United States Department of Agriculture

Rim Fire Reforestation (45612)
Watershed Management Report

Prepared:

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Forest Service

Stanislaus National Forest

April 2016

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WATERSHED

Analysis Framework: Statute, Regulation, Forest Plan and Other Direction

Protection of water quantity and quality is an important part of the mission of the Forest Service (USDA 2007). Management activities on NFS lands must be planned and implemented to protect the hydrologic functions of forest watersheds, including the volume, timing, and quality of streamflow. The following direction is relevant to the action alternatives as they affect water resources.

The Clean Water Act of 1948 (as amended in 1972 and 1987): establishes as federal policy for the control of point and non-point pollution, and assigns the states the primary responsibility for control of water pollution. Compliance with the Clean Water Act by national forests in California is achieved under state law (below).

Non-point source pollution on national forests is managed through the Regional Water Quality Management Handbook (USDA 2011), which relies on implementation of prescribed regional best management practices (BMPs), as well as national BMPs (USDA 2012). There are 35 regional BMPs and 23 National BMPs relevant to this project. These BMPs and their associated management requirements are listed in Chapter 2 and in Appendix B of the Watershed Report. One of the Regional BMPs (BMP 2.13) requires the development of an Erosion Control Plan for projects with ground-disturbing activities. A plan was developed for this project and is included in the project record.

The California Water Code consists of a comprehensive body of law that incorporates all state laws related to water, including water rights, water developments, and water quality. The laws related to water quality (sections 13000 to 13485) apply to waters on the national forests and are directed at protecting the beneficial uses of water. Of particular relevance for the Proposed Action is section 13369, which deals with non-point-source pollution and best management practices.

The Porter-Cologne Water-Quality Act, as amended in 2006, is included in the California Water Code. This act provides for the protection of water quality by the state Water Resources Control Board and the regional water quality control boards, which are authorized by the U.S. Environmental Protection Agency to enforce the Clean Water Act in California.

EO 11988 Floodplain Management (1977) and 11990 Protection of Wetlands direct federal agencies to avoid to the extent possible the impacts associated with the destruction or modification of floodplains and wetlands.

A Conditional Waiver of Waste Discharge Requirements for Discharges Relating to Timber Harvest Activities is issued to the Forest Service by the Central Valley Regional Water Quality Control Board (Water Board). These waivers are required for all timber harvest activities that will or will likely discharge waste that could affect the quality of the waters of the State.

The Forest Plan Direction (USDA 2010) includes standards and guidelines for Watershed Management. The standards and guidelines associated with Riparian Conservation Objectives that are applicable to this project are described in the “Compliance with the Forest Plan and Other Direction” section of this report.

Effects Analysis Methodology

The five project alternatives were analyzed at three watershed scales to determine direct, indirect and cumulative watershed effects of the Rim Reforestation Project. These included large scale watersheds (40,000 to 250,000 acres) and two nesting smaller scales: 10,000 to 40,000 acres and 2,000 to 10,000 acres.

Beneficial uses of water and water quality objectives in the California Water Quality Control Plan (Basin Plan) of the Water Board (CVRWQCB 2011) were utilized as a regulatory benchmark regarding the existing condition and to assess the effects of the proposed action and its alternatives on water quality. The water quality parameters considered in the watershed analysis were water temperature, sediment related parameters, and herbicides. These are the pollutants with the potential of being affected by project management activities.

Assumptions Specific to Watershed

- Watershed condition from the Rim Fire will recover, as will effects of the Rim Reforestation project.
- Water quality effects will occur at a magnitude below adversely affecting beneficial uses of water unless uncontrollable events occur. These include an abnormally high amount and/or intensity of precipitation or the occurrence of another fire in the project area as the watersheds recover from the effects of the Rim Fire.
- Water Quality Best Management Practices will be implemented and effective unless uncontrollable factors occur. These include an abnormally high amount and/or intensity of precipitation or the occurrence of another fire in the project area as the watersheds recover from the effects of the Rim Fire.
- See Appendix A of the Watershed Report for a list of assumptions associated with Equivalent Roaded Acres (ERA) modeling for cumulative watershed effects.

Data Sources

- Satellite Imagery – Worldview, Landsat, and Light Detection and Ranging (LiDAR)
- Forest Land Management Databases and planning documents – Forest Service Activity Tracking System (FACTS) and the Schedule of Proposed Actions (SOPA)
- Stanislaus StreamScape Inventory – Stream Survey Data from 2005-2012
- Benthic Macroinvertebrate Inventory, Clavey River Ecosytem project (CREP 2008)
- Burned Area Emergency Response Program – Past Fire information; Rim Fire watershed data
- Geographic Information Systems (GIS)
- Stanislaus National Forest Wild and Scenic River Study 1991
- Tuolumne River Wild and Scenic Management Plan 1988 (reprint 2002)
- CalFire – Timber Harvest Plans (THPs), Non-Industrial Timber Management Plans (NTMPs), and Notices of Emergency Timber Operations (Frese 2013-2014)
- Yosemite National Park – GIS shapefile with past and future activities within Park boundaries

Watershed Indicators

- Water Quality Parameters – temperature, sediment, herbicides (measure: meet water quality objectives)
- Stream Condition – channel form, streambank stability, pool sediment (measure: SSI protocol)
- Riparian Vegetation – recovery (measures: no damage from project activities; recruitment unimpeded)
- Ground Cover – riparian areas (measures: retention of existing; addition in riparian areas and watershed sensitive areas (WSA) (acres))
- Cumulative watershed effects (measure – ERA)

Watershed Methodology by Action

The direct, indirect and cumulative effects of the five project alternatives were evaluated using the following methods:

DIRECT AND INDIRECT EFFECTS

- Literature Review – A thorough review of the literature was conducted related to the direct and indirect effects of actions that affect the watershed resource proposed in this project.
- Modeling. Human Health and Ecological Risk Assessment (SERA, multiple references) were conducted to predict effects of project herbicides on water quality.
- Monitoring – A review of Water Quality Best Management Practices Evaluation Program (BMPEP) results on the Stanislaus National Forest (STF) for activities related to the project was conducted. BMPEP monitoring results over the past decade were useful for predicting outcomes of the management activities proposed in this project. In addition, a review of past herbicide monitoring results on the Stanislaus National Forest was conducted to help inform expected effects of herbicides on water quality related to this project (Watershed Report).
- Field Evaluation – Field review of proposed treatment units and watershed conditions within the project area was conducted.
- GIS – GIS was used for analyzing data collected from fieldwork, satellite imagery products and forest databases related to the project.

CUMULATIVE WATERSHED EFFECTS

A Cumulative Watershed Effects analysis was conducted using the CWE model adopted by the Pacific Southwest Region of the USDA Forest Service as a method of addressing cumulative watershed effects (USDA 1990). The model is referred to as Equivalent Roaded Acre (ERA). ERA values are calculated using a computer model developed on the STF (Rutten and Grant 2008). See Appendix A for further details.

Affected Environment

The Rim Fire started on August 17, 2013 in a remote area of the Stanislaus National Forest near the confluence of the Clavey and Tuolumne Rivers about 20 miles east of Sonora, CA. Exhibiting high to extreme fire behavior with multiple flaming fronts, the fire made runs of 30,000 to 50,000 acres on two consecutive days. It quickly spread up the Tuolumne River watershed and its main tributaries: North Fork Tuolumne, Clavey River, Cherry Creek, Middle Fork Tuolumne and South Fork Tuolumne. It also overlapped into the Merced River at the southern edge of the fire. Overall, 98% of the Rim Fire occurred in the Tuolumne River watershed. Over several weeks it burned 257,314 acres, or 400 square miles, including 154,530 acres of National Forest System (NFS) lands. The fire also burned within Yosemite National Park (78,895 acres), Sierra Pacific Industries private timberland (16,035 acres), other private land (7,725 acres) and Bureau of Land Management (BLM) land (129 acres).

The Rim Fire is the third largest wildfire in California history and the largest wildfire in the recorded history of the Sierra Nevada. It is also California's largest forest fire, burning across a largely conifer dominated forest landscape. The two larger fires were wind driven brush fires near San Diego in 2003 and in Lassen County in 2012.

Watershed Setting

WATERSHED DESCRIPTION

The Rim Fire burned through numerous watersheds in the central and southern portions of the Stanislaus National Forest, and some overlap eastward into Yosemite National Park where the remainder of the fire occurred. These watersheds are an important component of the water supply, fish and wildlife habitat, recreation, timber production and other values of the Sierra Nevada mountain range. Portions of the watersheds within the Rim Fire perimeter burned in several fires during the 20th century, while some areas have not burned in over 100 years. About 98% of the Rim Fire burned within the Tuolumne River watershed. The remaining 2% burned in the North Fork Merced River watershed along the southern edge of the fire.

Watersheds in the Rim Fire are delineated in accordance with the national watershed classification system (USGS 2013). This system is a spatial hierarchy of eight nesting watershed size classes ranging from very large (greater than 250,000 acres) to very small (less than 2,000 acres). This classification system uses the term Hydrologic Unit Code (HUC) to describe all watershed size classes (see Table 1). They are called HUC levels and are numbered in order from 1 to 8 in descending size class. Each HUC level code is a two digit number that ties to a watershed size and name. For example, HUC Level 1 is a two digit code whereas as HUC Level 5 is a 10 digit code. Table 1 shows an example of how this nesting system applies to the Rim Fire watersheds.

Table 1 Hydrologic Unit Code System (HUC)

HUC Level	HUC Name	HUC Size (average acres)	Rim Fire Examples
1	Region	100,000,000	NA
2	Sub-region	10,000,000	NA
3	Basin	7,000,000	San Joaquin River
4	Sub-basin	450,000	Tuolumne River
5	Watershed	40,000 to 250,000	Clavey River
6	Sub-watershed	10,000 to 40-000	Reed Creek
7	Drainage	2,000 to 10,000	Reynolds Creek
8	Sub-drainage	Less than 2,000	Lost Creek

The STF includes HUC Level 4 through 8 watersheds. (The term watershed is often used generically even though each HUC level has a unique name). The HUC Level 4 watersheds on the Forest are the headwaters of large rivers that continue downstream off the Forest (e.g., Tuolumne River).

While some of the HUC Level 5 watersheds on the forest extend somewhat downstream and upstream from the forest boundaries most are entirely within the forest. Many more HUC Levels 6 watersheds are within the forest boundary and nearly all HUC Level 7 and 8 watersheds are contained within the forest.

Within the Rim Fire there are nine HUC 5 Level watersheds. Within these, there are 18 HUC Level 6 watersheds. Table 2 displays the HUC Level 5 and HUC Level 6 watersheds relevant to the fire area, including total HUC Level 5 and HUC Level 6 watershed acreage. Note that the HUC Level 6 watershed acreage does not add up to that of 7 of the 9 HUC Level 5 watersheds. This is because in those watersheds there are additional HUC Level 6 watersheds that were fully outside the fire perimeter. Watershed acreage within the Stanislaus National Forest boundary is less in some watersheds and will be described in the existing condition and environmental consequences sections of this report. The HUC Level 5 watersheds in Table 2 are listed clockwise around the fire area beginning where the main channel of the Tuolumne River exits the Rim Fire perimeter.

Given the large size of the fire, the HUC Level 6 watersheds are the most appropriate scale for watershed description and analysis of the effects of the Rim Reforestation project. HUC Level 5 watersheds will be described for spatial context and broad scale analysis, and selected HUC Level 7 watersheds will be discussed where more detailed analysis is indicated. Figure 1 displays the HUC Level 6 watersheds relevant to the Rim Fire.

Table 2 Rim Fire Area Principal Watersheds and Condition Overview

HUC Level and Name	Acres	HUC within Rim Fire (%)	HUC within NF (%)	Soil Burn Severity (%)		
				High	Mod	Low[3]
Rim Fire Summary[1]		-	69	7	37	56
5 – Big Creek-Tuolumne River	81,721	56	70	5	27	68
6 – Big Creek	18,734	1	52	0	1	99
6 – Grapevine Creek-Tuolumne River	23,817	77	82	1	26	73
6 – Jawbone Creek-Tuolumne River	27,629	99	100	14	56	30
7 – Corral Creek	4,581	100	100	31	58	11
7 – Lower Jawbone Creek	5,670	100	100	10	75	15
5 – North Fork Tuolumne River	63,849	9	92	0	3	97
6 – Lower North Fork Tuolumne River	34,210	17	89	1	6	93
5 – Clavey River	100,645	52	100	3	15	82
6 – Lower Clavey River	17,871	100	100	4	45	51
7 – Bear Springs Creek-Lower Clavey River	7,090	100	100	7	43	50
6 – Middle Clavey River	26,912	69	100	2	11	87
6 – Reed Creek	24,527	66	100	7	16	77
7 –Lower Reed Creek	7,495	100	100	21	41	38
5 – Cherry Creek	90,892	24	93	3	12	85
6 – Lower Cherry Creek	24,383	84	98	10	43	47
7 – Granite Creek	4,126	100	100	30	62	8
6 – Upper Cherry Creek	16,344	7	100	0	1	99
6 – West Fork Cherry Creek	26,149	1	100	0	1	99
5 – Eleanor Creek[2]	59,906	28	2	1	9	90
6 – Miguel Creek-Eleanor Creek	15,798	76	6	4	31	65
5 – Falls Creek-Tuolumne River[2]	124,244	19	4	1	5	94
6 – Poopenaut Valley-Tuolumne River	18,232	99	30	6	33	61
5 – Middle Fork Tuolumne River[2]	46,635	68	34	7	32	61
6 – Lower Middle Fork Tuolumne River	14,928	100	100	6	57	37
6 – Upper Middle Fork Tuolumne River	31,707	53	3	8	21	71
5 – South Fork Tuolumne River[2]	57,855	88	41	4	29	67
6 – Lower South Fork Tuolumne River	19,988	100	100	4	43	53
6 – Upper South Fork Tuolumne River	37,866	83	9	3	22	75
5 – North Fork Merced River	79,110	8	81	0	3	97
6 – Bull Creek	21,064	6	100	0	2	98
6 – Bean Creek-North Fork Merced River	36,739	14	92	0	4	96

[1] Soil Burn Severity% is of the fire area.
[2] Substantial portion of the fire extends east into Yosemite National Park.
[3] Low and Unburned.

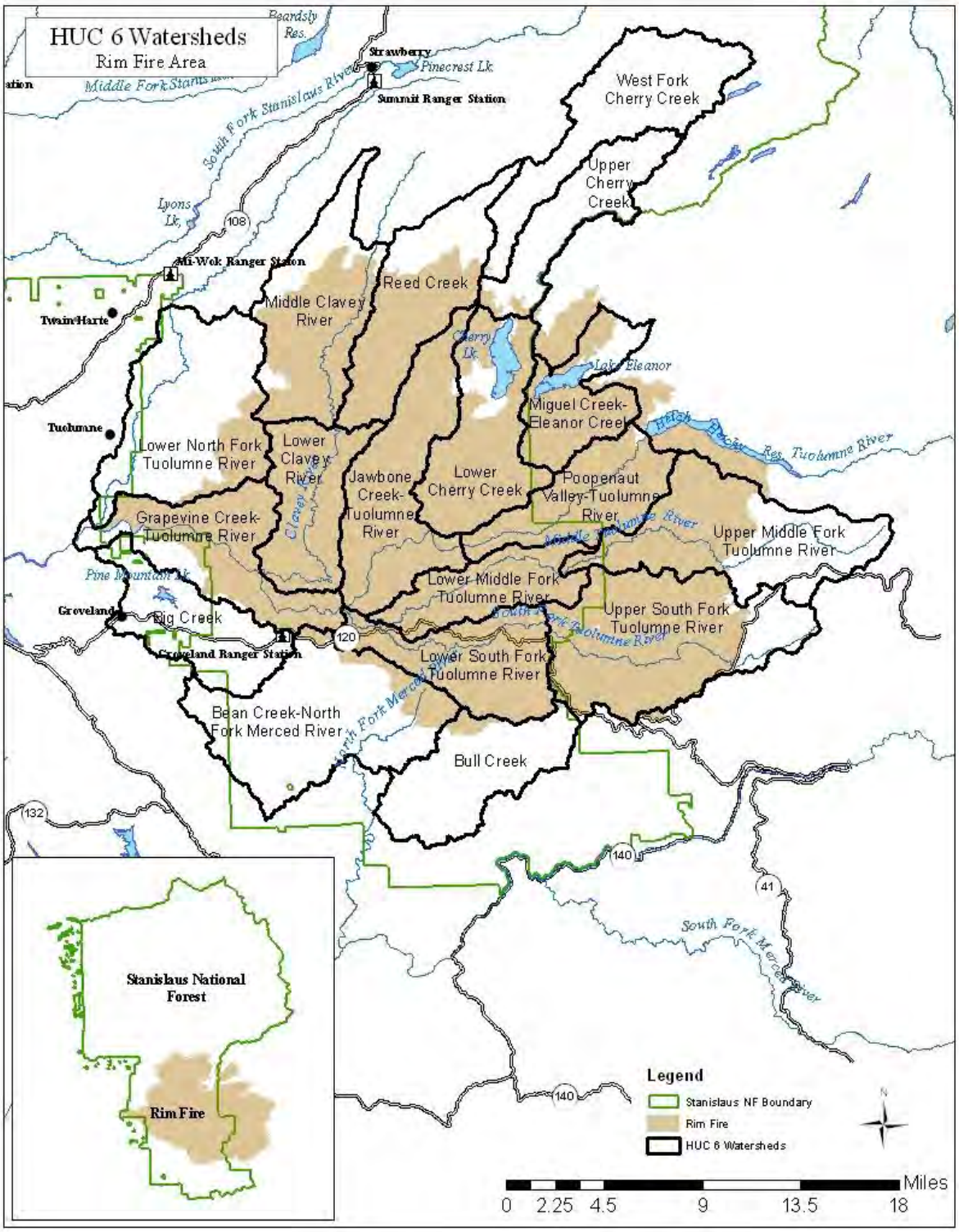

Figure 1 HUC Level 6 Watersheds in the Rim Fire Area

WATERSHED CHARACTERISTICS

The 400 square mile Rim Fire encompasses a diverse and complex landscape. The watersheds within the fire perimeter rise in elevation from about 1,000 to 7,000 feet and include rock-rimmed river canyons, mountain meadows, major rivers and small secluded streams.

Climate

The Rim Fire area is within the Mediterranean climate zone designated Csa in the Koppen-Geiger Climate Classification System (Kottek et al. 2006). This zone consists of warm, mostly dry summers and cool, wet winters. In degrees Fahrenheit, Rim Fire area average summer high temperatures are about 95 at the lowest elevations and 75 at the higher elevations. Average low winter temperatures are about 30 degrees at the lowest elevations and 20 degrees at the highest. Extreme high and low temperatures vary about 10-15 degrees from average. Precipitation increases in elevation, with a range of about 30 to 50 inches per year across the fire area. Annual variation in precipitation can vary up to about 50 to 150% of average depending on wet or dry years. About 80% of the annual precipitation occurs from November through March. Rain dominates areas below about 4,000 feet though occasional snow occurs in the coldest months. Between 4,000 and 5,000 feet rain and snow is mixed, and above 5,000 feet snow is more common across the landscape. Warm frontal storms can raise snow levels to 7,000 feet or higher.

Geology and Geomorphology

The Rim Fire landscape includes all three of the principal geologic types in the Sierra Nevada mountain range. Metamorphic rock occupies much of the lower elevations and the Sierra granitic batholith and relic volcanic flows generally occur at higher elevations.

Landforms within the Rim Fire are dramatic, punctuated by river canyons, glaciation, a lava cap, and large expanses of gentle to moderately steep slopes spread across much of the fire area.

The main geomorphic feature in the Rim Fire is the Tuolumne River canyon, which has carved an east-west chasm about 2,500 to 3,000 feet deep through the entire length of the fire area. The adjacent Clavey River has a similarly deep canyon in its lower reaches. The Jawbone Lava Cap lies atop the broad east ridge of the lower Clavey River, a remnant of an ancient lava flow that originated east of the Sierra Nevada mountain range prior to the Sierra uplift about 10 million years ago. North of the Tuolumne canyon the watersheds gradually rise to about 6,000 feet from Duckwall Mountain on the west to Woods Ridge on the east, near Cherry Lake. The landscape climbs to almost 7,000 feet west of Cherry Lake.

Glaciation is another striking geomorphic feature in some eastern locations of the Rim Fire. Glacial periods up to about 90,000 years ago have scoured the upper portions of Tuolumne River canyon as well as Cherry and Eleanor Creeks. Remnant small glaciated alluvial deposits are found in some stream valleys in the fire area down to about 4,500 feet.

The morphology of the landscape of the Middle and South Forks of the Tuolumne River south of the Tuolumne canyon to about state Highway 120 is the most gentle within the fire area. The river gradients are low until at their combined confluence they suddenly drop about 1,000 feet off into the Tuolumne Canyon near the Rim of the World vista point on Highway 120. The Upper South Fork Tuolumne watershed south of Highway 120 rises about 2,500 feet rather rapidly up its Big Creek tributary to Pilot ridge near the south edge of the fire area.

