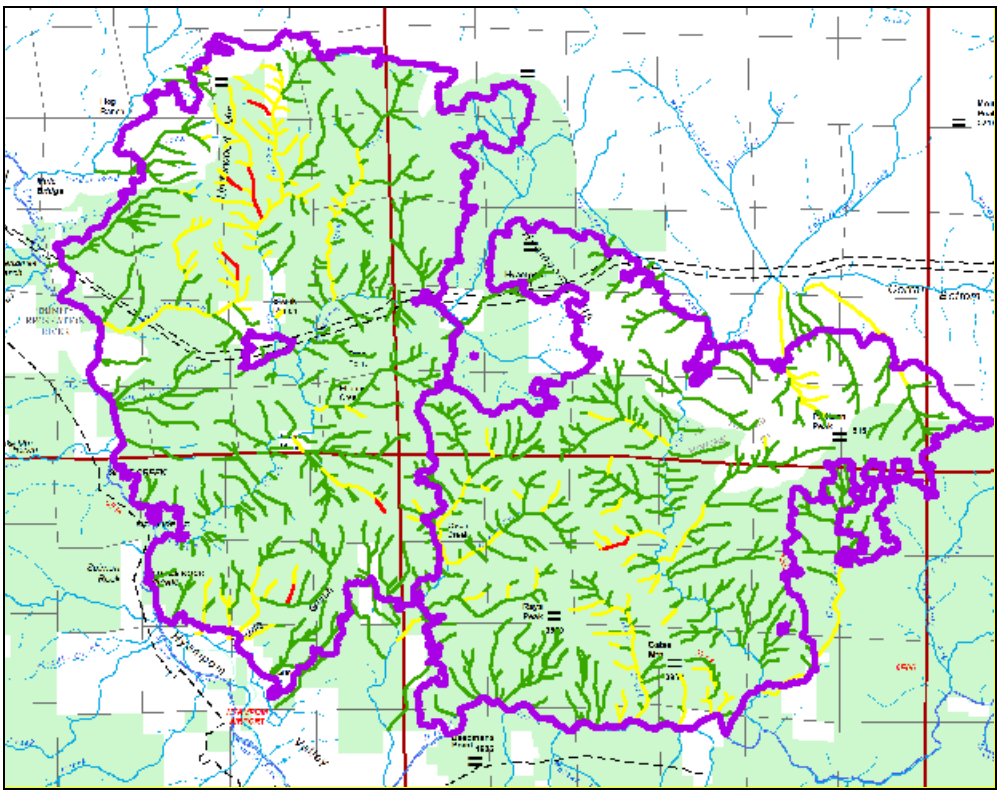
Dry Ravel: Dry ravel does not appear to be a dominant process in this burned area but was observed in very steep areas. Dry ravel increases after a fire because the vegetation that was holding the soil in place on the hillside is removed and/or aggregate stability is lowered by the fire.

Erosion Summary Statements

- Ash is likely to be mobilized during the first post fire runoff events. Some ash laden runoff and downstream transport of suspended/dissolved materials is likely to occur even in watersheds with relatively low amounts of moderate and high burn.

- Notable large areas of high and moderate soil burn severity occur in the upper reaches of the Buckhorn Creek and Young Gulch. Rates of runoff, soil erosion and sedimentation will be significantly higher in these areas for 3-5 years following the fire. USGS debris flow modelling shows increased potential for debris flows within and downstream from these areas.

Graphical Results of USGS Debris Flow Predictive Model
The following map shows the combined hazard rating for the 25 year storm.



Predictive debris flow model results were provided by the USGS-Geologic Hazards Division. http://landslides.usgs.gov/hazards/postfire_debrisflow/. A variety of storms were modelled but, for the purposes of this assessment, the discussion of debris flow risk is based on field observations and visual review of the maps generated from the USGS model.

The model outputs used are:

- Probability of debris-flow occurrence in % and classified probabilities where 1 = 0-20%, 2 = 20-40%, 3 = 40-60%, 4 = 60-80%, 5 = 80-100%
- Predicted volume for the design storm, in m^3 and classified volume predictions where 1 = <1,000m^3, 2 = 1,000-10,000m^3, 3 = 10,000-100,000m^3, 4 >100,000m^3
- Combined (numeric) hazard ranking = classified volume + classified probability
- Classified relative hazard ranking is based on the combined (numeric) hazard rating where 1-3 = low, 4-6=moderate and 7-9=high
- Stream segment predictions associated with the 25 year recurrence interval rainstorm
- Green=low, Yellow=moderate and Red= high.

II. Emergency Determination

Soil Productivity Emergency Determination

Although very high rates of post fire soil erosion are expected to occur in steep and severely burned areas, **an emergency for long-term soil productivity was not caused by the direct effects of fire in these fire adapted ecosystems.** Despite high rates of post-fire soil erosion in places, burned area soils will support recovery of native fire adapted vegetation in the burned area.

Six fires, totaling over 11,000 acres, have occurred in the South Complex area over the past 30 years. Past fire impacts, in combination with fire effects associated with the South Complex, increase risk for impacts to long term soil productivity. Additionally, infestation and/or spread of noxious weeds in these areas may adversely impact recovery of native vegetation and/or long-term soil productivity.

III. Treatments to Mitigate the Emergency.

Mulch treatments to lower the potential for soil erosion, increased runoff, flooding and debris flows was were considered but not recommended.

IV. References/Consultations:

- BAER team members
- USDA Forest Service, FSH 2509.13; Burned Area Emergency Rehabilitation Handbook
- USDA, NRCS. Soil Survey of the Shasta Trinity National Forest
- Web Soil Survey. http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
- Field Guide for Mapping Post Wildfire Soil Burn Severity
- BAER Treatments Catalog, 0625-1801-SDTC, 2006
- ERMiT model. http://forest.moscowfsl.wsu.edu/cgi-bin/fswepp/ermit/ermit.pl
- USGS Debris Flow Model. http://landslides.usgs.gov/hazards/postfire_debrisflow/