The Water Landscape

Rivers

The Rim Fire area is largely dominated by the Tuolumne River. It is the largest tributary of the San

Joaquin River, which originates in the southern Sierra Nevada and drains northward for about 200 miles to the San Francisco Bay delta. The Tuolumne River, with its headwaters at the Sierra crest in Yosemite National Park, has carved a spectacular river canyon for over 50 miles through the western part of the park and then down through the length of the Stanislaus National Forest, including the entire Rim Fire, before leveling out in the foothills.

The North Fork of the Merced River plays a minor role in the waterscape of the Rim Fire. The fire barely burned within it over the south ridge of the South Fork Tuolumne River.

Flow Regimes

The streamflow regime of the Tuolumne River watershed on the Stanislaus National Forest consists of a combination of free flowing and regulated flow river segments. The free flowing streams include the Clavey River and the North, Middle and South Forks of the Tuolumne River, which total about 103 river miles. Annual peak flows in these waters usually occurs during spring snowmelt runoff, often from late May to the middle of June. However, in years with large winter rain-on-snow storms, annual peak flows usually occur in December and January. The highest peak flows of record in the Tuolumne River have been recorded in these months. The annual low flow period is from late summer through fall. While this time period rarely varies, the low flow rates in the free flowing streams can be very low in dry years with even the HUC 5 main channels dropping well below 10 cubic feet per second.

The regulated flow regime portion of the Tuolumne River watershed occurs downstream of Hetch Hetchy Reservoir on the river's main channel in Yosemite National Park and from two of its HUC level 5 tributaries, Cherry Creek and Eleanor Creek. These reservoirs alter flows along a total of about 41 river miles. The dams forming Hetch Hetchy reservoir as well as at nearby Cherry Lake and Lake Eleanor impound and release water on a schedule primarily designed to produce hydroelectric power and divert water out of the watershed for domestic use. These operations alter the annual natural flow regime by decreasing peak flows, increasing low flows, and altering the natural timing of both.

The North Fork Merced River is a free flowing stream. It is the furthest downstream tributary of the Merced River which originates at the Sierra Crest and runs westward through Yosemite National Park. The Merced River is a fully free flowing river upstream of the Sierra Nevada foothills.

Stream Channels

The morphology of the main channels of the HUC 5 level streams in the Rim Fire are largely bedrock controlled. They rest in streambeds where bedrock dominates, though the streams also include boulders and cobbles with finer particles in pools and at stream margins. Most of the channels have large pools between steeper sections. Minimal length of the stream gradient along these channels is gentle enough to accumulate excessive sediment; that is, they are efficient at transporting most sediment and woody debris in high flows, though some is retained. The free flowing streams are generally at equilibrium between sediment transport and accumulation. Their flows are little affected by forest management activities and show response only to large natural disturbances such as floods. The main channel of the Tuolumne River, due to sediment trapping in the reservoirs, may be somewhat sediment starved as happens downstream of most reservoirs. The watersheds upstream of the Tuolumne River reservoirs are strongly dominated by glaciated bedrock.

The smaller streams in the fire area watersheds have more variable morphology. Though they, too, are mostly bedrock controlled, some have low gradient sections intermittently along their paths toward the larger streams. These gentle sections are more sensitive to disturbance where their streambeds and banks consist of finer grained materials. They are thus more erodible and have greater susceptibility to alteration by management activities and floods.

Key Watershed Values

The main channel of the Tuolumne River throughout the length of the fire on the Stanislaus National Forest was congressionally designated in 1984 as a Wild and Scenic River under the Wild and Scenic Rivers Act of 1968. It is also home to one of the premier whitewater rafting runs in the United States, and is recognized internationally as well. Its challenging waters provide a unique recreational experience on the Stanislaus National Forest.

The Clavey River is a proposed Wild and Scenic River. At 47 miles in length it is one of the longest remaining free flowing streams in the Sierra Nevada. It is also designated as a Critical Aquatic Refuge (CAR) in the Forest Plan Direction (USDA 2010). At 100,000 acres, the Clavey River is the largest CAR in the Pacific Southwest Region of the Forest Service. The Clavey River is also the first designated wild trout stream by the California Department of Fish and Wildlife, established in 1971. It has also since been designated a Heritage Trout Water by CDFW – one of only ten streams in California that "best exemplify indigenous strains of native trout within their historic drainages" (CDFW 2014). In addition, the middle portion of the Clavey River watershed contains the largest contiguous remaining old growth forest area on the Stanislaus National Forest.

The lowest two miles of the South Fork of the Tuolumne River is an eligible Wild and Scenic River. This is the deeply carved river segment which drops steeply from where the Middle Fork of the Tuolumne River meets it to the main channel of the Tuolumne River 1,000 feet below.

Vegetation Communities

Vegetation is a critically important watershed component. It shades soil to hold moisture, inputs organic matter which builds soil and provides cover that minimizes erosion and stream sedimentation. It also helps store water in the soil by intercepting precipitation, thus reducing excessive runoff and producing high quality water.

Hillslope vegetation in the Rim Fire area is dominated by broad expanses of coniferous forests above the deep river canyons of the Tuolumne and Clavey Rivers. These mid-elevation forests consist mostly of the Sierra Nevada mixed conifer association, which includes ponderosa, white fir, sugar pine, Douglas fir and incense cedar. As elevations increase within the fire area, the mixed conifer belt grades into Jeffrey pine and red fir-lodgepole pine stands in some locations. Grass-oak woodlands and mountain chaparral communities dominate river canyon vegetation, and oak stands often occupy drier sites at mid-elevations.

The other principal vegetation community in the fire area is in the riparian zone along its numerous waterways and in wetlands such as meadows, springs, fens, and ponds. This vegetation consists of a combination of riparian obligate plants (those associated with easily available water) and non-obligate trees and shrubs such as conifers and hardwoods. While these plants occupy a small portion of the landscape they provide a disproportionately large value for vegetative diversity and support a wide range of aquatic, wildlife, recreational and aesthetic values. Principal obligate vegetation species in the Rim Fire area include dogwoods, maples, willows, alders, cottonwoods and aspens, and non-obligates are the conifer species commensurate with the elevations at which they mostly occur.

Watershed Condition

HISTORIC WATERSHED CONDITION

Past natural events and management activities provide context for understanding the existing and potential future condition of the watersheds in the Rim Fire Reforestation Project area.

Wildfire

There have been ten large fires over 1,000 acres fully or partly within the Rim Fire perimeter since 1950, most of which are orders of magnitude smaller than the Rim Fire. This portion of the Stanislaus

National Forest is truly a wildfire dominated landscape (as is the portion of the Rim Fire within Yosemite National Park). Figure 2 displays the fire history in the Rim Fire watersheds.

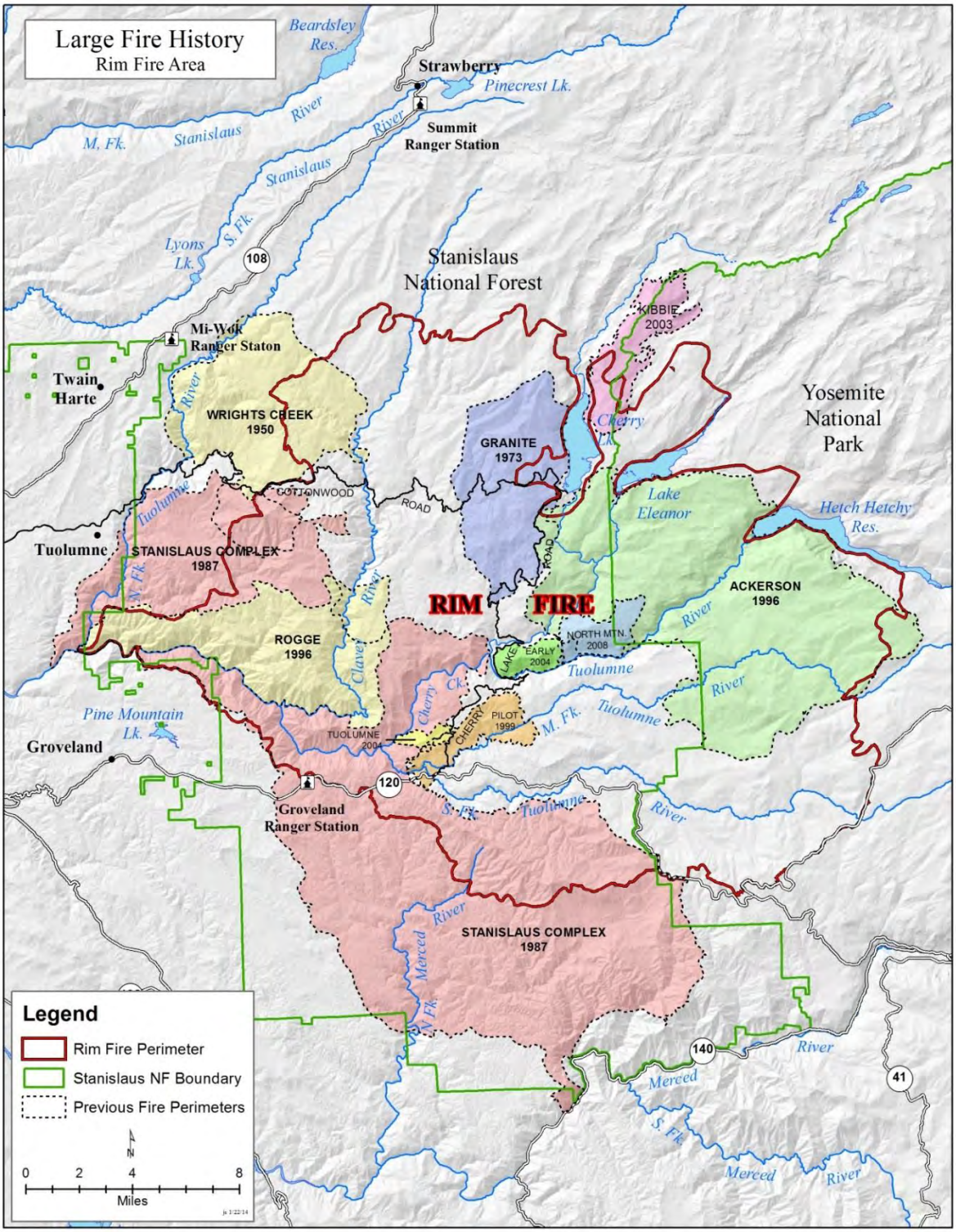

Figure 2 Fire History in the Rim Fire Area

The two largest fires, the Rim Fire and the Stanislaus Complex Fire of 1987 have some strikingly similar characteristics. Even though 26 years apart, both began in August in dry years and ended up burning a similar number of acres within the forest boundary. Both had nearly the same initial rate of spread –burning up to nearly 100,000 acres within the first five days - even though the fire causes were different. The 1987 fire was ignited by lightning; the Rim Fire was human caused. And in both fires, the initial rapid spread occurred soon after the fires entered the Tuolumne River canyon. Some areas within the Rim Fire perimeter, in portions of the Clavey River and in the Middle and South Forks of the Tuolumne River, have burned for the first time on record. Other areas have had overlapping burns twice and one other has burned up to four times. Table 3 describes the burn frequency in the Rim Fire area.

Table 3 Burn Frequency within the Rim Fire

Fire Name	Fire Year	Number of Times of Fire Occurrence, Including Initial Fire[1]	Years Reburn Occurred
Wrights Creek	1950	3	1987, 2013
Granite	1973	3	1996, 2013
Stanislaus Complex	1987	4	1996, 2004, 2013
Rogge	1996	2	2013
Ackerson	1996	3	1996, 2013
Pilot	1999	2	2013
Early	2004	2	2013
Tuolumne	2004	2	2013
North Mountain	2008	2	2013
Previously Unburned[2]	2013	1	NA

[1] Burned acreage of repeated fires within the Rim Fire perimeter varies widely due to size and location of overlapping fires.
[2] Areas within the Rim Fire which appear as unburned in Figure 2.

In addition to the occurrence of the numerous past wildfires in this area, burn mapping provides a more detailed assessment of where these fires have burned most severely. Figure 3 shows the fire history by soil burn severity to portray where these fires have burned hottest, often more than once.

Fires designated in this figure by the Stand Replacing Fire label indicate that soil burn severity mapping was not conducted or is not on record. This label is a surrogate measure that approximates a combination of high and moderate soil burn severity (see definitions below). Reforestation maps and data were used to locate where all trees were removed and/or the presence of timber plantations within a known fire perimeter to determine where stand replacing fire occurred.

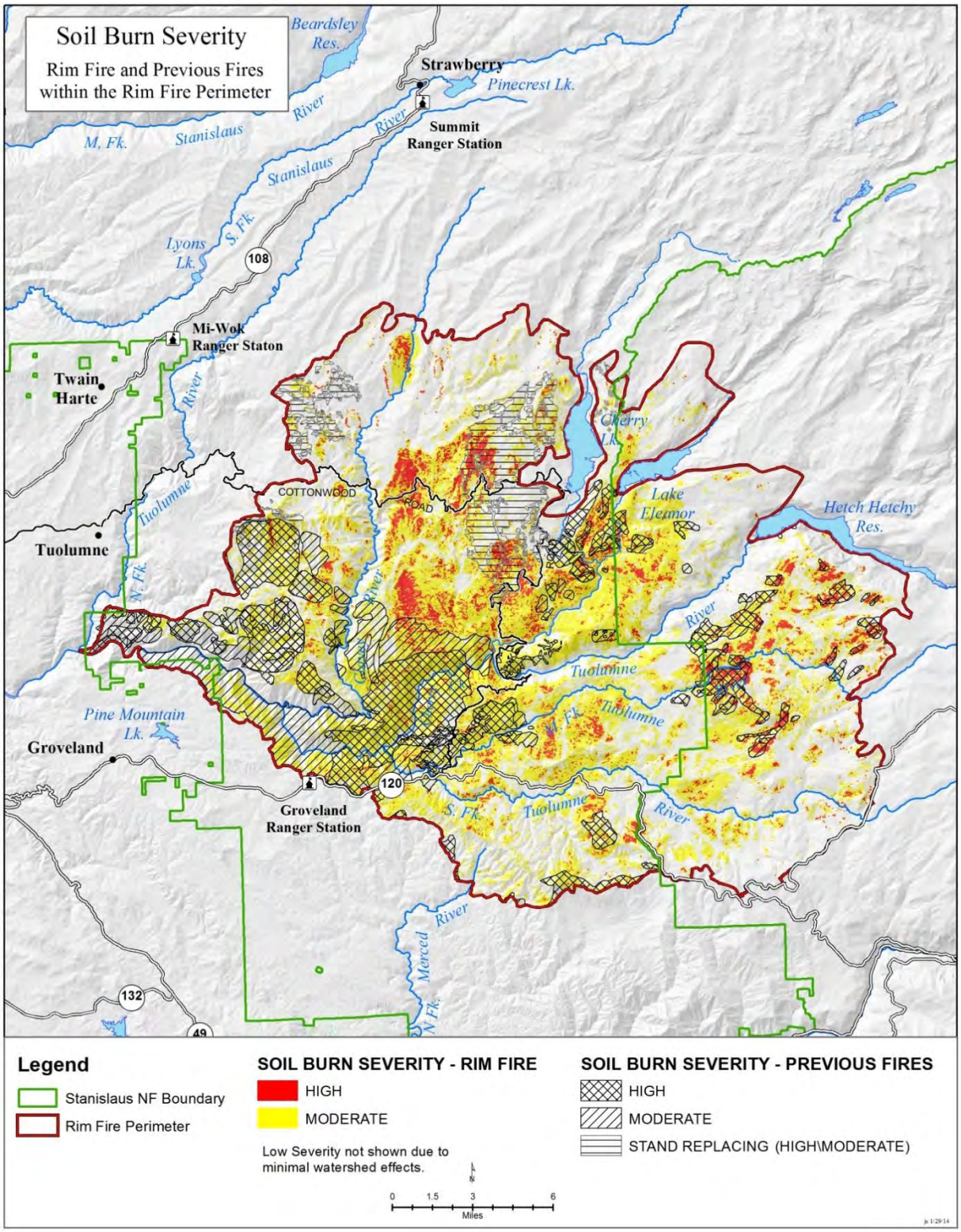

Figure 3 Soil Burn Severity

There are three classes of soil burn severity. High soil burn severity usually chars the soil crust, damaging soil structure, killing plant roots, removing all or mostly all ground cover (litter and duff) and often results in strongly water repellent soil. Moderate soil burn severity does less damage since its soil structure effect and degree of water repellency is usually lower. Low soil burn severity has minimal soil impact, usually scorching ground and portions of tree trunks and bases of tree crowns; few trees are killed. The combination of high and moderate soil burn severity usually represents what is known as a stand replacing fire since nearly all trees are killed. Often in forested areas, post-fire vegetation condition acts as a visual indicator of soil burn severity. High soil burn severity is indicated by fully killed trees with all needles and often many branches consumed. Moderate soil burn severity is viewed as killed trees with browned needles remaining (most fall before winter, providing natural ground cover). Low soil burn severity usually results in patchy ground fire with lower portions of trunks blackened and some lower crowns singed.

Soil burn severity is a measure of the effect of ground heat as a fire burns across a landscape, and is not the same as fire intensity or vegetation burn severity. Fire intensity is a measure of heat produced by a fire (BTUs). Vegetation burn severity measures both vegetation canopy mortality and vegetation basal area mortality resulting from wildfire. For the remainder of this report reference to burn severity will mean soil burn severity unless otherwise noted.

Vegetation Management

Timber harvest was first conducted at a large production scale on the forest with the advent of railroad logging in the early 20th century, including in parts of the Rim Fire area. Harvesting accelerated in time with improvements in truck transportation and the national demand for wood after World War II. Timber was mostly clear cut in the early days and though that practice continued to be a method of harvest, other silvicultural methods were developed such as partial cutting that removed and retained some trees in the same area. Reforestation usually occurred where large blocks of trees were removed. The result to date is a mix of second growth timber plantations, stands where some trees were unlogged, and some areas unlogged due to difficult access or for other reasons.

Most recently, silvicultural practices have focused on thinning timber stands to help make them more resilient to the effects of wildfire. The objective of these practices, including very recent projects within the Rim Fire area, is to reduce fuel loading and help restore forest health. Thinning also reduces stand density, which is a tree stressor that makes the stands more susceptible to insect and disease problems.

Active fuel reduction, such as prescribed fire and allowing all or portions of selected wildfires to burn, has been conducted for the past few decades in order to reduce fuel buildup resulting from long term fire suppression and to improve wildlife habitat or other forest values. These vegetation management practices have benefits for forest health and public safety though they remain challenged to be implemented at the large scale by budget limitations and air quality regulations.

Transportation

Road development on the Stanislaus National Forest, including the Rim Fire area, began in the first half of the 20th century. The principal period of road development occurred after World War II, with the majority of the forest roads being built between 1950 and 1990, primarily for timber harvest access. In addition, higher standard roads were also built, designed for multiple uses including public access. All these routes serve as the backbone of the forest's transportation system. In the 1980s the Stanislaus constructed about 30 miles of new roads per year, with a high of 104 miles in 1980. About 5 miles of new roads were built per year in the 1990's, and lesser amounts since then. Some road segments have actually been decommissioned as they are no longer needed. The current emphasis for road management is maintenance and reconstruction. Both of these activities are challenged by a backlog of projects due to budget limitations.

Water Developments

Though not under Forest Service management jurisdiction, water use developments on or near Forest Service lands can affect water resources and/or be affected by large natural events such as the Rim Fire. Two major water use developments occur at present. One is within and immediately adjacent to the Rim Fire, and one is closely downstream.

The federal Raker Act of 1913 authorized the City and County of San Francisco exclusive use of large areas of the Tuolumne River watershed to develop a water supply and hydroelectric power. This includes the three large reservoirs in proximity to one another adjacent to the northeast boundary of the Rim Fire (see Figure 1). Two large associated hydroelectric power plants also exist within the fire area on the Stanislaus National Forest, one on the main channel of the Tuolumne River and one on Cherry Creek. This is the water use development that has resulted in the regulated flows that occur in portions of the Tuolumne River watershed.

Another large water use development is New Don Pedro Reservoir on the Tuolumne River in the Sierra Nevada foothills. This very large impoundment, beginning about one mile downstream of the Stanislaus National Forest boundary, is the 6th largest reservoir in California, with a capacity of 2,030,000 acre feet. It is close to the Rim Fire and is subject to receiving stream sediment transported beyond the forest as a consequence of the Rim Fire.

Stream Condition

Streams inventoried for condition assessment in recent years, as well as field observations, have shown that past stream channel alterations have occurred in some locations. Most have occurred in lower gradient stream reaches. These legacy effects are usually seen as changes in channel shape such downcutting, channel widening, or both. Streambanks may still be unstable and the natural composition of streambed materials (boulders, cobbles, gravels) may be altered.

Legacy effects are results of natural events such as fire and flood, and likely also from past management activities dating back 50 years or much longer in some cases. The most prevalent activities are historic logging and road building. Recent effects of these activities are significantly less since management practices have improved over time.

Recent stream inventories have determined locations of recovering, or rejuvenating, stream reaches, including numerous sites within the Rim Fire area. Rejuvenating reaches are those with obvious stream channel shape alteration beyond the natural range of variability. While they are evidence of past disturbance, they occur in a minor portion of watershed stream mileage. Most are recovering though some will remain as altered channel segments well into the future.

Floods and Droughts

As a natural process, floods can be viewed as both a positive and adverse landscape feature. Floods scour and erode and at the same time replenish streams. But floods in a place or time of watershed susceptibility to accelerated erosion and sedimentation, such as soon after wildfire, can also affect soil productivity, stream condition in reaches sensitive to disturbance, aquatic habitat, and watershed infrastructure. Infrastructure in this context consists primarily of roads and bridges but can include buildings, pipelines or other such features in a flood's way.

The floods of record that have had the most effect on watershed condition occur from what are known as rain-on-snow storms. These infrequent but often very large events almost always occur in December and January, and are the result of relatively warm winter rainstorms lasting many days. The rain not only produces high runoff but dissolves some of the watershed snowpack that additively can create extremely high peak flows.

Several of these have occurred on the forest over the past century, including within the Rim Fire area. Large such events include December 1955 and 1964, January 1980, February 1986, and January

1997. The latter event was the largest recorded at many stream gages in California (Berenbrock 2014, personal communication). For example, peak flow in the Clavey River was 47,000 cubic feet per second on January 3, 1997, which was rated between a 100 and 200 year event, and by interpolation of various data analysis models was likely close to a 150 year event (Gotvald et al. 2012).

Large floods can be a significant factor affecting watershed condition. They can result in minimal effects to streams in good condition and past vegetation management activities whose ground disturbances have recovered. But they can notably affect watersheds with very recent management activities or wildfires until vegetation and management impacts have recovered. Large floods also correlate with significant occurrences of forest road damage.

Droughts are also a factor in watershed condition, mostly affecting vulnerability to wildfire and forest insect infestations. Fire occurrence is not always correlated with droughts but they can worsen fire behavior due to low fuel moisture. Droughts can also be followed by bark beetle outbreaks when trees become moisture stressed, especially in dense stands where there is high competition for water. A major outbreak occurred across much of the forest from about 1978-1981 as a result of the extreme drought years 1976-1977, the two driest consecutive years of the 20th century.

Watershed Recovery

Natural recovery is an important factor in watershed condition, including in the Rim Fire area. It is a process that occurs with the same frequency as natural disturbances and management activities. Watersheds have shown the ability to recover, as is evident from past fires, floods and land management practices. Though small scale disturbances in sensitive stream reaches such as meadows, or on erodible soils impacted by vehicles, may take decades or longer to naturally recover, or need active restoration, watershed scale recovery begins soon after disturbances. Reduced watershed cover resulting from ground disturbing activities or natural events often emerges within a year. Forested sites are usually replanted and elsewhere pioneering herbaceous and woody plants capture most sites in a few years, providing watershed cover until trees are replanted or natural tree regeneration occurs. Oaks and riparian trees and shrubs usually resprout. Aquatic habitat recovers or is replenished; many aquatic species are adapted to natural and management disturbances and rebound soon thereafter. Much living cover rebounds within a few years.

Current watershed scale management activity disturbances are less impacting than decades ago, due to improvements in management practices that minimize effects on watershed condition. In most cases natural events such as wildfires and large floods are more significant at the watershed scale.

Watershed Quality

Though historic detailed water quality assessments have not been made or are not available in the Rim Fire area, there is broad evidence that water quality at the HUC 5, 6 and 7 levels in the Rim Fire area has been good over time, though some impairment has occurred for short durations due to natural events and from management activities.

Observations of water quality after the 1987 Stanislaus Complex Fire, comparable to the Rim Fire, were that post-fire stream turbidity occurred from the initial storms the first winter after the fire. New stream sedimentation continued for a few years in many streams within the fire area. The evidence of this postfire watershed response diminished rapidly and was essentially gone within 3-5 years. Large-scale downstream effects were apparently negligible since no effects were noted in New Don Pedro Reservoir downstream of the fire.

Road related sediment increases have occurred as a result of large winter storm events. The major rain-on-snow storms of the 1980's and the largest on record in 1997 resulted in significant road damage, with culvert and stream crossing failures, and road surface erosion from drainage function failures. Stream sedimentation from these occurrences lasted until road repairs were accomplished, usually within a year or two.

Though these occurrences impaired water quality during and shortly afterward, aquatic organisms in stream channels remained viable and showed little or no effect. Fish and amphibian populations remained sustainable, providing evidence that they have survived even longer past intermittent alterations in water quality from management activities and natural events.

Water quality has remained excellent in the main channel of the Tuolumne River as evidenced by the Hetch Hetchy water supply system. Since the 1930's the City and County of San Francisco has diverted water from Hetch Hetchy reservoir without having to filter it for domestic use.

The Tuolumne River has never been listed as an impaired stream under Section 303(d) of the federal Clean Water Act.

Existing Conditions

Several factors that affect watershed condition have occurred in the Rim Reforestation project area. These include natural events and management activities that create ground disturbance and alter natural hydrologic processes. The effects of the Rim Fire have a strong influence on existing conditions, and will be discussed further below. The Rim Fire Hazard Tree (Rim HT) project and the Rim Fire Recovery (Rim Recovery) project, which began the Rim Fire restoration process, are the most recent projects within the analysis area. Rim HT is essentially completed and Rim Recovery is about 70 percent complete and implementation will continue regardless of the decision that is made for the Rim Reforestation project. This watershed analysis considers the effects of the initial two projects as part of the existing condition in the cumulative effects analysis (Rim Reforestation EIS, Appendix B).

WILDFIRE EFFECTS

The Rim Fire, like almost all wildfires, is a mosaic of high, moderate and low soil burn severity plus unburned areas within its perimeter. Many past fires occurring within the Rim Fire perimeter have nearly half or more of their total acreage in the low and unburned categories that resulted in minimal to negligible watershed impact. Most watershed damage occurs from high soil burn severity, and lesser from moderate soil burn severity.

The principal effects of soil burn severity are the reduction of ground cover and infiltration capacity. High soil burn severity has the most watershed effect since it usually results in very low remaining ground cover, ranging from 0 to 20%, and the most increase in water repellency. These factors make it insufficient to adequately prevent accelerated soil erosion and, where eroded soil can reach waterways, cause stream sedimentation. Moderate soil burn severity is usually less damaging since the soil is not as impacted and the singed conifer needles fall to the forest floor initiating replacement of burned ground cover. Low soil burn severity is usually an insignificant factor since most pre-fire cover remains and infiltration is mostly retained.

While the Rim Fire area is the largest of the fires within the forest to date, it does not have the highest soil burn severity. Its high soil burn severity is the second lowest of the principal fires within its perimeter since 1973. Though its high soil burn severity is much less than its next largest predecessor, the Stanislaus Complex Fire of 1987, the Rim Fire has resulted in about 10,000 acres of very low ground cover distributed in various sized large to small patches across the 154,530 acres of NFS land it burned. Table 4 displays soil burn severity for the six largest fires within the Rim Fire perimeter that have soil burn severity information.

Table 4 Soil Burn Severity for Selected Fires in Relation to the Rim Fire

Fire Name	Fire Year	NFS (acres)	Soil Burn Severity (%)		
			High	Mod	Low[3]
Rim	2013	176,800	7	37	56
Stanislaus Complex	1987	147,100	36	20	44
Rogge[1]	1996	19,400	0	41	59
Granite	1973	17,100	55	30	15
Ackerson[2]	1996	11,300	19	14	67
Pilot	1999	4,000	46	25	29

[1] No high soil burn severity due to low fuel loading over much of the area because of new plantations after the Stanislaus Complex fire.
[2] This fire was much larger overall, with most acreage in Yosemite National Park.
[3] Low and Unburned

Distribution of soil burn severity within a fire area is also important. A spatial mosaic of all severities can reduce on and off site soil and water effects while concentrations of high soil burn severity can cumulatively increase effects. The largest concentrations of high soil burn severity in the Rim Fire occured in Granite Creek, within the 1973 Granite Fire, and in the Corral Creek and Reed Creek areas, both believed unburned in about 100 years. Other lesser high soil burn severity concentrations are scattered throughout the fire area, surrounded by moderate and/or low soil burn severity areas as well as unburned areas.

These concentration areas, and other smaller severely burned sites in the fire, were identified by the Rim Fire BAER team as a watershed value at risk for loss of soil productivity and delivery of stream sedimentation. As a result, action to minimize the risk was taken in November, 2013. Helicopters applied weed free rice straw mulch to 4,300 acres of the highest priority portions of these locations (i.e., steep slopes, high erosion risk, and stream proximity). Helicopter mulching produces a uniform layer of straw, about 1 to 1.5 inches deep that provides 80 to100% ground cover. An additional BAER action, mastication, was conducted on 40 acres of high soil burn severity area to increase ground cover. Mastication is mechanical chipping of small trees. Low-ground-pressure tracked equipment with an articulated arm and a chipping head provides immediate cover to bare areas.

The Tuolumne River canyon is another burn concentration area in the Rim Fire. The fire began near the Clavey River confluence, continued upstream to Cherry Creek, then up Cherry Creek to Eleanor Creek in Yosemite National Park. Much of the canyon vegetation is dominated by chaparral and other flashy fuels which burned hot and fast up canyon, where the fire then spread northward and led to the conifer dominated high soil burn severity concentrations mentioned above. The canyon soil burn severity is classed as moderate, even though vegetation was well consumed, since the fire here had little residence time and thus, minimally degraded soil properties or increased watershed runoff response. This concentration area is a near repeat of the 1987 Stanislaus Complex Fire. The Tuolumne River canyon burns easily, and the mature 26-year-old vegetation was ready to burn again.

Overall in the Rim Fire, effective watershed cover exists on about 56% of the land within the fire perimeter (the total of the low soil burn severity and the unburned portion within the fire perimeter). This cover consists of living vegetation which primarily includes conifer trees with forest floor litter and duff, plus brush and smaller woody shrubs. This ground cover has been supplemented in much of the moderately burned conifer areas due to needlecast. While this is not as effective as living cover it does provide a measure of effectiveness compared to high burn severity areas since it resists initiation of rainsplash erosion. Helicopter mulching and mastication mitigated some of the worst high soil burn severity areas, but other locations of high soil burn severity areas remained with inadequate cover soon after the fire. However, it is worth to note that natural recovery of live vegetation has been happening at a fast pace throughout the project area.

In summary, the Rim Fire was a mixed severity fire, not only across the entire fire, but at all watershed scales. Patch size of each soil burn severity class in this mosaic was also mixed with some patches hundreds to several hundreds of acres, others tens to hundreds, and yet others where all three classes occurred within ten acres. Mixed severity was also distributed similarly from stream to ridge within most watersheds. Riparian areas burned in a mosaic as did the hillslopes above them. The largest high soil burn severity patches occurred in the uplands, mostly on south-facing slopes where the fire could easily pre-heat fuels.

At the Rim Fire scale, the amount of soil burn severity varies widely among and within all HUC level watersheds. In general it is least for the HUC 5 watersheds, more for the HUC 6 watersheds and greatest for the HUC 7 watersheds. Many HUC 5 watersheds, being the largest, have substantial portions outside the Rim Fire perimeter. The HUC 6 watersheds, though generally having more acreage within the fire, also have a highly variable amount of soil burn severity based on fire location and watershed acreage within the fire perimeter. The HUC 7 watersheds, that have the highest burn severity, have been selected as watershed analysis emphasis areas due to severe burn and/or concentrated post-fire management activities.

Table 2 provides an overview of the three watershed scales and the portion each occupies within the Rim Fire and the STF. It also shows the soil burn severity of each watershed as an indicator of existing condition relative to ground cover and vegetation alteration by the fire. Rim Fire information is provided at the top of the table for comparison with the HUC Level 5, 6, and 7 watersheds. Refer to Figure 1 for the locations of the HUC 6 watersheds as well as to gain an understanding of the locations of their HUC 5 and 7 counterparts.

Table 2 shows the similarities and variations among watersheds. Watershed area within the fire perimeter ranges from 1 to100% among the HUC 5 and 6 watersheds, and all the HUC 7 watersheds are 100% within the perimeter. The percentage of watershed area within the STF is high for all watersheds except for portions of the 4 HUC 5 watersheds that extend east of the Forest into Yosemite National Park.

The amount of soil burn severity across the fire also exhibits similarities and variations by watershed. Moderate soil burn severity is greater than high severity in every watershed, ranging from 2 to 10 times as much. High soil burn severity is similar in almost all HUC 5 and HUC 6 watersheds; all 9 HUC 5s are less than 10% as are 16 of the 18 HUC 6s. HUC 7 watersheds are dissimilar to their larger counterparts in that they almost all have greater high and moderate soil burn severity.

Table 2 also shows that 25 of the 32 watersheds have more than 50% acreage in the low soil burn severity and unburned class. Half of those watersheds have greater than 75% in this same class. The remaining 7 watersheds include all 5 HUC 7s and 2 of the more heavily burned HUC 6s: Lower Cherry Creek and the Lower Middle Fork of the Tuolumne River. The fire wide average of 56% in the low and unburned class is made up of a high percentage of predominantly low and unburned watersheds punctuated by several highly burned ones.

The most visible watershed impact of the fire was in the high soil burn severity areas since it reduced ground cover to less than 20%, often near zero. Ground cover in the moderate soil burn severity areas was also substantially reduced as nearly all trees were killed by the fire, though needlecast replacement cover of 50% or more occurred in many of the conifer forested areas before winter. However, a vegetation monitoring was conducted this field season 2015 by Forest Service personnel on units proposed for reforestation (approximately 26,009 acres, including deer and natural regeneration units). Within the Composite Burn Index (CBI) of high, moderate, low, and unchanged severity areas, vegetation cover averaged 61%, 50%, 23% and 4%, respectively. Overall cover of shrubs, grasses, and forbs have a positive correlation with burn severity, increasing on average from 4% cover in unchanged areas to greater than 60% cover in high-severity burn areas. The Vegetation Chapter 3.13 has additional information on post-fire vegetation monitoring.

The description of existing condition by watershed that follows will be made in the order of Table 2 and will include the parent HUC 5 watersheds and their smaller HUC 6, and where applicable, HUC 7 nesting watersheds.

Big Creek-Tuolumne River

This HUC 5 watershed has the most contrasting burn severity condition of any of the nine HUC 5 watersheds. It has the most high burn severity of any watershed, the HUC 7 Corral Creek. It also has the lowest amount of burned area of any watershed within the fire perimeter, the HUC 6 Big Creek, where only 10 acres burned. Thus, the conditions in this HUC 5 watershed range from unaffected to severely affected.

The Grapevine-Tuolumne River HUC 6 is the furthest downstream watershed in the Rim Fire. It mostly straddles the lower Tuolumne River canyon and extends up into its south facing Grapevine Creek tributary. Watershed soil burn severity was very low with only 1% in high severity. Its 26% moderate burn severity was well scattered across Grapevine Creek and in the Tuolumne River canyon. Much of this watershed in the river canyon and lower Grapevine Creek is covered with Oak grassland and brush. Higher elevations in Grapevine Creek and the riparian river corridor have conifers. This watershed has a history of minimal response to fire; that is, erosion rates are not significantly greater after than before a fire. Much of the canyon has shallow soils and the fire adapted vegetation regrows rapidly. Little alteration of watershed condition has occurred as a result of the Rim Fire.

The Jawbone Creek -Tuolumne River HUC 6 watershed, in contrast to the above two, has the greatest amount of combined high and moderate soil burn severity (70%) of any HUC 6 in the Rim Fire. As the fire raced up the Tuolumne River canyon into this watershed the river turns north giving the fire the opportunity to jump northerly out of the canyon and into the forested areas along three of the river's direct tributaries - Alder, Corral and Jawbone Creeks. From there it burned nearly continuously for about 10 miles, almost to the Jawbone Creek headwaters. This area includes about 7,500 acres of forest inholdings, nearly all private timberland though several smaller parcels occur as well.

This watershed is the only one in the Rim Fire to warrant selection of two HUC 7 watersheds for analysis due to high burn severity. Lower Jawbone Creek, with a combined 85% high and moderate soil burn severity, and Corral Creek immediately west, with a combined 89%, was the largest contiguous area of high severity burn in the Rim Fire. In addition, Corral Creek, a small perennial stream, was severely burned in its near-stream area. In order to mitigate these effects, BAER mitigations were implemented soon after the fire. Approximately 1,000 acres of straw mulch was aerially applied to the most severely burned portions of these two HUC 7 watersheds.

The two HUC 7 watersheds were expected to produce the highest erosion and sedimentation in the fire area. In addition, the Corral Creek stream channel environment is likely to be altered in the process. A stream inventory conducted in 2012 showed much of the channel to be rejuvenating from past disturbance and still sensitive to further disturbance such as wildfire. The Corral Creek tributaries are also incised, and the riparian conservation area was nearly all burned at high severity. Shade has been nearly fully removed along the channel and some of the streambed large woody debris was burned out in the fire.

North Fork Tuolumne River

Only 9% of the North Fork Tuolumne HUC 5 watershed was within the Rim Fire perimeter, and only 17% of the Lower North Fork Tuolumne HUC 6. Soil burn severity was extremely low and most of it was concentrated in a mosaic of low, moderate and a minor amount of high soil burn severity in Upper Hunter Creek, a HUC 7 watershed on the south side of Duckwall Mountain. This same area burned in the 1987 Stanislaus Complex Fire, though much of it was high soil burn severity. (See

Figure 3; the polygon of the Hunter Creek burned area is shown just inside the Rim Fire boundary due east of Tuolumne). Post fire erosion and sedimentation occurred shortly after the fire due to a short duration intense rainstorm in that part of the fire (little other erosion occurred in other parts of the fire). Log jams and a partial kill of the stream's fish were observed in Hunter Creek near the road 1N01 crossing but no more substantial erosion occurred that winter, and natural recovery of ground cover began the next spring. The fishery was not materially affected as fish were commonly observed the next summer.

Field observations in this area soon after the Rim Fire indicated that only minor fire-caused stream effects are expected due to the minimal amount of high burn severity.

Clavey River

The Clavey River is the only Rim Fire HUC 5 watershed fully within the Stanislaus National Forest. Three of its four HUC 6 watersheds experienced fire as the burn moved northward from the fire origin near the Clavey River confluence with the Tuolumne River. The fire did not quite reach the Upper Clavey HUC 6 watershed.

The Lower and Middle Clavey River HUC 6 watersheds were modestly burned, with a well distributed mosaic of mostly low soil burn severity surrounding smaller patches of moderate severity encompassing even smaller patches of high soil burn severity. The near-stream corridor of the main channel of the Clavey River experienced very little moderate or high soil burn severity throughout its 24 miles within the Rim Fire except for one approximately 2 mile moderate and high soil burn severity patch straddling it just downstream of the road 3N01 crossing. The Bear Springs Creek-Lower Clavey River HUC 7 watershed was the least impacted by the Rim Fire among the five HUC 7 watersheds. However, since it has a substantial amount of proposed management activities it is considered for condition assessment and project effects analysis. About 50% of this HUC 7 watershed was in high and moderate soil burn severity, though only 7% was high severity. While its mosaic pattern of low, moderate and high patches was well scattered around the portion of the watershed west of the Clavey River, a single large concentration of high and moderate burn was located in the upper end on the east side of the river. About 160 acres of straw mulch was applied to the most sensitive areas here as part of the BAER watershed stabilization effort.

The Reed Creek HUC 6 watershed burned moderately but with a large contrast within. The lower third of the watershed, downstream of the Bourland-Reynolds Creek confluence, was mostly burned severely. The middle third burned mostly at low burn severity, and the upper third was upstream of the fire perimeter. The concentration of the severe burn in Reed Creek was in the Lower Reed Creek HUC 7 watershed. It was an area as wide as the Reed Creek HUC 6 watershed for about a mile above and two miles below the Reed Creek Cottonwood Road crossing. The fire burned the Reed Creek corridor almost fully within this area. The condition of the Lower Reed Creek watershed burn concentration is likely to produce a notable amount of erosion and stream sedimentation that will be transported through Reed Creek and down into the Clavey River about one mile downstream. However, this is a small portion of the overall length of Reed Creek since upstream the contributing streams either have low severity or no burn. The portion of Lower Reed Creek that burned severely was also an area of BAER mulch application soon after the fire, receiving about 1,900 acres of straw, the highest single concentration of post-fire mulching.

It is not likely that Reed Creek's stream channel will be altered since it is bedrock controlled in this area and highly erosion resistant. Riparian vegetation is likely to be altered substantially in the short term since much of the riparian area was burned to a moderate and high severity.

Overall for the Clavey River watershed in the Rim Fire, it is likely that the fire caused minimal damage to any of the HUC 6 watersheds within the Clavey River. After two year of the fire, erosion leading to stream sedimentation will be minimal in the context of the values of the Clavey River, and

the erosion resistant stream channels should not be damaged. The Wild and Scenic River value, the Critical Aquatic Refuge and the state designation of a Heritage Trout Water will remain unaffected.

Cherry Creek

The Rim Fire burned within 3 of the 5 HUC 6 watersheds in the Cherry Creek HUC 5 watershed. Yet it essentially burned in only Lower Cherry Creek, the lowermost of the HUC 6 watersheds, and nearly all of that was in the lower half. All of the other upstream HUC 6 watersheds had minimal or no fire. Upper Cherry Creek had about 700 acres of fire and the West Fork had about 80 acres. The Rim fire did not reach the North and East Forks of Cherry Creek, which like the Upper and West Fork are mostly rockbound wilderness.

Though the Rim Fire occupied only 24 percent of the entire Cherry Creek watershed, its concentration in the lowermost portion was noteworthy. The fire reburned nearly all of the 17,000 acre Granite Fire of 1973, 40 years to the month of the Rim Fire, including the lower half of it which now has burned twice with high severity, especially in the Granite Creek HUC 7 watershed.

Lower Cherry Creek watershed values at risk include the City and County of San Francisco water development features, Cherry Lake and the Holm Powerhouse at the confluence of Cherry Creek and the Tuolumne River. Neither of these will be adversely affected by the Rim fire. Fire surrounded about 75% of Cherry Lake but the burn was nearly all in the low and unburned category thus not posing a sedimentation risk. The Powerhouse can function without being affected by wildfire.

Granite Creek experienced the greatest burn severity of any of the HUC 7 watersheds evaluated for Rim Fire watershed effects. Only 8% of this 4,100 acre watershed remained in the low and unburned soil burn severity class. Of the remaining 92%, or about 3,800 acres, 30% was high soil burn severity, also the highest per HUC 7 watershed, and moderate severity occupied 62%. This steep south facing watershed is apparently no match for extreme fire, having been twice burned to the same extent. Granite Creek is expected to see substantial erosion and subsequent turbidity and stream sedimentation delivered to Cherry Creek. The granitic soil prevalent in the watershed is highly erodible. To minimize the erosion to the extent possible, this was another BAER straw application area, about 750 acres.

Eleanor Creek

Only 28% of this HUC 5 watershed is within the Rim Fire, just 2% is within the Stanislaus National Forest, and nearly all of the watershed is in Yosemite National Park wilderness. Miguel Creek-Eleanor Creek watershed is the only one of its 4 HUC 6 watersheds that had notable fire, and it is the only one that drains directly into the Cherry Creek watershed. The remaining upstream watersheds all had very small amount of fire and nearly all of it was low and unburned. In addition, they all drain into Eleanor Lake where fire related stream sediment will be mostly trapped.

Only 4% of the Miguel Creek-Eleanor Creek watershed burned at high soil burn severity. And almost all of this was upslope and buffered from streams by surrounding areas of moderate severity. A minor amount of stream sedimentation likely occurred from this watershed.

Falls Creek-Tuolumne River

Similar to Eleanor Creek, this HUC 5 watershed saw a very small amount of the Rim Fire. About 96% of the watershed is in Yosemite National Park. The only portion on the Stanislaus National Forest is its downstream most HUC 6 watershed, Poopenaut Valley, and only the lower 30% of that is within the Forest. Much of the Falls Creek-Tuolumne HUC 5, the largest of any burned by the Rim Fire, is upstream of and thus drains into Hetch-Hetchy Reservoir, and little fire occurred in those watersheds.

Most of the fire in the Poopenaut Valley watershed occurred on its upper slopes, substantially distant from the Tuolumne River below. Little stream sedimentation from this upslope erosion is expected.

Middle Fork Tuolumne River

Among the nine HUC 5 watersheds in the Rim Fire, the Middle Fork Tuolumne has the highest combined high and moderate soil burn severity, and its Lower Middle Fork HUC 6 watershed is the second highest among the 18 HUC 6 watersheds in the Rim Fire. Much of this ranking is due to the very high amount of moderate burn severity somewhat uniformly spread across the lower three quarters of the Lower Middle Fork. The 8% of high soil burn severity overlays this moderate burn in relatively small patches compared with more severely burned watersheds. The Rim Fire in the western third of the Lower Middle Fork was a reburn of the 4,000 acre Pilot Fire of 1999. The south facing slope of the Middle Fork in the Pilot Fire, mostly vegetated with brush, was once again thoroughly burned.

The upper half of one long unnamed tributary of the Lower Middle Fork about a mile southwest of Bear Mountain sustained a linear patch of high severity burn on the slope just south of the stream. This area, known as Bear Gully, is a long, incised low gradient stream channel in a highly erodible narrow alluvial valley. This was another of the straw mulch sites identified during the BAER assessment shortly after the Rim Fire. This area, about 75 acres of which had straw aerially applied, was one of four such sites totaling about 240 acres in this watershed.

The Upper Middle Fork of the Tuolumne River, of which 97% is in Yosemite National Park wilderness, was burned in a notably different mosaic pattern. Seventy one percent was in the low and unburned soil burn severity class, well distributed across the 53% of the watershed within the Rim Fire perimeter. Most patches of moderate and high severity were also well scattered with almost all of the high severity areas within the bounds of surrounding moderate severity patches.

Together the Lower and Upper Middle Forks of the Tuolumne River had about 40% of their watersheds burned in a combination of relatively broadly distributed high and moderate burn severity. The remainder was in low or unburned status, including the upper 40% of the Upper Middle Fork which was outside the fire perimeter.

Watershed values at risk in the Middle Fork Tuolumne River include 2 river side recreation camps and a private land lodging facility. All were barely avoided being burned by both the Pilot and Rim Fires. They experienced stream turbidity and sedimentation as the Middle Fork passed through them in the first winter after the fire, then will likely see much lesser amounts and a decreasing frequency after that. Flooding from potential increases in peak streamflow following the Rim Fire is not expected to affect them. The major flood of 1997, which was greater than a 100 year event, did minimal damage to these facilities.

Notable stream sedimentation and first winter turbidity was expected as a result of erosion from the amount and severity of burn in the Middle Fork of the Tuolumne River. Though the Upper Middle Fork is almost entirely within Yosemite, it will deliver downstream sediment to the Stanislaus National Forest. As with most streams in the fire area, first winter turbidity would be common.

South Fork Tuolumne River

This HUC 5 watershed is comprised of the Lower South Fork, 100% within the Stanislaus National Forest, and the Upper South Fork, 91% in Yosemite National Park. The Rim Fire burned the South Fork HUC 5 watershed similarly in distribution as the Middle Fork but overall to a somewhat lesser extent of high and moderate soil burn severity.

The Lower South Fork saw much of its most active fire along the southwest and northeast perimeter of the watershed, and a concentration at the headwaters of Soldier Creek and along Crocker Ridge. The Soldier Creek burn area was another of the BAER straw treatment areas, about 200 acres. Watershed values at risk included the Carlon Day Use area along the Evergreen Road, Berkeley-Tuolumne Camp and the private inholding at Harden Flat. None of these were damaged by post-fire

events though the Berkeley camp was largely destroyed by the fire. HazMat cleanup occurred at the camp soon after the fire.

The Upper South Fork of the Tuolumne River, like the Upper Middle Fork, is almost entirely in Yosemite wilderness. It was burned less than the Lower South Fork but like the Upper Middle Fork will deliver stream sediment to the Stanislaus National Forest.

The HUC 5 South Fork Tuolumne River will see moderate stream sedimentation as a result of the Rim Fire. First winter turbidity would be common during and after storms. Watershed values described above should not be noticeably impacted by stream sediment.

North Fork Merced River

The Rim Fire burned southerly over Pilot Ridge into minor portions of 2 HUC 6 watersheds in the North Fork Merced River HUC 5 watershed, in which there was essentially no high soil burn severity and only 3% moderate severity burn. This is the near opposite of the Stanislaus Complex Fire of 1987 where much of the North Fork Merced was burned at high severity. Overall, 97% of these watersheds remained unburned following the Rim Fire. The small amount of fire activity that did occur was in the headwaters, and thus downstream watershed effects are likely to be negligible. No watershed values were at risk in the North Fork Merced River.

VEGETATION CONDITION

Hillslopes

The remaining live vegetation within the Rim Fire perimeter consists largely of second growth forest stands from legacy logging as well as more recent various aged timber plantations. It also consists of unlogged natural stands, some of which are very old. Despite the diversity of this vegetation, it almost all currently shares a common trait: high stand density. An excessive number of tree stems per acre creates closed canopies and an undesirable fuel ladder. This dense condition leaves unburned forest vegetation elsewhere as vulnerable to future high severity wildfires as has recently occurred. In addition, these overstocked stands are more susceptible to episodic insect outbreaks as the trees become moisture stressed and better able to host to bark beetles in or following dry weather cycles. Several large scale fuel reduction treatments have occurred in the Rim Fire area over the past decade. These projects involve tree thinning to reduce fuel loading which also decreases stand density for fire resilience. In the face of the Rim Fire they had mixed success due to its unprecedented magnitude.

The amount of live vegetative canopy cover lost in the Rim Fire watersheds can be estimated by summing the acreage of high and moderate soil burn severity since nearly all vegetation in those soil burn classes is killed by fire. This measure correlates well with vegetation burn severity, as measured by canopy mortality. Canopy mortality assessment is done by placing mortality estimates into quartile classes. Combined high and moderate soil burn severity is similar in acreage to that from 75 to100 percent canopy mortality class. Either method is suitable for approximating fire effects on vegetation since results are comparable. For example, in the Middle Clavey River watershed, one of the lesser burned HUC 6 watersheds, 13% of its acreage is in the high and moderate class of soil burn severity. That percentage of the watershed can be estimated to have lost canopy vegetation from the fire, with 87% of the vegetation remaining alive in the watershed. At the other end of the spectrum, Granite Creek had 92% of its 4,000 acre watershed burned at high or moderate soil burn severity. Only 8% of the pre-fire canopy remained.

At the scale of the Rim Fire approximately 44% of live vegetative canopy was lost, in various mosaic patterns, and about 56% remained largely unaffected. And as Table 2 showed, the amount of soil burn severity and vegetation burn severity varied substantially among the watersheds in the fire area.

Riparian Conservation Areas

Riparian Conservation Areas (RCAs) are corridors along stream channels and surrounding meadows, springs and other wetland areas that provide habitat for plants that thrive on a high water table. These riparian obligate species include resprouting trees such as alders, big leaf maples, dogwoods, cottonwoods and aspens, shrubs such as willows, and a variety of streamside and meadow herbaceous plants. Conifers also coexist in RCAs with obligate species, often growing well near streams.

The Rim Fire resulted in a similar mosaic burn pattern in RCAs as on hillslopes. Some perennial and intermittent stream reaches burned at high soil burn severity. Some did not burn at all while the adjacent hillslopes did. In burned RCAs, resprouting shrubs and trees began responding with new leaves emerging within several weeks after the fire. In addition, burned overstory conifers in RCAs have created canopy openings that will allow more sunlight to reach the streamside areas to stimulate the growth response of the riparian obligate species, many of which are shade intolerant. In many areas they have become suppressed over time by conifer trees overtopping and shading them in the absence of fire and or nearstream silvicultural practices such as thinning. A rush of regrowth of these riparian obligates is expected in the next decade in burned RCAs within the Rim Fire. However, while the sudden addition of sunlight favors renewal of the riparian obligate species the reduction of pre-fire stream shading has the potential to increase stream water temperature. The magnitude and duration of the latter effect is uncertain though streams within and downstream of past fires on the STF have not been notably altered since stream biotic productivity and aquatic species remain present in sustainable numbers. Rose Creek in the Ruby Fire of 1992 on the Mi-Wok Ranger District is a principal example of such a recovery process in a setting where a dense riparian conifer overstory was completely burned. The trout population survived and became more abundant in the years following with more sunlight and an increase in summer baseflow due to loss of transpiration from tree mortality. In addition, the suppressed willows beneath the pre-fire canopy grew to about 15 feet high within about 5 years after the fire.

The watershed effect of the Rim Fire on vegetation condition in Riparian Conservation Areas (RCAs) is shown by watershed in Table 5. A 100 foot zone along all perennial and intermittent streams (100 feet on each side for a total width of 200 feet) was selected to focus on the immediate near-stream complex of obligate and non-obligate vegetation in the cooler, moister microclimate along streams, often referred to as the “riparian bubble.” These RCAs often includes the immediate channel and its flood prone areas and or adjacent terrace. The upslope remainder of the 300 or 150-foot RCA widths are usually dominated by hillslope vegetation and warmer air temperatures. Both soil and vegetation burn severity measures were assessed for validation of comparability. This 100 foot buffer represents an average of about 7% of the total area in the Rim Fire watersheds, with a range of 5 to 9% among all watersheds.

In Table 5, the RCA columns display soil and vegetation burn severity for all HUC 6 and HUC 7 watersheds in the Rim Fire. The RCA H + M column is the sum of high and moderate soil burn severity in the 100-foot stream buffer. The Watershed column displays the sum of the high and moderate burn severity for the entire watershed. The RCA H + M column is the key information for comparing soil to vegetation burn severity and RCA-to-watershed soil burn severity.

Table 5 shows that RCA soil and vegetation burn severity match closely in almost all watersheds. In 21 of 23 watersheds soil and vegetation burn severity are within 5% of one another, and the remaining two are 7% and 8%. In most cases the vegetation burn severity is equal to or slightly less than the soil burn severity. The two measures validate they are comparable for estimating vegetation loss. Soil burn severity has the added advantage of also being able to indicate ground cover condition.

Comparing RCA to watershed, the Table 5 shows that RCA soil burn severity is in most cases less than for the watershed as a whole. RCA soil burn severity is not higher than watershed soil burn

severity in 19 of the 23 watersheds in Table 5. The 4 that are higher are barely so, and many of the watershed soil burn severity percentages are much higher than the RCA.

The Rim Fire burned less severely near the streams than in the uplands in almost all watersheds, and substantially less in many. And though it burned less in RCA there was still a notable loss of the stream shade capacity of conifers and riparian obligate trees and shrubs in many watersheds. But while the conifers will be long in returning to replace shade, the riparian trees will fill the void in the short run and also provide biodiversity along stream reaches burned in the Rim Fire.

Table 5 Riparian Conservation Area Soil and Vegetation Burn Severity

HUC Level and Name	Riparian Conservation Area (RCA) (100-foot stream buffer)					Watershed (total acres)
	Soil Burn Severity % acres in RCA				Vegetation Burn Severity % acres with 75-100% Canopy Mortality	Soil Burn Severity % acres in Watershed
	High	Mod	Low	H+M		High+Mod
5 – Big Creek-Tuolumne River						
6 – Big Creek	0	0	100	0	0	0
6 – Grapevine Creek-Tuolumne River	0	11	89	11	15	27
6 – Jawbone Creek-Tuolumne River	11	38	51	49	50	70
7 – Corral Creek	41	51	9	92	88	89
7 – Lower Jawbone Creek	3	42	55	45	49	85
5 – North Fork Tuolumne River						
6 – Lower North Fork Tuolumne River	1	8	91	9	6	7
5 – Clavey River						
6 – Lower Clavey River	1	19	80	20	19	49
7 – Bear Springs Creek-Lower Clavey River	2	17	81	19	14	50
6 – Middle Clavey River	1	7	92	8	7	13
6 – Reed Creek	3	10	87	13	11	23
7 –Lower Reed Creek	12	31	56	43	41	62
5 – Cherry Creek						
6 – Lower Cherry Creek	13	34	53	47	45	53
7 – Granite Creek	35	59	6	94	91	92
6 – Upper Cherry Creek	0	0	100	0	0	1
6 – West Fork Cherry Creek	0	0	100	0	0	0
5 – Eleanor Creek[1]						
6 – Miguel Creek-Eleanor Creek	4	34	62	38	41	35
5 – Falls Creek-Tuolumne River[1]						
6 – Poopenaut Valley-Tuolumne River	5	27	68	32	32	39
5 – Middle Fork Tuolumne River[1]						
6 – Lower Middle Fork Tuolumne River	5	50	45	55	50	63
6 – Upper Middle Fork Tuolumne River	3	22	75	25	17	29
5 – South Fork Tuolumne River[1]						
6 – Lower South Fork Tuolumne River	2	23	75	25	18	46
6 – Upper South Fork Tuolumne River	4	19	77	22	17	25
5 – North Fork Merced River						
6 – Bull Creek	0	2	98	2	2	2
6 – Bean Creek-North Fork Merced River	0	2	98	2	2	4

[1] Substantial portion of the fire extends east into Yosemite National Park.

TRANSPORTATION SYSTEM CONDITION

Road density in the Rim Fire area ranges from 1 to 6 miles of road per square mile, with an average of about 4 miles per square mile. This is similar to other roaded multiple-use areas within the forest. Prior to the Rim Fire, the existing road network within its perimeter was adequate to serve the needs

of forest management activities. As part of the post-fire salvage harvest, minimal road construction had a negligible change in road density.

Because of the maturity of the transportation system in the Rim Fire area, with nearly all roads built 25 to more than 50 years ago, most road cuts and fills have stabilized with vegetation or other ground cover. Over time the sediment discharges that usually result following new construction have decreased. Most road related sediment in recent times originated at locations known as hydrologically connected segments (HCS). These are road portions where drainage from road surfaces or inside ditches can reach stream courses at road stream crossings or through underdrains that can transport sediment to streams. Elsewhere, pre-fire road sediment discharges on outsloped roads were usually filtered by vegetation or other cover on fill slopes and the forest floor. Pre-Rim Fire stream sedimentation from the road system was believed to be low based on stream condition data in the area collected through 2012. Refer to the section below on stream channel condition.

In the fall of 2013, as a Rim Fire BAER action, road drainage improvements such as culvert repair, armored crossings, rolling dips and water bars were installed as needed along approximately 320 miles of roads. In addition, funding was approved for personnel to monitor and repair roads over the winter if needed. These actions were expected to minimize road damage and thus reduce watershed impacts during the first winter after the fire. They represent an emergency improvement to road condition in the fire area. Additional road reconstruction was done under the Rim Fire Recovery Project (USDA 2014).

Road sediment discharge increases are expected as a result of the Rim Fire. Most increases are likely to occur in high soil burn severity areas within the Rim Fire, and to a lesser extent in moderate soil burn severity areas. Problems include locations of improper road drainage function and culverts at road-stream crossings. The undersized culverts cannot handle post-fire flow volume and the additional woody debris and sediment it carries. The quantity and effect of fire-related sediment-delivery increase is uncertain, due to variability in winter weather prior to the implementation of the Rim Reforestation. Following wildfire, the ability of the landscape to filter runoff from roads can be reduced due to a decrease in ground cover (Peterson et al. 2009).

STREAM CONDITION

Stream channels in the Rim Fire range from major rivers to small streams that flow only seasonally. Most streams are dominated by moderate slope gradients (2 to 4%) and secondarily by steep gradients (4 to10%). Gentle stream gradients, less than 2%, occur occasionally on some small streams, and more frequently on some of the larger streams. Most streams are bedrock controlled with substantial cobble substrate and lesser amounts of boulder and gravel in the streambeds.

Stream condition inventories were conducted along portions of 23 streams within the Rim Fire area between 2005 and 2012. These are part of the forestwide Stanislaus StreamScape Inventory (SSI) program to determine stream condition prior to management activities or for baseline watershed information (Frazier et al. 2008). SSI consists of 21 attributes of stream condition measured continuously along wadeable stream channels in lengths that have ranged from about 1 to nearly 10 miles. Some larger streams become wadeable by late summer, such as the Middle and South Forks of the Tuolumne River, the Clavey River and Reed Creek. They, among many of their tributaries, comprise the streams represented here. The main channel of the Tuolumne River has not been inventoried due to its size and regulated flow regime which create unsafe SSI working conditions. A summary of the existing condition of these streams, based on key indicators, is shown in Table 6.

Table 6 Rim Fire Stream Condition Summary

Stream Channel Indicators				Stream Habitat Indicators					
Streambank Stability		Channel Form		Pool Tail Fine Sediment		Pool Bed Fine Sediment		Water Temperature Maximum	
%	Streams	% Normal or Rejuvenating	Streams	%	Streams	%	Streams	Degrees F	Streams
over 75	21	over 75	16	less than 10	16	less than 10	18	less than 59	10
50 to 75	1	50 to 75	4	10 to 20	3	10 to 20	3	59 to 68	9
less than 50	1	less than 50	3	over 20	4	over 20	2	over 68	4

Stream Channels

Streambank stability is assessed in quartile percentage classes at 328-foot (100-meter) increments. The summary above represents the percentage of streambank stability on all streams inventoried. Twenty one of the 23 streams have a majority of their stream length in the greater than 75% stability quartile with no 328 foot increments less than 50% stable. This indicates the streambank stability for the surveyed stream is either fully or highly likely to be greater than 75%, which represents a very stable stream system. Numerous streams have over 90% of their length fully classified in the upper quartile.

Channel form, or cross-sectional shape, is assessed in SSI in four classes which depict excellent to poor condition. The Normal class is one whose channel fits proper morphological features for its stream type. These factors include width-to-depth and entrenchment ratios, streambank angle, and other measures of channel shape (Rosgen 1996). The Rejuvenating class is a channel form that shows evidence of legacy disturbance but is recovering or has recovered to good condition. These classes are combined to assess condition of the channel form. For example, a stream with more than 75% of its length in these classes, provided the Normal class is greater, is in very good condition. Sixteen of the inventoried streams are in this condition, while the remaining streams have some portions with evidence of accelerated incision or widening.

Overall, the two stream channel indicators show a high percentage of the inventoried streams were in very good condition prior to the Rim Fire. Stream condition is expected to be affected by post-fire erosion and sedimentation though the magnitude is uncertain, and is largely reliant upon winter weather events. Effects may be mitigated in areas that received BAER hillslope and road treatments in the fall of 2013 as well as in areas where effective and adequate natural re-growth has taken place to a level that can minimize surface erosion and sedimentation.

Stream Habitat

SSI quantitatively measures stream pool sediment serving as indicators of stream habitat quality and sedimentation. Pools are the sediment reservoirs in streams. Sediment in stream pools is an indicator of erosion from the upstream watershed, and thus shows whether excessive input is present. Excessive sedimentation can arise from ground disturbing management activities such as timber harvest or roads, or from fires, floods or mass wasting (e.g., landslides, debris flows). Fine sediment is measured since it represents the smallest soil particles, which are the key components of aquatic habitat. Excessive fine sediment in stream pool tails can reduce fish spawning success. Excess pool bed sediment reduces pool area that can be used for fish rearing and productivity. Pool tail fine sediment is calculated at pool outlets, and pool bed fine sediment is measured throughout the full length of stream pools. Pool tail sediment less than 20% is usually considered suitable for fish spawning. Pool bed sediment, measured as the length of fine sediment deposition in a pool, characterizes the amount of settleable material (material heavy enough to sink to the bottom of a pool) sourced from the watershed. The same percentage threshold is used for pool bed sediment as for pool tails.

As shown in Table 6, pool tail and pool bed sediment were very low in the inventoried streams. It is not excessive since presence of native fish of all age classes are common or abundant in these streams. The amount of pool sediment in these streams is an indicator of a very stable watershed landscape, including recovery from past disturbances by wildfire and ground-disturbing management activities.

Water temperature was also excellent in these streams. The SSI data in Table 6 are the maximum daily temperatures and all are suitable for the native aquatic organism communities. Even the streams with maximum temperatures exceeding 68 degrees Fahrenheit, a threshold of concern for cold water fish, were only slightly higher and their minimum daily temperatures are well below the threshold.

Benthic macroinvertebrates (BMI) are another indicator of stream health. They were sampled in the Clavey River in 2007 as well as several of its tributaries within the Rim Fire perimeter as part of the stream condition inventory for the Clavey River Ecosystem Project (CREP 2008). The BMI data were evaluated using the River Invertebrate Prediction and Classification System (RIVPACS) (Hawkins et al. 2000). Numeric values very close to 1 indicate reference condition, meaning streams are in as good of condition as naturally occurs. Numbers exceeding 1 are better than what is expected. A score of 0.9 or 90%, means the stream health is in excellent condition. Streams and their BMI scores are as follows: Two Mile Creek (0.991), Hull Creek (1.106), Clavey River (0.927), Reed Creek (1.021), Bourland Creek (1.166), Cottonwood Creek (1.166), and Bear Springs Creek (0.932). No impairment of stream habitat or water quality was evident.

Between the time of collection of the stream condition data and the Rim Fire there were no significant management activity disturbances or natural events that would have been likely to substantially alter stream conditions.

WILD AND SCENIC RIVER CONDITION

One congressionally designated Wild and Scenic River lies within the Rim Fire perimeter. This includes all of the 29 miles of the main channel of the Tuolumne River that flows through the STF. In addition, the lower half of the Clavey River (24 miles) is a proposed Wild and Scenic River, and the lowest 2 miles of the South Fork Tuolumne River is an eligible Wild and Scenic River.

All of these rivers have had Outstandingly Remarkable Values (ORVs) identified which makes them unique among rivers of the United States (USDA 2010). Some ORVs are water related such as Ecologic (which includes free flowing characteristics), Fish, and Recreation (water contact recreation such as boating and swimming). Other ORVs include Scenic, Historical and Cultural, Geologic, Wildlife, and other Recreation activities.

The water related ORVs of the Tuolumne River are recreation, whitewater boating and fish. The water related ORVs of the Clavey River within the Rim Fire are fish and ecologic (free flowing characteristics). There are no water related ORVs for the South Fork Tuolumne River. Its ORV is Scenic (high quality scenery of the river canyon).

The water related ORVs of the Tuolumne and Clavey rivers were in excellent condition prior to the Rim Fire. The condition of the white water boating ORV in the Tuolumne River and the fish ORV in both rivers are expected to remain so as they were following the comparable Stanislaus Complex Fire of 1987. The free flowing ORV in the Clavey River will not be affected.

WATER QUALITY CONDITION

Prior to the Rim Fire, water quality within the fire perimeter was considered excellent at all the watershed scales previously described. Throughout the main Tuolumne River and its tributaries there is substantial evidence of high quality water. The EPA maintains a list of waters with impaired water quality under Section 303(d) of the Federal Clean Water Act (CVRWQCB 2010). The Tuolumne River is not listed as an impaired stream, nor is the Merced River. At the smaller scale, SSI and BMI

data collected in the Rim Fire area have shown evidence of excellent water quality where sampled in the watersheds across the fire area.

Water quality effects during the fire from Rim Fire ash deposits into the main channel of the Tuolumne River upstream of and including Hetch Hetchy Reservoir did not impact the San Francisco domestic water supply system. Nor is it likely that later notable sedimentation from the Rim Fire into the reservoir will occur since there is a negligible amount of fire acreage upstream of the Hetch Hetchy dam. Downstream effects of the fire in the Tuolumne River will not impact the water supply system since its diversion infrastructure is essentially closed to environmental effects. Water is transported through tunnels and pipelines all the way from the source at Hetch Hetchy Reservoir to the end point near San Francisco.

Water quality degradation resulting from erosion and stream sedimentation following the Rim Fire occurred as expected for a winter (2013/2014) that turned out to be only about 50% of average precipitation with few storms exceeding a 1 to 2 year return interval. Early winter rainfall began to mobilize easily dislodged ash and streamside sediment in highly burned areas with little ground cover. Streams and rivers ran variably turbid, some very much so, during and after succeeding storms depending on rainfall intensity, soil type and other factors. Decreases in turbidity and sediment transport occurred between storms. This process of storm driven sediment delivery and transport repeated itself over the low rainfall winter of 2014/2015. Sediment mobilization, transport and deposition were minor to moderate, without major degradation.

Environmental Consequences

Alternative 1 (Proposed Action)

DIRECT AND INDIRECT EFFECTS

Direct and indirect effects of proposed activities are described below for 13 of 18 HUC 6 watersheds and 5 HUC 7 watersheds. Five HUC 6 watersheds (Big Creek, Upper Cherry Creek, Bull Creek, Bean Creek-North Fork Merced River, and West Fork Cherry Creek) are not assessed below due to the negligible amount of high and moderate soil burn severity (Table 2) and proposed project activities in their watersheds (See Appendix A). Proposed treatments within these watersheds cover a relatively low percentage of the total watershed acres and therefore are too small for consideration in this analysis. Project consequences in these watersheds would be negligible and not likely detectable. The selection of 5 HUC 7 watersheds is described in Appendix A: Cumulative Watershed Effects Analysis Methodology of this report.

Erosion and Sedimentation

Factors Affecting Erosion and Sedimentation

Soil Compaction

Compaction of soil from mechanized equipment can lead to hydrologic effects such as lower infiltration rates and increased runoff. These effects are anticipated to occur in the portion of the project area where thinning in existing plantations and mechanical site preparation are proposed. The effects would be minimized on those areas where deep tilling and forest cultivation would be combined as a follow-up site preparation activity. Conversely, equipment tracking could break down the hydrophobic layer, providing a positive effect.

Management requirements include methods to prevent and mitigate compaction and subsequent hydrologic effects within RCAs. This includes mechanized equipment restrictions, wet weather restrictions, and subsoiling requirements.

Soil compaction is anticipated to occur under the proposed action. However, by implementing BMPs and management requirements, these effects would be mitigated. These soil compaction mitigations would, in turn, minimize reductions in infiltration and increases in runoff.

Soil Displacement

In existing plantation thinning units, feller-bunchers "bunch" the logs into a pile for the skidder to move. Minor displacement of soil may occur in the feller-buncher tracks, particularly where the equipment has turned.

Management requirements of mechanical impacts (e.g., slope and wet season limitations) are anticipated to minimize or prevent erosion and sedimentation. Mastication, while potentially causing some on-site soil displacement, also provides a mulch cover to mitigate erosion risk.

Ground Cover

Ground cover protects soil from rainsplash erosion and slows and filters surface runoff. Management requirements were designed to maintain or increase ground cover in near-stream areas. Within RCAs, ground cover is expected to increase under the proposed action as a result of maintaining post-fire conifer needle cast, application of ground cover by leaving dead plant material and limbs, or by mastication, along with the natural recovery of live vegetation. A maximum of 20 tons per acre of fuel loading would remain.

Erosion and Sedimentation from Treatment Activities

Mechanized equipment activities

Effects of site preparation with tractors and thinning existing plantations with feller bunchers on water quality could include increases in sedimentation caused either by the transport of eroded material out of treated areas into stream channels, or by increased flows that result in channel erosion that in turn increases sedimentation. Best Management Practices (BMPs) are applied to minimize erosion and sediment delivery to streams. MacDonald and Stednick 2003 note that fuels treatments should have little effect on water quality if they are well-planned and BMPs are implemented.

Mastication has the potential to disturb or compact soil but has not been widely studied (Robichaud et al. 2010). Hatchett et al. 2006 concluded that erosion and compaction on their study area's coarse sandy loam were minimal, but that their findings were probably the result of the equipment being operated on masticated material rather than on bare ground. The precipitation simulations in their study did not produce runoff on the plots with masticated material for groundcover. Moghaddas and Stephens 2007 found that commercial thinning of a mixed conifer forest followed by mastication did not increase compaction of the Holland and Musick series soils in their study area. Based on these studies and previous experience with the treatment on the STF, mastication is expected to increase soil cover and organic matter and cause slight or minimal decrease in porosity. The treatment leaves good groundcover and does not significantly increase erosion, so increases in runoff or erosion are not expected to occur.

Despite the variability in research results, some key points are brought up repeatedly in the literature including: 1) Minimize compaction to the extent possible; 2) Minimize soil displacement; 3) Maintain or increase ground cover to filter sediment. Management requirements and BMPs were designed to accomplish these three tasks.

From a hydrologic standpoint, increased compaction, increased soil displacement, and changes in ground cover are most critical in the near stream areas where stream sedimentation is most likely. Knowledge of soil burn severity in these areas is important because areas of low soil burn severity have much greater potential to filter sediment than areas of high soil burn severity. Table 7 describes mechanical activities acres (thin/biomass, machine piling, mastication, deep tilling and forest

cultivation) within 100 feet of perennial or intermittent streams and special aquatic features (SAFs) by soil burn severity.

Table 7 Alternative 1: Mechanical Activities by Soil Burn Severity

HUC Level and Name	SBS HIGH	SBS MOD	SBS LOW
6. Grapevine Creek-Tuolumne River	0	26	46
6. Jawbone Creek-Tuolumne River	68	96	94
7. Corral Creek	32	46	7
7. Lower Jawbone Creek	0	0	1
6. Lower North Fork Tuolumne River	0	19	20
6. Lower Clavey River	1	47	30
7. Bear Springs Creek	0	3	1
6. Middle Clavey River	0	6	4
6. Reed Creek	11	12	16
7. Lower Reed Creek	11	10	6
6. Lower Cherry Creek	66	135	44
7. Granite Creek	54	76	2
6. Miguel Creek-Eleanor Creek	0	0	2
6. Poopenaut Valley-Tuolumne River	4	4	0
6. Lower Middle Fork Tuolumne River	16	101	43
6. Upper Middle Fork Tuolumne River	0	6	6
6. Lower South Fork Tuolumne River	5	38	37
6. Upper South Fork Tuolumne River	0	1	3

LOW=Low and Unburned; **MOD**=Moderate; **SBS**=Soil Burn Severity (percent of Fire area)

Research has shown that buffers reduce overland flow and sediment yield. This is because, in the absence of soil disturbance and compaction caused by machinery, overland flow stands a greater chance of infiltrating the soil profile, resulting in sediment deposition within the buffer. One such experiment found that a 10 meter (33 feet) undisturbed buffer removed 80-90% of runoff and over 95% of sediment produced by logging skid trails (Lacey 2000). Therefore, addition or maintenance of ground cover is needed to reduce overland flow and sediment yield.

The effectiveness of BMPs is monitored annually on the STF. Between 2006 and 2012, 20 streamside management zones (SMZs) were evaluated on green timber sales. Of these, only one site was rated as not effective. At this site, sediment had entered the stream channel at an approved crossing. There was minor sheet erosion (no rills or gullies) on the main skid crossing due to low ground cover. This ground cover was predicted to recover in the next year, so no corrective actions were recommended (STF 2007-2013).

Research has indicated that erosion and sedimentation following timber harvest most often originates from skid trails. Between 2006 and 2012, 21 skid trails were evaluated on the Stanislaus National Forest. Of these, BMPs were ineffective at only one site. This was where a skid trail crossed an intermittent channel and surface/sheet erosion deposited approximately 0.5 cubic feet of sediment into the channel. Ground cover on the skid trial was improving with needle cast, so no corrective actions were recommended (STF 2007-2013).

Landings are another area of disturbance that has been monitored on the Forest. Between 2006 and 2012, 27 landings were evaluated, and BMPs were found to be ineffective at only one site. At this site, the landing fill slope had rills, but sediment did not reach surface waters.

In addition to conducting BMP monitoring at randomly selected sites on the Forest, BMPs were also evaluated at selected sites following the Darby Fire of 2001 and its subsequent salvage sale (Brown Darby Timber Sale). Eight SMZs, 7 skid trails, and 7 landings were evaluated. All BMPs were found to be effective at protecting surface waters (STF 2004). The Darby Fire resulted in mostly low and

moderate soil burn severity, so these BMP results apply to those circumstances, not high soil burn severity.

Overall, the effectiveness of BMPs at preventing erosion and sedimentation on the STF has been very good in green sales and in areas burned at low or moderate soil burn severity. It is therefore anticipated that BMPs would be effective at minimizing erosion under the proposed action in areas of low and moderate soil burn severity. In areas of high soil burn severity, the risk of erosion and sedimentation is higher. However, natural regrowth vegetation as well as management requirements including the requirement to maintain ground cover are anticipated to further reduce this risk.

Despite implementation of BMPs and management requirements, increased stream sedimentation is anticipated as a result of the proposed action, particularly in areas where mechanical activities create more effective sediment transport networks to stream channels. This is more likely to occur in the Jawbone Creek-Tuolumne River, Corral Creek, Lower Cherry Creek, and Granite Creek watersheds than in other HUC 6 or HUC 7 watersheds due to the larger acreages of near-stream high soil burn severity.

Piling and Burning (Tractor and Hand piling)

Jackpot burning and hand piling and burning would result in reduced fuel loading with very little ground disturbance. Although some soil movement could occur following these activities, it is anticipated to be minor and short term. Pile burning essentially results in small isolated areas of high-severity burn spots located beneath the piles. High-severity impacts include increased runoff and erosion (MacDonald et al. 2004). The associated effects on runoff and erosion would be mitigated by the small size of the burned patches, the unburned areas between them, and buffers along streams where piles will not be burned to ensure a filter strip between these areas and streams (Appendix B). A recent study (Hubbert et al. 2013) found that burning piles within 23 feet of streams did not affect water quality. Hand cut and pile treatments have not been shown to cause ground disturbance that would lead to erosion and sediment delivery. These treatments are considered to have minimal potential to impact water quality.

Machine piling could be implemented using either a dozer (dozer piling) or an excavator or other similar piece of equipment (grapple piling). Tractors with brush rakes cause more direct soil disturbance than the other proposed methods. The possible effects of this treatment include reduced soil cover, decreased infiltration capacity, increased runoff, and increased erosion that could result in rilling or gullying, especially on steeper slopes or soils that are sensitive to disturbance. Increased sediment delivery that exceeds the streams' capacity to transport it could result in increased sedimentation. Water quality could also be affected if equipment leaks fuel or other fluids into a stream. Management requirements would prohibit machine piling within 25 feet of an ephemeral stream and within 50 feet of a perennial stream, intermittent stream, or SAF. The disturbance caused by dozer piling is expected to be greater than that caused by grapple piling. That is because the dozer would push the fuels into a pile, whereas an excavator would pick up and place fuels into a pile.

In areas of low soil burn severity, riparian buffers are anticipated to be largely intact and have ground cover capable of filtering sediment movement resulting from machine piling. In areas of moderate soil burn severity, riparian buffers may be variable. However, ground cover in the form of needle cast and resprouting vegetation can help filter runoff caused by machine piling disturbance. In areas of high soil burn severity little, if any, ground cover remained after the Rim Fire. However, two years post fire these areas have shown a dramatic increase in the amount of vegetation returning to these areas (Vegetation Report). This new vegetation can help filter sediment laden runoff resulting from the impacts of machine piling. In addition, management requirements state a minimum of 60% of well distributed ground cover should be left within 100 feet and to exclude dozer operations within 50 feet of a perennial streams, intermittent streams or SAF. Although it is anticipated that some sediment

could reach streams as a result of machine piling, streamside buffers, needle cast, new and resprouting vegetation or placed ground cover should minimize this.

According to Reid 2010, the impacts of mechanical fuel treatments (similar to the site preparation activities proposed here), on erosion and sediment yield are likely to result from direct soil disturbance where these activities affect swales and low-order stream channels. In this project, swales have no riparian buffers since mechanized access is not prohibited. Ephemeral channels have a 15-foot buffer where equipment is excluded.

Six BMP evaluations for machine piling were conducted on the STF between 1992 and 1998 following green sales. Four of these sites showed no evidence of sediment transport from treated area to the streamside management zone (SMZ). Two evaluations showed sediment deposited in the SMZ, but it did not reach a stream channel (STF 1992-1998). In addition to BMP evaluations, a machine piling unit in the Long Shanahan Project was reviewed in spring, 2010. No rills were seen and sediment did not reach surface water (Janicki 2010).

Roads

Forest roads cause hydrological effects by concentrating and channelizing surface and subsurface flow. Following wildfire, the ability of the landscape to filter runoff from roads can be reduced due to a decrease in ground cover (Peterson et al. 2009).

Road Reconstruction and Maintenance

In this project area, road work was recently completed under previous projects and the effects are reflected in the existing condition of the project area. On road surfaces that are draining well, maintenance is important because a lack of road maintenance can result in progressive degradation of road-drainage structures and functions (USDA 2013). This is particularly important with increased runoff from hillslopes following fire. In these situations, reconstruction is required to adequately improve drainage features and minimize impacts.

The effectiveness of BMPs at protecting water quality following road reconstruction or maintenance has been evaluated on the Forest. Between 2006 and 2012, 24 roads were randomly selected for evaluation of road surface drainage and stream crossings following maintenance or reconstruction. Of these, two reconstructed or maintained roads and two stream crossings were not effective. Effects of these were determined to be insignificant or minor and no corrective actions were recommended (STF 2007-2013).

Erosion and sedimentation is anticipated along maintained and reconstructed roads. However, implementation of BMPs and management requirements are expected to minimize these effects. Road reconstruction may actually reduce erosion and sedimentation as this treatment would involve improving road drainage features.

Fuel Loading

Site preparation and thinning existing plantations would reduce the fuel loading in project area watersheds. Coarse woody debris would be reduced to about 20 tons per acre. This would result in lower flame lengths and fireline intensities, allowing for direct attack of future wildfires. Increased erosion following prescribed fire is related to the amount of vegetation removed. Prescribed burns, by design, do not consume extensive areas of organic matter (Baker 1990). Therefore, prescribed fires have little impact on erosion and sedimentation, whereas intense wildfires may have substantial impacts (Brooks et al. 1997). Reducing fuel loading and then maintaining this with prescribed fire has less potential for erosion and sedimentation than allowing fuel loading to increase as snags fall and having another large stand-replacing wildfire in the future. See the Fuels report for more information on fuel loading.

Riparian Vegetation

Riparian vegetation may be beneficially affected by the proposed action where thinning of trees in riparian areas are prescribed. Increasing sunlight in streamside areas provides an energy input that often stimulates regrowth of the riparian plant community. Riparian vegetation is often resilient even following wildfires (Ellis 2001; Dwire and Kauffman 2003; Beschta et al. 2004) and resprouting riparian vegetation such as willows and sedges is often observed quickly after the fire (note that in the Rim Fire, resprouting vegetation was observed in less than two weeks of actively burning at multiple riparian zones that burned at high intensity). Though this effect is largely a result of the fire removing stream shade cover and moisture competition, removal of tree boles may have a slight incremental effect. Another variable affecting riparian plant growth is the short-term increase in streamflow and near-stream ground water following a fire as a result of a reduction in plant transpiration due to tree mortality.

No fens are within treatment areas and would therefore not be affected.

Project activities along meadow edges are not expected to affect the 100 acres of meadows identified within the proposed action treatment units, as management requirements would be implemented.

This project identified the need to eradicate noxious weeds and invasive non-native pest plants in and adjacent to project units. Methods for removing noxious weeds include burning, grazing, grubbing, herbicides and hand pulling. Weed infestations near streams could potentially spread by wind, water, birds and other animals to new sites downstream. Once population of weeds and pest plants expand into riparian areas their potential to overtake desirable riparian species is high. This can lead to impairment of riparian function, increased sediment delivery, reduced quality of aquatic habitat, reduced flood control function and reduced function of soil water delivery to streams.

Stream Condition

Stream Flow

Water yield typically increases in the first year following wildfire due to a reduction in soil water storage, interception, and evapotranspiration when vegetation is killed. This change decreases with time as vegetation reoccupies a watershed (Peterson et al. 2009). Under Alternative 1, small and immeasurable hydrologic changes in canopy throughfall, plant transpiration and uptake processes would occur from removing, shredding and burning vegetation. Canopy openings and reduced fuel loading are expected to occur in SMZs as allowed under the mechanized equipment constraints of the BMP's in RCAs. The creation of canopy openings in SMZs may favor riparian vegetative species and potentially increase available soil moisture, during otherwise high transpiration periods.

Thinning activities will remove forest cover decreasing interception and transpiration and in wetter areas, increase annual water yields. The increases in annual water yield are proportional to the amount of forest cover removed, but at least 15 to 20% of the trees must be removed to produce a statistically detectable effect (MacDonald and Stednick 2003), and this project would remove at least that amount. The reduction in forest canopy also increases the amount of solar radiation that reaches the surface of the snow pack and the transfer of advective heat. These changes increase the rate of snowmelt and may alter the timing of peak runoff (MacDonald and Stednick 2003).

Planting seedlings would serve to improve the long-term watershed and riparian stability and function by enhancing and restoring the species diversity and structural composition of the forest surrounding riparian communities. Alternative 1 would restore or improve riparian RCA functions such as surface and subsurface filtering mechanisms. Planting trees would also increase live vegetation helping restore post-fire natural water storage, another positive watershed effect.

Modeling has indicated that increased surface roughness promotes infiltration and reduces overland flows, leading to reduced storm peak events and total flows (Smith et al. 2011). BMPs and management requirements under the proposed action would involve maintaining ground cover and

minimizing compaction. Therefore, measurable changes in stream flow are not anticipated to result under the proposed action beyond the changes that already occurred as a result of the fire.

Stream Morphology

Prior to the Rim Fire, stream surveys throughout the project area indicated that most stream banks were stable and that channel form was predominately either normal (no active downcutting or evidence of accelerated past incision) or rejuvenating (evidence of legacy disturbance, but channel has recovered or is recovering to good condition).

Increased high peak flows following the Rim Fire have the potential to cause channel incision and stream bank erosion, primarily in low-gradient stream reaches with small, mobile substrate. However, measureable changes in flow are not anticipated as a result of the proposed action. Therefore, if channel incision does occur within the project area, it is likely the result of the fire or from large storms, not the proposed action.

Streambanks that were stable pre-fire may no longer have adequate cover to maintain their stability. This is particularly true in areas of high soil burn severity. As discussed above, riparian vegetation is resilient following fires and is expected to flourish in the post-fire conditions of increased sunlight and water. This would allow for natural recovery of bank stability. The effect of the proposed action on streambank stability is expected to be minimal. Mechanized equipment exclusion zones are applied to all streams so that equipment is only allowed on streambanks at designated crossing locations. Skid trail stream crossings are limited to two per mile on perennial and intermittent streams and three per mile on ephemeral streams. Management requirements to maintain or provide ground cover within 100 feet of perennial and intermittent streams would provide for stability while riparian vegetation continues recovering. Indirect effects that could occur in the case of increased flow or sediment delivery from adjacent hillslopes are also not expected, since hillslope effects would also be minimized by the implementation of project management requirements.

Large Woody Debris

Following wildfire, snags falling into streams may be the main source of wood to streams until trees in the post-fire riparian areas are large enough to fall into streams and create habitat (Reeves et al. 2006). Large woody debris (LWD) in and across channels typically helps to maintain channel stability, decrease flow velocity, trap sediment, and protect banks from erosion. The proposed thinning would not remove large existing snags and would primarily harvest smaller diameter trees (very few trees over 20 inches dbh exist within these stands). LWD recruitment would not be effected and the remaining trees would actually grow faster and become larger sooner. Given the quantity of large fire-killed trees that currently exist along streams in the project area, future recruitment is high and little potential for modification of its role in any subdrainage is likely. The role of LWD is less important in steep bedrock dominated systems such as these, where the wood does not form stable jams capable of trapping sediment for long periods of time (Berg et al. 1998). LWD recruitment in streams would increase in the long-term following project implementation. See the Aquatics report for more information on large woody debris.

Wild and Scenic Rivers

The Tuolumne River main channel throughout the length of the fire on the Stanislaus National Forest was congressionally designated in 1984 as a Wild and Scenic River under the Wild and Scenic Rivers Act of 1968. Under alternative 1, there are no proposed treatments within or adjacent to the Wild and Scenic River corridor. A cluster of units are located to the south, approximately half a mile from the southern boundary and to the north of Highway 120. These units are proposed for reforestation and thinning. Due to their location, the water related ORVs would not be affected.

The South Fork Tuolumne River has a continuous two mile segment upstream from its confluence of the main channel of the Tuolumne River that is eligible as a Wild and Scenic River with a scenic

classification. Under alternative 1, there are no proposed treatments within the Wild and Scenic River corridor. Two treatment units are proposed immediately adjacent to the south of the proposed Wild and Scenic River boundary. The two units, a reforestation and a reforestation and thinning unit near Rim of the World and Colfax Spring, are located well above the river. Additional units proposed for thinning are located near the high point of the boundary to the south. As these are located well above the river and outside the boundary, impacts are not expected to occur to the water related ORV of this river.

The Clavey River is a proposed Wild and Scenic River. More than half of the Clavey's eligible length falls within the Rim Fire area. Under alternative 1, there are no proposed treatments within the Wild and Scenic River corridor. Proposed actions adjacent to the proposed Wild and Scenic River boundary include a variety of treatments, including thinning existing plantations, understory burning, and reforestation. The vast majority of treatments near the Wild and Scenic River corridor are reforestation units.

Free flowing Condition

Maintaining the free-flowing condition of the Tuolumne River, Clavey River, and South Fork Tuolumne River is necessary to maintain their wild and scenic values. The treatments proposed under Alternative 1 would not affect the existing flow regimes of these rivers, as nothing would be placed in their stream channels.

Water Quality

Maintaining high water quality is also needed to maintain the wild and scenic values of the Tuolumne, Clavey, and South Fork Tuolumne Rivers. Though treatments would not occur within the corridors, there could be slight indirect impacts to the water quality in tributaries of the proposed Wild and Scenic River due to sedimentation and herbicide use. As described in the section on erosion and sedimentation (above) and the water quality section (below), management requirements have been designed to minimize water quality impacts. This includes requirements such as maintaining ground cover, preventing and mitigating compaction, and the use of buffer zones around drainages and SAFs. While some sedimentation could occur as a result of the Alternative 1, it is anticipated to be minimal and of short duration and is not expected to affect the long-term beneficial uses and purposes for which these rivers were designated or made eligible. No herbicide contamination is expected as a result of Alternative 1.

Water Quality

Uses of water for the Tuolumne River from its source to New Don Pedro Reservoir are municipal and domestic supply, irrigation, stock watering, power, contact and non-contact recreation, warm and cold water freshwater habitat, and wildlife habitat. Existing uses of water for the Merced River from its source to McClure Lake are irrigation, power, contact and non-contact recreation, warm and cold water freshwater habitat, and wildlife habitat. A potential use for the Merced River is municipal and domestic water supply (CVRWQCB 2011). Beneficial uses are maintained when their related water quality objectives are met. Water quality objectives that could be affected by the proposed action are water temperature, sediment related parameters (sediment, settleable material, suspended material, and turbidity), and pesticides. There are no 303(d) listed impaired waterbodies within the project analysis area. This indicates that water quality is excellent at this large scale.

Water Temperature

Stream channel shade is highly influential in regulating water temperatures (Rutherford et al. 2004). Channel shade was reduced in portions of the project area where near-stream trees were killed by the fire. Elevated stream temperatures occur most frequently in mid- to late summer and early fall, when stream flows are at their lowest. Channel shading in seasonal channels has little influence on water temperature further downstream during these late season periods, because the seasonal streams are

generally not flowing. Removal of the near-stream dead or live conifer trees on existing plantations is anticipated to have very little effect on stream shading. Even in drainages that could have an increase in water temperature (Corral Creek and Granite Creek), when the water reaches the Tuolumne River, it will mix with cooler water and the effect will be diluted. These small and localized effects would not affect beneficial uses in these drainages or downstream. Therefore, warm and cold water freshwater habitat would not be affected by the proposed action. In the long-term, planting conifer seedlings within riparian corridors would help to restore the shading component that was lost after the Rim Fire.

Sediment-Related Parameters

Ground-based treatments in RCAs would cause ground disturbance, due to tractor / heavy equipment use, skidding, and development and use of skid trails, and landings. Disturbed ground could result in increased erosion (erosion rates above pre-project levels). If project-generated erosion is delivered to a stream channel, that sedimentation could result in a water quality impact that would affect beneficial uses. For example, delivery of fine sediments from the project could decrease the quality of cold water fish habitat by filling pools and embedding spawning gravels. Some effects to water quality could result from ground disturbance associated with mechanical equipment treatments in unscoured swales that receive no SMZ buffers. These effects would consist of small, short-term (1-3 years) increases in sediment delivery to streams, which are not expected to be measurable. The project was designed to minimize or avoid these impacts, though management requirements including BMPs. Piling and burning of material near stream courses could contribute ash or sediment to streams. Ash can change the chemical properties of water if contributed in sufficient quantity. Water quality would be protected from potential effects of pile burning by locating burn piles outside of SMZs, which reduces the risk of ash from pile burning reaching the channels.

None of the sediment related beneficial uses of water should be impaired as a result of the proposed action. Minor, short term increases in sediment related parameters are expected but not to the extent of adversely affecting beneficial uses. Anticipated sediment increases vary by watershed based on amount of project activity and watershed effects of the Rim Fire. None of the streams with special designations such as Wild and Scenic Rivers or Heritage Trout Waters are expected to be adversely affected. No known impairment of beneficial uses has occurred as a result of past fire salvage harvesting on the STF in settings where the percentage of high soil burn severity was greater than the Rim Fire.

Herbicides

The risk of petrochemicals reaching streams would be reduced by implementing BMP 2.11, which requires that equipment servicing and refueling activities occur outside of RCAs. Suitable locations for such activities would be designated prior to project implementation.

Alternative 1 uses Glyphosate (trade name Accord® or equivalent) for reforestation treatments where competing vegetation cannot be effectively controlled by other means. The proposed action also includes a combination of hand pulling, digging, grazing, prescribed fire and herbicide applications of Glyphosate, Clopyralid, Aminopyralid and Clethodim to target noxious weeds.

Use of herbicides has the potential to expose areas of bare soil. In addition, manual treatments such as weed eating, pulling, and digging up weeds or competing vegetation may occur within buffers where herbicides are not allowed.

Potential water quality impacts are assessed based on the probable or reasonably expected concentrations that might be encountered in water following herbicide application as well as a worst case or spill scenario. Potential herbicide impacts include: 1) Herbicides directly entering water bodies by heavy storm runoff; 2) Accidental spill or fugitive drift from spray applications; 3) Localized erosion and transport of soil to water bodies due to loss of vegetation cover; and 4)

Leaching of herbicides through specific soil types. These potential impacts are compared to State Water Quality Objectives and Federal Objectives.

Applicable objectives in the Water Board Basin Plan include:

1) No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses.
2) Discharges shall not result in pesticide concentrations in bottom sediments or aquatic life that adversely affect beneficial uses.
3) Pesticide concentrations shall not exceed those allowable by applicable antidegradation policies.
4) Pesticide concentrations shall not exceed the lowest levels technically and economically achievable.
5) Waters designated for domestic or municipal supplies shall not contain concentrations of pesticides in excess of the Maximum Contaminant Levels (MCL) set forth in California Code of Regulations, Title 22, Division 4, Chapter 15.

Where more than one objective may be applicable, the most stringent objective applies (CVRWQCB 2011). The most stringent numerical objective is to not exceed Maximum Contaminant Levels (MCL). The MCL for glyphosate is 0.7 mg/l or 700 ppb. MCLs have not been set in the California Code of Regulations for aminopyralid, clopyralid, and clethodim. The most stringent narrative objective is to "not exceed the lowest levels technically and economically achievable."

The Safe Drinking Water Act requires the EPA to determine safe levels of contaminants in drinking water which do or may cause health problems. EPA has set the MCL for glyphosate at 0.7 mg/l or 700 ppb (EPA 2010). MCLs have not been set for aminopyralid, clopyralid, and clethodim.

Management requirements, including buffer widths, were developed for herbicide use to protect water resources from contamination (Appendix B).

Glyphosate:

Glyphosate is a broad-spectrum foliar herbicide. It is proposed for use via a backpack sprayer and a 1quarter pressurized handheld sprayer. Glyphosate is relatively immobile in most soil environments as a result of its strong adsorption to soil particles. It also has low leaching potential. Glyphosate is inactivated in soil and water by microbial degradation. Soil studies have determined glyphosate half-lives ranging from 3 to130 days (Schuette 1998). According to the specimen label, heavy rainfall soon after application may wash the product off of the foliage (Dow AgroSciences 2014).

Glyphosate Risk Assessment:

A Human Health and Ecological Risk Assessment (worksheet version 6.00.13) was conducted for glyphosate (USDA 2015). Glyphosate for site preparation and release purposes is proposed in this project on approximately 26,036 acres. A total of approximately 1,739 acres of chemical treatment areas, or 6.7% of the total acres, are located within 100 feet of a perennial, intermittent or SAF. The values range from approximately 0.3 acres in the RCAs of the Miguel Creek-Eleanor Creek watershed to a maximum of 444 acres on the Jawbone Creek-Tuolumne River watershed. The project also proposed the use of glyphosate for weed eradication purposes on about 5,042 acres within the project area. This number is an overestimation since this does not take into consideration areas that would be treated with glyphosate for site preparation and release overlap with areas of noxious weeds species. A total of approximately 436 acres to be treated with glyphosate for weeds, or 9% of the total acres, are located within 100 feet of a perennial, intermittent or SAF. The values range from approximately 0.1 acres in the RCAs of the Upper South Fork-Tuolumne River to a maximum of 107 acres on the Lower Cherry Creek HUC 6 watersheds. With ground-based application, the use of

buffers around drainages (no spraying in SMZs, unless streams are dry), and all other applicable BMPs (Appendix B), these herbicides are not expected to enter surface water.

The risk assessment estimates the peak Expected Environmental Concentration (EEC) of glyphosate in water. Estimated concentrations range from 0.0065 mg/L to 0.415 mg/L. In addition, the peak EEC does not account for the dilution that would occur should the glyphosate reach a flowing stream, particularly one the size of for example Reed Creek, Clavey River, and the Tuolumne River. Therefore, even the lower end of the peak EEC range may overestimate concentrations in water.

The risk assessment also estimated concentrations in water at distances downwind after direct spray or after drift from backpack sprayers. A 10-foot buffer is proposed for the Rim Reforestation project when using Glyphosate near perennial waters, ephemeral streams, springs, seeps, or wet areas as well as near obligate riparian vegetation. Although a 10-foot distance is not modeled in the risk assessment for direct spray or after drift from backpack sprayers, direct spray into streams (0-foot buffer) and a 25-foot buffer are modeled. The proposed 10-foot buffer would have concentrations within this range. Direct spray into a stream was estimated to have a concentration of 457 µg/L of glyphosate and a 25-foot buffer would have a concentration of 3.8 µg/L of glyphosate. The direct spray does not account for dilution in a stream, and therefore likely is an overestimate. Project management requirements limit wind speeds during spraying to 5 miles per hour.

Under both the peak EEC and direct spray or drift scenarios, concentrations of glyphosate in water would remain below the 0.7 mg/L MCL. In addition, toxicity values for tolerant cold water fish and amphibians would not be exceeded (USDA 2015, Worksheet G03). This means that even under the case of the accidental spill, glyphosate concentrations in water would be so low that no effect to aquatic species would be observed. This finding has been supported by the monitoring data described below.

The Human Health and Ecological Risk Assessment estimated concentrations of glyphosate in pond water from an accidental spill (20 gallons) (USDA 2015, Refer to the worksheet B04b). Under this spill scenario, the concentration of glyphosate in water would be 1.14 mg/L. Although under this spill scenario the state and federal MCLs of 0.7 mg/L is somewhat exceeded, this is an overestimation because management requirements would prohibit the storage of herbicides on RCAs and require that mixing and loading be performed as far from water and on ground level as possible and on areas predetermined by the Contracting Officer Representative (Appendix B). In addition, the amount that a single backpack sprayer can handle is from 3 to 5 gallons. This means that even under the case of the accidental spill, glyphosate concentrations in water would be so low that no effect to water quality and aquatic species would be observed. Management requirements, such as buffer zones, were developed to further minimize the risk of and impact from a spill.

Glyphosate Monitoring Data:

Herbicide monitoring conducted on the STF has indicated that ground application of glyphosate can be conducted with little risk of entrainment in water. Between 1992 and 2002, 63 water samples and 21 streambed sediment samples were collected following backpack sprayed glyphosate application on over 4,500 acres. Buffers for glyphosate varied from a 10-foot buffer on flowing streams to a 20-foot buffer on all streams (flowing or dry). There were no detections in any of these samples (Bakke 2001; Frazier and Grant 2003).

Monitoring on the Sierra, Eldorado, and Angeles National Forests have had similar results. Fifty water samples collected following glyphosate application have resulted in only one detection (15 ppb). This was on the Angeles National Forest where glyphosate was applied adjacent to and within riparian areas, including in-channel application. Streambed sediment sampling resulted in 23 no detects and 1 detect (88 ppb). This detection on the Eldorado National Forest was ascribed to either

sample contamination or private land contribution (Bakke 2001). Both detections of glyphosate were well below the 700 ppb MCL for the EPA and State.

The Region 5 herbicide monitoring report concluded that, "Based on monitoring to date, glyphosate applications, as generally practiced in reforestation projects, will not result in stream sediment or water contamination" (Bakke 2001). Buffer widths proposed on the project are similar to those used previously on the STF with no resulting detections in water or streambed sediments. The proposed management requirements, including not applying during rain or when rain is predicted within 24 hours, would prevent glyphosate from washing off foliage, further reducing the potential for movement.

Clopyralid:

Clopyralid is a selective (narrow-spectrum) foliar herbicide proposed for use via a backpack sprayer. It is effective in killing plants in the sunflower family and some legumes and buckwheat family plants. Clopyralid has a low soil adsorption coefficient and a very high movement rating. The very high movement ratings of clopyralid do not necessarily imply delivery to ground or surface waters in detectable amounts. The amount applied, the breakdown of the herbicide between application and precipitation, and streamside buffers ameliorate the potential for delivery. California's dry summer climate means significant breakdown of the chemicals occurs in the time between spring application and fall rains. Persistence of clopyralid in soil is variable with documented half-lives ranging from 10 days to 10 months depending on soil type and climate. Although clopyralid does not bind readily to soil, it dissipates rapidly in some common soil conditions and typically is not expected to leach appreciably in non-sandy, low-to-moderate rainfall conditions. According to the specimen label, applications of Transline are rainfast within two hours after application (Dow AgroSciences 2011).

Clopyralid Risk Assessment:

A Human Health and Ecological Risk Assessment (worksheet version 6.00.13) was conducted for clopyralid (USDA 2015a). Clopyralid is proposed for noxious weeds eradication on 528 acres within the project area. This number is an overestimation since this does not take in consideration species overlaps that could be treated in the same area with other herbicides (i.e. glyphosate). A total of approximately 66.4 acres of chemical treatment areas, or 13% of the total acres, are located within a 100 feet of a perennial, intermittent or SAF. The values range from about 0.2 acres in the RCAs of the Upper Middle-Tuolumne River watershed to a maximum of 59 acres on the Lower Cheery Creek watershed. With ground-based application, the use of buffers around drainages (50 feet from edge of any perennial, intermittent, ephemeral stream, special aquatic feature, or wet area that has standing water at the time of application; or ten feet away from obligate riparian vegetation; 15 feet from edge of any intermittent, ephemeral stream, or special aquatic feature that is dry at the time of application), and all other applicable BMPs (Appendix B), this herbicide is not expected to enter surface water.

The risk assessment estimated the peak expected environmental concentration (EEC) of clopyralid in water. Estimated concentrations range from 0.005 mg/L to 0.07 mg/L. In addition, the peak EEC does not account for the dilution that would occur should the clopyralid reach a flowing stream, particularly one the size of, for example, the Clavey River and the Tuolumne River. Therefore, even the lower end of the peak EEC range may overestimate concentrations in water.

The risk assessment estimated concentrations in water downwind after direct spray or after drift from backpack sprayers by modeling at 0-foot buffer (direct spray into streams) and at 50-foot buffer. Under the 50 foot-buffer scenario, as proposed in this project near perennial waters, ephemeral streams, springs, seeps, or wet areas that have standing water at the time of application, the estimated concentration of clopyralid is 0.121 µg/L in pond water and 0.0989 µg/L in stream water (assuming the water was downwind of treatment site). This is a conservative estimate, and actual concentrations would be less. Direct spray into water with a 50-foot buffer is highly unlikely as the spray from the backpack sprayer would not reach that far. Project management requirements limit wind speeds

during spraying to 5 miles per hour. In addition, vegetation within the 50-foot buffer would intercept drift spray, further reducing the likelihood of clopyralid reaching surface water.

The State and EPA have not established MCLs for clopyralid with which to compare the risk assessment values. However, project management requirements would reduce the risk of clopyralid reaching surface water.

The Human Health and Ecological Risk Assessment estimated concentrations of clopyralid in pond water under three different volumes of accidental spill ranging from 20 gallons to 200 gallons. Under these spill scenarios, concentrations of clopyralid in water would range from 0.056775 mg/L to 1.1355 mg/L. This exceeds the NOEC for aquatic macrophytes. However, these concentrations are higher than what would be expected should an accidental spill occur on the Rim Reforestation project. The accidental spill scenario is based off of spill into a pond, and there are no ponds in the project area that are near weed treatment sites. The highest risk site is a yellow star-thistle and tocalote site near Granite Creek within the Lower Cherry Creek HUC6 watershed. In the case of an accidental spill into the river, dilution would greatly reduce the concentrations of clopyralid in water. In addition, vegetation within the 50-foot no-spray would intercept the spill.

Clopyralid Monitoring Data:

There is minimal monitoring data on clopyralid use in Region 5. Clopyralid was used on the STF as part of the Granite Noxious Weed Control project. This project used a 50-foot buffer on all streams with water in them at the time of application. Samples were obtained during three runoff events following herbicide application. All eight samples were no detects. Twelve water samples were collected on the Eldorado National Forest following clopyralid application. Of these samples, 11 were no detects and there was one detect with a value of 3.75 µg/L. The site where clopyralid was detected had a 25-foot buffer on a small perennial stream. It was considered a high risk site because of very steep slopes (approximately 60%) which have dry ravel (Markman 2010, personal communication). This detection value is multiple orders of magnitude less than the 0.1 mg/L NOEC for aquatic macrophytes.

Clopyralid was applied aerially at Fort Hunter Liggett in Montery County, CA. One-hundred-foot (thirty-meter) buffers were established along Stony Creek and around vernal pools. Following aerial application during a 5 miles per hour wind blowing from the treatment zone towards Stony Creek, no clopyralid was detected in Stony Creek. Applicator error resulted in clopyralid being applied nearly at the water's edge of a vernal pool. Concentrations of clopyralid in this pool were 0.25 µg/L (DiTomaso et al. 2004). This is less than the low value of the peak EEC from the risk assessment, supporting the argument that the risk assessment is likely overestimating concentrations.

Another study of aerial applications of clopyralid was conducted in Australia. Although buffers were applied in this study, buffer widths were not specified. The first rainfall occurred 31 hours after application. It was of low intensity and did not cause a significant rise in stream levels. Therefore, the concentration of clopyralid in stream water (0.017 mg/L) was determined to be more likely from spray drift deposits being washed off streamside vegetation than the herbicide being transported to the stream via overland flow. However, a heavy rainfall occurred during the third day after spraying, causing widespread overland flow and minor flooding of stream channels. A total of 2.2 inches of rain was received in 11 hours, with a peak intensity of 1.4 inches for a 30 minute period. Despite this large event, only low concentrations of clopyralid (0.004 mg/L or 4 µg/L) were detected in stream water during and after the storm (Leitch and Fagg 1985). This extreme storm event is near the central concentration for the peak EEC from the risk assessment.

Runoff of clopyralid is most likely to occur as a result of heavy rainfall immediately after application. The likelihood of this occurring on the Rim Reforestation project is reduced due to the fact that application is not allowed when rain is forecast in the next 24 hours. In addition, clopyralid is

considered rainfast after 2 hours (Dow AgroSciences 2011). Over 100 years of precipitation in Sonora, CA indicates that the likelihood of heavy precipitation decreases throughout the spring. Average precipitation in April, May, and June is 2.70, 1.24, and 0.30 inches respectively. The region's dry summer climate means that little, if any, precipitation would occur during the summer months, allowing for breakdown of clopyralid in the time between spring application and fall rains.

According to the SERA report, "clopyralid does not bind tightly to soil and thus would seem to have a high potential for leaching. While there is little doubt that clopyralid will leach under conditions that favor leaching – sandy soil, a sparse microbial population, and high rainfall – the potential for leaching or runoff is functionally reduced by the relatively rapid degradation of clopyralid in soil. A number of field lysimeter studies and a long-term field study indicate that leaching and subsequent contamination of ground water is likely to be minimal. "This conclusion is also consistent with a monitoring study of clopyralid in surface water after aerial application" (SERA 2004). BMPs were also designed to minimize the risk of leaching. This includes not applying clopyralid when soils are saturated and monitoring weather forecasts prior to application. Leaching is therefore unlikely to be a factor affecting water quality in this project.

The small amount of acreage proposed for treatment within 100 feet of a stream or SAF as well as the implementation of BMPs, including the use of buffers, limits on wind speed during application, and monitoring of weather and soil conditions prior to application, would minimize potential contamination of water. Therefore, the proposed application of clopyralid meets the State's narrative objective to "not exceed the lowest levels technically and economically achievable" in all instances except that of an accidental spill.

Aminopyralid:

Aminopyralid is a new herbicide that has been registered provisionally as a reduced risk pesticide for the control of broadleaf weeds. It is proposed for use via a backpack sprayer. Aminopyralid is more mobile in soil than glyphosate, leading to a greater risk of this compound being translocated in the soil profile and possibly entering groundwater. Aminopyralid is likely to be non-persistent and relatively immobile in the soil profile (EPA 2005). Leaching below 6 to 12 inches (15 to 30 cm) is minimal (EPA 2005). The use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in ground water contamination.

Aminopyralid Risk Assessment:

A Human Health and Ecological Risk Assessment (worksheet version 6.00.13) was conducted for aminopyralid (USDA 2015b). The Rim Reforestation project is proposing the use of aminopyralid for noxious weeds eradication purposes on approximately 546 acres within the project area. This number is an overestimation since this does not take in consideration species overlaps that could be treated in the same area with other herbicides (i.e. glyphosate). A total of about 61.3 acres of chemical treatment areas, or 11% of the total acres, are located within a 100 feet of a perennial, intermittent, or SAF. The values range from approximately 3.2 acres in the RCAs of the Lower North Fork-Tuolumne River watershed to a maximum of 37.5 acres on the Grapevine Creek-Tuolumne River watershed. With ground-based application, the use of buffers around drainages (50 feet from edge of any perennial, intermittent, ephemeral stream, special aquatic feature, or wet area that has standing water at the time of application; or ten feet away from obligate riparian vegetation; 15 feet from edge of any intermittent, ephemeral stream, or special aquatic feature that is dry at the time of application), and all other applicable BMPs (Appendix B), this herbicide is not expected to enter surface water.

The risk assessment estimated the peak expected environmental concentration (EEC) of aminopyralid in water. Estimated concentrations range from 0.00022 mg/L to 0.066 mg/L. In addition, the peak EEC does not account for the dilution that would occur should the aminopyralid reach a flowing stream, particularly one the size of, for example, Lower North Fork-Tuolumne River and Lower

South Fork-Tuolumne River. Therefore, even the lower end of the peak EEC range may overestimate concentrations in water.

The risk assessment estimated concentrations in water downwind after direct spray or after drift from backpack sprayers by modeling at 0-foot buffer (direct spray into streams) and at 50-foot buffer. Under the 50 foot-buffer scenario, as proposed in this project, the estimated concentration of aminopyralid is 0.0534 µg/L in pond water and 0.0435 µg/L in stream water (assuming the water was downwind of treatment site). This is a conservative estimate, and actual concentrations would be less. Direct spray into water with a 50-foot buffer is highly unlikely as the spray from the backpack sprayer would not reach that far. Project management requirements limit wind speeds during spraying to 5 miles per hour. In addition, vegetation within the 50-foot buffer would intercept drift spray, further reducing the likelihood of aminopyralid reaching surface water.

The State and EPA have not established MCLs for aminopyralid with which to compare the risk assessment values. However, the modeled concentrations of aminopyralid in water should not affect aquatic life.

The Human Health and Ecological Risk Assessment estimated concentrations of aminopyralid in pond water under three different volumes of accidental spill ranging from 20 gallons to 200 gallons. Under these spill scenarios, concentrations of aminopyralid in water would range from 0.024981 mg/L to 0.49962 mg/L. These concentrations remain below the NOEC for aquatic macrophytes. However, these concentrations are higher than what would be expected should an accidental spill occur. The accidental spill scenario is based off of spill into a pond, and there are no ponds in the project area that are near weed treatment sites. The highest risk areas are an Italian thistle, star-thistle and tocalote site near intermittent tributaries of Grapevine Creek within the Grapevine Creek-Tuolumne River HUC6 watershed. In the case of an accidental spill into the river, dilution would greatly reduce the concentrations of aminopyralid in water. In addition, vegetation within the 50-foot no-spray buffer would intercept the spill.

Aminopyralid Monitoring Data:

There is minimal monitoring data on aminopyralid use in Region 5. This is a limitation in the risk assessment and a source of uncertainty. The lack of monitoring data reflects the fact that aminopyralid is a relatively new herbicide. However, based on literature review, very little risk is posed to water quality from this herbicide application in this project. In order to ensure compliance with the LRMP, spraying in the special land allocations designed to protect water resources (RCAs and SMZs) will be subject to monitoring evaluation following the Best Management Practices Evaluation Program (BMPEP) (USDA 2002).

Clethodim:

Clethodim is a selective postemergence herbicide used for the control of annual or perennial grass weeds proposed for use via a backpack sprayer. Clethodim is of low persistence in most soils with a reported half-life of approximately 3 days (SERA 2014). Breakdown is mainly by aerobic processes, although photolysis may make some contribution. Volatilization loss and hydrolysis are probably not important processes in the soil breakdown of clethodim. The main breakdown products in soils under aerobic conditions are sulfoxide, sulfone and oxazole sulfone. Clethodim and these degradates are weakly bound to soils. Thus, while it may be somewhat mobile in the soil environment, it is very short-lived.

Clethodim Risk Assessment:

A Human Health and Ecological Risk Assessment (worksheet version 6.00.13) was conducted for clethodim (USDA 2015c). Clethodim is proposed for noxious weeds eradication on 3,002 acres within the project area. A total of 117 acres of chemical treatment areas, or 4% of the total acres, are located within a 100 feet of a perennial, intermittent, or SAF. The values range from 1.4 acres in the

RCAs of the Grapevine-Tuolumne River watershed to a maximum of 1,253 acres in the Jawbone Creek-Tuolumne River watershed. With ground-based application, the use of buffers around drainages (50 feet from edge of any perennial, intermittent, ephemeral stream, special aquatic feature, or wet area that has standing water at the time of application; or ten feet away from obligate riparian vegetation; 15 feet from edge of any intermittent, ephemeral stream, or special aquatic feature that is dry at the time of application), and all other applicable BMPs (Appendix B), this herbicide is not expected to enter surface water.

The risk assessment estimated the peak expected environmental concentration (EEC) of clethodim in water. Estimated concentrations range from 0.00000375 mg/L to 0.1325 mg/L. In addition, the peak EEC does not account for the dilution that would occur should the clethodim reach a flowing stream, particularly one the size of, for example, the Clavey River. Therefore, even the lower end of the peak EEC range may overestimate concentrations in water.

The risk assessment estimated concentrations in water downwind after direct spray or after drift from backpack sprayers by modeling at 0-foot buffer (direct spray into streams) and at 50-foot buffer. Under the 50 foot-buffer scenario, as proposed in this project near perennial waters, ephemeral streams, springs, seeps, or wet areas that have standing water at the time of application, the estimated concentration of clethodim is 0.121 µg/L in pond water and 0.0989 µg/L in stream water (assuming the water was downwind of treatment site). This is a conservative estimate, and actual concentrations would be less. Direct spray into water with a 50-foot buffer is highly unlikely as the spray from the backpack sprayer would not reach that far. Project management requirements limit wind speeds during spraying to 5 miles per hour. In addition, vegetation within the 50-foot buffer would intercept drift spray, further reducing the likelihood of clethodim reaching surface water.

The State and EPA have not established MCLs for clethodim with which to compare the risk assessment values. However, aquatic macrophytes are the most sensitive of all aquatic species analyzed. For aquatic macrophytes, data was only available for *Lemna gibba* on the risk assessment, and an NOEC of 0.3 mg/L was used for risk characterization. Because *Lemna* are monocots, this NOEC is presumed to apply to sensitive species of aquatic macrophytes. The risk assessment for clethodim estimated hazard quotients for the central and upper values as 1.3 and 4, respectively, indicating an elevated toxicological risk to aquatic macrophyte individuals under the accidental acute exposure scenario. However, project management requirements, would reduce the risk of clethodim reaching surface water.

The Human Health and Ecological Risk Assessment estimated concentrations of clethodim in pond water under three different volumes of accidental spill ranging from 20 gallons to 200 gallons. Under these spill scenarios, concentrations of clethodim in water would range from 0.056775 mg/L to 1.1355 mg/L. However, these concentrations are higher than what would be expected should an accidental spill occur on the Rim Reforestation project. The accidental spill scenario is based off of spill into a pond, and there are no ponds in the project area that are near weed treatment sites. The highest risk sites are medusahead sites near the intermittent Bull Meadow Creek and Alder Creek streams within the Lower Clavey River and the Jawbone Creek-Tuolumne River HUC6 watersheds, respectively. In the case of an accidental spill into the river, dilution would greatly reduce the concentrations of clethodim once it gets into the Tuolumne River, if not before. In addition, vegetation within the 50-foot no-spray would intercept the spill.

Clethodim Monitoring Data:

There is a general lack of monitoring data on clethodim in surface water and groundwater. This is a limitation in the risk assessment and a source of uncertainty. The lack of monitoring data reflects the fact that clethodim is a relatively new herbicide. But, based on literature review, there is very little risk posed to water quality from this herbicide application in the Rim Reforestation project. In order

to ensure compliance with the Forest Plan monitoring would be done when herbicide applications occur within RCAs and SMZs (USDA 2002).

HERBICIDE SURFACTANTS

Syl-tac™:

Syl-tac™ is a surfactant that is proposed for use as an additive during herbicide application. It has a Caution signal word and may cause slight skin and eye irritation. Syl-tac™ is a mixture of the following two products:

1) Hasten® has a Caution signal word. It may be irritating to the skin and to the eyes. The main ingredient in Hasten® contained in the Syl-tac™ product is esterified canola seed oil. The MSDS lists isopropylamine as a hazardous ingredient at levels of 2 percent in the formulation (Bakke 2007).

2) Sylgard® 309 has a Warning signal word. It is considered slightly irritating to the skin and is considered severely irritating to the eyes. It is not a skin sensitizer. The MSDS describes a 28-day oral dosing study in rats, in which rats were fed doses of 0, 33, 300, or 1,000 mg/kg/day. No significant findings of biological relevance were seen in females, while males showed some effects at highest dose (body weight gain, and changes in food consumption). This would indicate a subchronic NOEL of 300 mg/kg/day (Bakke 2007).

The rainbow trout 96-hr LC50 for Syl-tac™ is >5mg/L. The daphnia 48-hr EC50 for Syl-tac™ is also >5mg/L (Bakke 2007). According to the Syl-tac™ label, the product should not exceed 5 percent of the finished spray volume. The project is proposing to use for Syl-tac (0.4 percent). Due to the small amount of surfactant being used and stream buffers being applied, it is unlikely that these toxicity levels would be exceeded.

ColorfastTM Purple:

Colorfast™ Purple dye is not required to be registered as a pesticide, therefore it has not a signal word associated with it. It is a water-soluble dye that contains no toxic chemicals (SERA 1997). It is mildly irritating to the skin, but because of the acetic acid content, can be severely irritating to the eyes, and can cause permanent damage. Acetic acid is the ingredient in household vinegar, although vinegars are normally 4-10 percent acetic acid, whereas Colorfast™ Purple contains 23.4 percent by weight. Colorfast purple contains gentian violet, which is a common laboratory reagent and stain. This dye is commonly used as an antifungal or antibacterial medication for dermal or mucous membrane infections (SERA 1997).

Summary

None of the sediment related beneficial uses of water should be impaired as a result of the proposed action. Minor, short term increases in sediment related parameters are expected but not to the extent of adversely affecting beneficial uses. Anticipated sediment increases vary by watershed based on amount of project activity and watershed effects of the Rim Fire. Streams with special designations such as Wild and Scenic Rivers or Heritage Trout Waters are not expected to be adversely affected.

Water temperature is not expected to be altered as a result of this alternative. In the long-term, planting conifer seedlings within riparian corridors would help to restore the shading component that was lost after the Rim Fire.

No herbicide contamination is expected as a result of the proposed action.

CUMULATIVE EFFECTS

The process for analyzing cumulative watershed effects (CWE) consists of two steps: 1) An office evaluation to determine the risk of cumulative effects using a predictive model and researching watershed history and 2) Field evaluation of stream course indicators of cumulative effects.

Step 1, the risk of cumulative effects, is evaluated using the Forest Service equivalent roaded acreage (ERA) methodology, adopted by Region 5 as a method of addressing cumulative watershed effects (USDA 1990). A description of the ERA methodology can be found in Appendix A: Cumulative Watershed Effects Analysis Methodology.

Understanding watershed history (i.e. past management activities, hydrologic events, wildfire) is important to build a temporal context of past impacts, current condition and potential future effects. Analysis of watershed history, including land disturbance history, is essential to help predict effects of future management activities on water quality and watershed condition. This history is considered in the ERA model. The temporal scope analyzed is based upon the estimated time of recovery from each past activity or event. It varies by activity and ranges from 1 to 10 years. The temporal scope for known future activities also varies by activity and ranges from 1 to 10 years into the future. Not all future activities used to calculate ERA values have a defined proposed action. Therefore, assumptions were made about when and where activities would likely occur. These assumptions were documented in Appendix A.

Step 2, field evaluation, is necessary for comparing the modeled ERA prediction with actual and expected future field conditions. Project-related water quality parameters and watershed condition are evaluated via in-stream and near-stream indicators of condition. This evaluation is essential to help interpret cumulative effects of past projects and potential cumulative effects given proposed activities and other reasonably foreseeable future activities. Field review was used to verify that the geographic and temporal extent of analysis was adequate for evaluation of cumulative watershed effects (Connaughton 2005).

Equivalent Roaded Acres (ERAs)

The CWE ERA analysis was conducted on all lands (public and private) within 13 HUC 6 and 5 HUC 7 level watersheds. GIS analysis was used to calculate acreages of activities in the watersheds. ERA values for these activities were summed and then were compared to a Threshold of Concern (TOC). The TOC range for all HUC 6 and HUC 7 watersheds analyzed was 12 to 14%. Table 8 gives a summary of ERA values by watershed.

Of the 13 HUC 6 watersheds analyzed, 7 were well below the TOC of 12-14%. These watersheds (Grapevine Creek-Tuolumne River, Lower North Fork-Tuolumne River, Middle Clavey River, Miguel Creek-Eleanor Creek, Poopenaut Valley-Tuolumne River, Upper Middle Fork Tuolumne River, and Upper South Fork Tuolumne River) all had ERA values of less than 6%.

An additional 4 HUC 6 watersheds (Lower Clavey River, Reed Creek, Lower Cherry Creek, and Lower South Fork Tuolumne River) approached, but didn't exceed, the TOC. Two HUC 6 watersheds (Jawbone Creek-Tuolumne River and Lower Middle Fork Tuolumne River) exceeded the TOC.

Five HUC 7 watersheds were evaluated for cumulative watershed effects using the ERA methodology. The description as to how and why these were selected can be found in Appendix A: Cumulative Watershed Effects Analysis Methodology. All watersheds exceeded the TOC with the exception of Lower Jawbone Creek that approached, but did not exceed, the TOC.

All watersheds that approached or exceeded the TOC are discussed in detail below. Cumulative watershed effects are not anticipated on the 7 HUC 6 watersheds that were well under the threshold of concern (ERA values less than 6%), so these are not discussed individually.

Previous analyses on the Forest indicate the effects of livestock grazing at the watershed scale are very low. Ground disturbance from livestock grazing is essentially a site issue rather than a watershed scale issue. This is because the spatial impacts of livestock grazing are much higher in low gradient stream channels through meadows than in upland areas, and low gradient stream areas make up an extremely small percentage of the watershed acreage in this project. This results in negligible change

to ERA values. Because of this, cumulative impacts of grazing are described narratively for this project.

HUC 6 and 7 Watersheds

Management requirements and BMPs were proposed to maintain or improve current conditions in the watersheds. This includes maintenance of a minimum of 60% well distributed ground cover within a 100 feet of a perennial stream, intermittent stream, or SAF and exclusion zones for ground-based equipment. Effectiveness monitoring is done annually on projects throughout the forest at randomly selected sites to determine if BMPs were effective. The Water Board requires that additional monitoring beyond effectiveness monitoring be conducted on watersheds (both HUC 6 and HUC 7) over the TOC with commercial timber related activities. Forensic monitoring inspections are conducted during the winter period. These inspections are designed to detect potentially significant sources of pollution such as failed management measures or natural sources. The goal of winter forensic monitoring is to locate sources of sediment production in a timely manner so that rapid corrective action may be taken where feasible and appropriate (CVRWQCB 2014). Under this project, the majority of the thinning units within the watersheds over the TOC are located on areas that may be inaccessible during the winter. In such situations, forensic monitoring would be conducted during spring runoff, as this is the time when erosion is most likely.

The Rim Recovery EIS project was also required to conduct forensic monitoring on the watersheds that exceeded the TOC and would continue doing it until all the activities and waiver conditions have been met under that project. Under this project 2 HUC 6 and 4 HUC 7 watersheds exceeded the TOC. These watersheds are the same watersheds that exceeded the TOC under Rim Recovery with the exception of the Lower Jawbone Creek HUC7 watershed that remained under TOC under this project. All of the rest of the analysis watersheds under this project were well below the TOC (see Table 8).

A project specific monitoring plan will be developed to ensure compliance with the State Water Board timber waiver and the Region 5 Forest Service Water Quality Management Handbook.

Table 8 Alternative 1: Annual Percent ERA for HUC 6 and HUC 7 Analysis Watershed

HUC Level and Name	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
6 - Grapevine Creek-Tuolumne River	2.63	2.46	2.34	2.27	2.24	2.02	1.84	1.63	1.48	1.42
6 - Jawbone Creek-Tuolumne River	13.41[1]	12.32[1]	11.38	9.44	7.53	6.62	5.32	4.08	2.87	2.32
7 - Corral Creek	22.37[1]	23.03[1]	23.01[1]	19.36[1]	15.27[1]	12.99[1]	10.63	8.27	5.59	4.01
7 - Lower Jawbone Creek	10.65	9.35	8.64	7.43	5.83	5.14	4.20	3.52	2.78	1.95
6 – Lower North Fork-Tuolumne River	3.19	2.94	2.79	2.60	2.36	2.17	1.98	1.79	1.66	1.64
6 - Lower Clavey River	8.41	7.92	7.26	6.15	5.52	4.73	3.93	2.97	2.16	1.75
7 - Bear Springs Creek	12.09[1]	11.76	10.93	9.76	8.86	8.12	7.48	6.82	6.23	1.62
6 - Middle Clavey River	5.29	4.88	5.22	5.47	4.78	4.20	3.63	3.08	2.55	2.15
6 - Reed Creek	8.12	7.51	6.90	6.06	5.07	4.52	3.95	3.23	2.56	2.20
7 - Lower Reed Creek	14.55[1]	12.95[1]	11.17	8.88	6.99	6.25	5.54	4.35	3.33	2.92
6 - Lower Cherry Creek	7.71	6.79	6.09	5.05	4.00	4.05	3.35	2.71	2.08	1.82
7 - Granite Creek	18.85[1]	16.45[1]	15.40[1]	12.72[1]	9.66	8.45	6.71	5.30	4.04	3.47
6 - Miguel Creek-Eleanor Creek	1.25	1.03	0.80	0.55	0.31	0.29	0.25	0.22	0.18	0.16
6 - Poopenaut Valley-Tuolumne River	2.04	1.73	1.40	1.05	0.70	0.63	0.57	0.51	0.46	0.42
6 - Lower Middle Fork Tuolumne River	13.23[1]	12.47[1]	11.67	10.68	9.29	7.95	6.72	5.27	4.04	3.05
6 - Upper Middle Fork Tuolumne River	1.76	1.38	1.01	0.63	0.25	0.22	0.19	0.16	0.14	0.12
6 - Lower South Fork Tuolumne River	8.40	7.84	7.47	6.72	6.13	5.40	4.62	3.84	3.14	2.66
6 - Upper South Fork Tuolumne River	1.54	1.35	1.15	0.97	0.81	0.76	0.73	0.69	0.66	0.64

[1] Denotes watersheds over the TOC

Stream condition in the project area watersheds was evaluated to identify indications of past or present cumulative effects, and the potential for adverse impacts from future cumulative effects. The evaluation of stream condition included pre-fire stream surveys in most watersheds following the StreamScape Inventory (SSI) Protocol, which included observations of streambed sediment, streambank stability, and attributes of stream morphology (Frazier et al. 2008).

All watersheds that approached or exceeded the TOC are discussed in detail below.

Jawbone Creek-Tuolumne River (HUC 6), Corral Creek (HUC 7), and Lower Jawbone Creek (HUC 7)

ERA Summary

Under Alternative 1, the ERA in the Jawbone Creek-Tuolumne River watershed would increase from its current 13.24% (no action) to 13.41%, its maximum ERA, in the first year of implementation, 2016. The ERA falls back below the TOC by 2018 and by 2025 is down to 2.32%. The previous activities in the watershed, which have an ERA value of 10.64% in 2016, are large contributors to the high ERA values. These activities include the fire itself, fire suppression, timber harvest on private and NFS lands before the fire and salvage activities on private and NFS lands after the fire.

The ERA in the Corral Creek HUC 7 watershed would increase from its current 22.04% (no action) to 22.37% in the first year of implementation, 2016. This would further increase in 2017, with a maximum ERA of 23.03%. The ERA falls back below the TOC by 2022 and by 2025 is down to 4.01%. The ERA is over the 12 to 14% threshold of concern for this watershed. This is due mainly to the previous activities in the watershed, which have an ERA value of 17.26%. Land management activities in the watershed include salvage activities post fire (Rim HT and Rim Recovery projects) and private salvage activities. However, the main reason the previous ERA was so high was because 89% of the watershed burned at high or moderate soil burn severity.

The ERA in the Lower Jawbone Creek HUC 7 watershed would remain the same as its current 10.65% (no action) in the first year of implementation, 2016. This is the maximum ERA and does not exceed the 12 to 14% TOC. The ERA gradually decreases to a low of 1.95% in 2025. Approximately three quarters of the 10.65% ERA was due to previous activities, including the fire itself and salvage activities post fire on both private and NFS lands.

Stream Condition Summary

Pre-fire stream surveys in the Jawbone Creek-Tuolumne River watershed were conducted in Drew Creek and Corral Creek. Surveys indicated that the condition of Drew Creek was good overall (i.e., stable banks, normal channel morphology, and low pool bed sediment). The RCA surrounding Drew Creek burned at low severity, so stream condition post-fire is likely the same as pre-fire. Very little treatment is proposed under Alternative 1 in the southern part of the Jawbone Creek-Tuolumne River watershed near Drew Creek, so stream condition is anticipated to remain good.

Pre-fire stream surveys in Corral Creek, on the other hand, showed much of the channel to be rejuvenating from past disturbance. Pre-fire bank stability was moderate, and was substantially reduced by the fire. This stream is still sensitive to further disturbance. Due to this sensitivity, additional management requirements were put in place for Corral Creek. A large equipment exclusion zone prohibits mechanized equipment between Corral Creek and its near-stream roads. Ground cover will be maintained or provided along its banks to minimize erosion and increase stability. This is in addition to 700 acres of straw mulch that was applied to the watershed as part of BAER treatments. Despite these treatments, Corral Creek is one of the areas which have the greatest potential for stream sedimentation following treatment.

Pre-fire stream surveys were not conducted in the Lower Jawbone Creek HUC 7 watershed. However, the acreage of high soil burn severity in this watershed was relatively low (10%). There was only 3% high soil burn severity within 100 feet of streams, meaning that most of the high soil burn severity was on the hillslopes. In this watershed, there are not mechanical activity treatments

proposed in a high soil burn severity area within 100 feet of a perennial stream, intermittent stream, or SAF. Therefore, sedimentation from mechanical activity treatments are not expected.

The proposed action is anticipated to result in increased sedimentation in the Jawbone Creek-Tuolumne River watershed, particularly in the Corral Creek HUC 7 watershed. However, management requirements and BMPs are anticipated to minimize these effects to the extent feasible. Monitoring is anticipated to identify any problem areas so that corrective action could be taken quickly. Due to these measures, the proposed action is not anticipated to result in adverse off-site cumulative effects to sediment-related water quality parameters or to watershed condition (i.e. degradation of stream channel morphology, accelerated erosion or loss of soil productivity.

Lower Clavey River (HUC 6) and Bear Springs Creek (HUC 7)

ERA Summary

The ERA in the Lower Clavey River watershed would increase from its current 8.29% (no action) to 8.41% in the first year of implementation, 2016. This is the maximum ERA and does not exceed the 12 to 14% TOC. The ERA gradually decreases to a low of 1.75% in 2025. Approximately three quarters of the 8.41% ERA was due to previous activities, including the fire itself, timber harvest (both green sales and salvage) on private land, and post fire salvage on NFS land.

The ERA in the Bear Springs Creek HUC 7 watershed would increase from its current 11.79% (no action) to 12.09% in the first year of implementation, 2016. This is the maximum ERA. The ERA falls back below the TOC the following year 2017 and by 2025 is down to 1.62%. The ERA is slightly over the 12 to 14% threshold of concern for this watershed. This is due mainly to the previous activities in the watershed, which have an ERA value of 9.89%. These previous activities include the fire itself, in which 50% of the watershed burned at moderate or high soil burn severity, as well as salvage activities on NFS land and timber activities (both green tree sales and salvage) on private lands.

Stream Condition Summary

Pre-fire stream surveys in the Lower Clavey River watershed were conducted in Bull Meadow Creek. Surveys indicated that the condition of Bull Meadow Creek was variable. Although most of the bank stability was high, there were transects with less than 50% stability, and 17% of the surveyed channel length was incised. Despite this, pool bed sediment and pool tail sediment was low. The RCA surrounding Bull Meadow Creek burned primarily at low and moderate severity, so stream condition post-fire is likely the same as pre-fire. In this watershed, there are 1 acre and 47 acres of mechanical activity treatments proposed in high and moderate soil burn severity areas, respectively, within 100 feet of a perennial stream, intermittent stream, or SAF. Project management requirements are in place to further reduce any adverse effect from project activities, so stream condition is anticipated to remain unchanged.

Pre-fire stream surveys were not conducted in the Bear Springs Creek HUC 7 watershed. However, the acreage of high soil burn severity in this watershed was low (7%). Only 2% high soil burn severity occurred within 100 feet of streams, meaning that most of the high soil burn severity was on the hillslopes. In the Bear Springs Creek watershed, mechanical activities are not proposed in a high soil burn severity area within 100 feet of a perennial stream, intermittent stream, or SAF, but are proposed on only 3 acres within moderate soil burn severity. Due to low acreage of treatment proposed within moderate soil burn severity and zero acreage within the highest risk area, the creation of effective sediment transport networks to stream channels are not expected. Due to implementation of management requirements and BMPs, as well as monitoring to identify problem areas, the proposed action is not anticipated to result in adverse off-site cumulative effects to sediment-related water quality parameters or to watershed condition (i.e. degradation of stream channel morphology, accelerated erosion or loss of soil productivity).

Reed Creek (HUC 6) and Lower Reed Creek (HUC 7)

ERA Summary

The ERA in the Reed Creek watershed would increase from its current 8.09% (no action) to 8.12% in the first year of implementation, 2016. This is the maximum ERA and does not exceed the 12 to 14% TOC. The ERA gradually decreases to a low of 2.20% in 2025. More than half of the ERA value in 2016 was due to previous activities, including the fire itself, fire suppression, timber harvest on private and FS lands before the fire, and salvage activities on private and NFS lands after the fire.

The ERA in the Lower Reed Creek HUC 7 watershed would increase from its current 14.46% (no action) to a maximum 14.55% in the first year of implementation, 2016. The ERA falls back below the TOC by 2018 and by 2025 goes down to 2.92%. The ERA is over the 12 to 14% threshold of concern for this watershed. This is due mainly to the previous activities in the watershed, which have an ERA value of 11.71% in 2016. These previous activities include the fire itself, in which 62% of the watershed burned at moderate or high soil burn severity, as well as timber activities (both green tree sales and salvage) on private and NFS lands.

Stream Condition Summary

Over 30 miles of pre-fire stream surveys in the Reed Creek watershed were conducted in Bourland Creek, Little Reynolds Creek, Lost Creek, Niagara Creek, Reed Creek, and Reynolds Creek. Surveys indicated that the condition of these creeks was predominately good. Bank stability was high or moderate for 80 to 100% of stream lengths. Channel form was mostly normal or rejuvenating, with the exception of a large incised section of Lost Creek and smaller sections of incision elsewhere. Despite these areas of instability, pool bed sediment and pool tail sediment was low.

Reed Creek and Niagara Creek are the main channels in the Lower Reed Creek watershed. Reed Creek had high bank stability pre-fire and had 99% of its length in a normal channel form. Niagara Creek had more evidence of past instability, with sections of low bank stability (6% of surveyed length) and almost half its length incised, incised and widened, or rejuvenating. Despite this, both streams had low pool bed and pool tail sediment.

In the Reed Creek watershed, there are 11 acres of mechanical activity treatment proposed in a high soil burn severity area within 100 feet of a perennial stream, intermittent stream, or SAF. All of this treatment is located within the Lower Reed Creek watershed. Reed Creek is bedrock controlled and highly erosion resistant, so changes in stream channel form are unlikely. Niagara Creek is more sensitive to disturbance, as its dominant substrate is gravel which is much more easily mobilized in high flows. Management requirements and BMPs were designed to address this sensitivity. This includes equipment exclusion zones and ground cover requirements. In addition, about 1,900 acres of straw mulch was applied to this watershed as part of BAER treatments. Despite these treatments, the Lower Reed Creek HUC 7 watershed is one of the areas which have the greatest potential for stream sedimentation following treatment.

The proposed action is anticipated to result in a slightly increased sedimentation in the Lower Reed Creek watershed. However, management requirements and BMPs are anticipated to minimize these effects to the extent feasible. Monitoring is anticipated to identify any problem areas so that corrective action could be taken quickly. Due to these measures, the proposed action is not anticipated to result in adverse off-site cumulative effects to sediment-related water quality parameters or to watershed condition (i.e. degradation of stream channel morphology, accelerated erosion or loss of soil productivity).

Lower Cherry Creek (HUC 6) and Granite Creek (HUC 7)

ERA Summary

The ERA in the Lower Cherry Creek HUC 7 watershed would remain the same as its current 7.71% (no action) in the first year of implementation, 2016. This is the maximum ERA and does not exceed the 12 to14% TOC. The ERA gradually decreases to a low of 1.82% in 2025. More than three quarters of the 7.71% ERA was due to previous activities, including the fire itself, fire suppression, and timber activities (both green tree sales and salvage) on private and Forest Service lands.

The ERA in the Granite Creek HUC 7 watershed would stay on its current 18.85% (no action) to the maximum 18.85% in the first year of implementation, 2016. The ERA falls back below the TOC by 2020 and by 2025 is down to 3.47%. The ERA is over the 12 to 14% threshold of concern for this watershed. This is due primarily to the previous activities in the watershed, which have an ERA value of 15.42% in 2016. These previous activities include the fire itself, in which 92% of the watershed burned at moderate or high soil burn severity, as well as timber activities (both green tree sales and salvage) on private and NFS lands.

Stream Condition Summary

No pre-fire SSI data was collected for the Lower Cherry Creek watershed. In Granite Creek, 54 acres of mechanical activities are proposed in high soil burn severity area within 100 feet of a perennial stream, intermittent stream, or SAF. The granitic soil prevalent in this watershed is highly erodible. About 30% of the watershed burned at high soil burn severity, and an additional 62% burned at moderate soil burn severity. Because of this sensitivity, about 750 acres of straw mulch was applied to the Granite Creek watershed as part of BAER treatments.

The proposed action is anticipated to result in increased sedimentation in the Granite Creek watershed. This watershed experienced the greatest burn severity of any of the HUC 7 watersheds. However, management requirements and BMPs are anticipated to minimize these effects to the extent feasible. Monitoring is anticipated to identify any problem areas so that corrective action could be taken quickly. Due to these measures, the proposed action is not anticipated to result in adverse off-site cumulative effects to sediment-related water quality parameters or to watershed condition (i.e. degradation of stream channel morphology, accelerated erosion or loss of soil productivity).

Lower Middle Fork Tuolumne River (HUC 6)

ERA Summary

The ERA in the Lower Middle Fork Tuolumne River watershed would increase from its current 12.57% (no action) to the maximum 13.23% in the first year of implementation, 2016. The ERA falls back below the TOC by 2018 and by 2025 is down to 3.05%. The ERA is over the 12 to 14% threshold of concern for this watershed. This is due mainly to the previous activities in the watershed, which have an ERA value of 9.53% in 2016. These previous activities include the fire itself, of which 63% of the watershed burned at moderate or high soil burn severity, as well as timber activities on private and NFS lands.

Stream Condition Summary

Nearly 10 miles of pre-fire stream survey data was collected on the main channel of the Middle Fork Tuolumne River. Bank stability was very high and channel form was normal for its entire length, indicating no evidence of past channel incision. Pool tail and pool bed fine sediment was also low. In this watershed, 16 acres of mechanical activities are proposed in high soil burn severity area within 100 feet of a perennial stream, intermittent stream, or SAF. Part of this watershed was burned previously in the Pilot Fire, and good pre-Rim Fire condition indicates that impacts of past wildfire have not affected stream channel stability. The areas of high soil burn severity in the Lower Middle Fork Tuolumne River watershed were relatively small patches well distributed throughout the

watershed. The spatial mosaic of severity classes can reduce on and off site soil and water effects by interrupting erosion pathways and reducing sediment delivery to streams.

The proposed action is anticipated to result in increased sedimentation in the Lower Middle Fork Tuolumne River watershed. However, management requirements and BMPs are anticipated to minimize these effects to the extent feasible. Monitoring is anticipated to identify any problem areas so that corrective action could be taken quickly. Due to these measures, the proposed action is not anticipated to result in adverse off-site cumulative effects to sediment-related water quality parameters or to watershed condition (i.e. degradation of stream channel morphology, accelerated erosion or loss of soil productivity).

Lower South Fork Tuolumne River (HUC 6)

ERA Summary

The ERA in the Lower South Fork Tuolumne River watershed would increase from its current 8.37% (no action) to 8.40% in the first year of implementation, 2016. This is the maximum ERA and does not exceed the 12 to14% TOC. The ERA gradually decreases to a low of 2.66% in 2025. More than half of the 2016 ERA value was due to previous activities, including the fire itself, in which 47% of the watershed burned at moderate or high soil burn severity, fire suppression, and timber activities (both green tree sales and salvage) on private and Forest Service lands.

Stream Condition Summary

Nearly 7 miles of pre-fire stream survey data was collected on the main channel of the South Fork Tuolumne River. Sections of Big Creek, Rush Creek, and Soldier Creek were also surveyed. Bank stability was moderate to high and all four streams had normal channel form for 100% of their lengths. Pool tail and pool bed sediment was higher than that seen in the other watersheds described above, but all size classes of fish were present in streams, indicating that sediment was not excessive regarding aquatic life.

In this watershed, there are 5 acre and 38 acres of mechanical activity treatments proposed in high and moderate soil burn severity areas within 100 feet of a perennial stream, intermittent stream, or SAF, respectively. The proposed action has the potential to further increase sedimentation in the Lower South Fork Tuolumne River watershed. However, management requirements and BMPs are anticipated to minimize these effects to the extent feasible. Monitoring is anticipated to identify any problem areas so that corrective action could be taken quickly. Due to these mitigations, the proposed action is not anticipated to result in adverse off-site cumulative effects to sediment-related water quality parameters or to watershed condition (i.e. degradation of stream channel morphology, accelerated erosion or loss of soil productivity).

Grazing

Active grazing allotments are located in all of the analysis HUC 6 and HUC 7 watersheds except Miguel Creek-Eleanor Creek. Grazing on these allotments has the potential to slow recovery of riparian vegetation and increase ground disturbance, particularly along streambanks. However, Forest Plan Standards and Guidelines require the prevention of disturbance from livestock from exceeding 20% of stream reach or 20% of natural lake and pond shorelines. It also limits browse to no more than 20% of the annual leader growth on mature riparian shrubs and no more than 20% of individual seedlings. In this project area the browse limit would apply to streamside areas where riparian obligate trees and shrubs are naturally resprouting and reseeding after the fire. Although continuing of grazing is anticipated to result in ground disturbance and a reduction in riparian vegetation, these effects are anticipated to be localized and adherence to Standards and Guidelines should allow for riparian vegetation recovery to progress naturally.

Alternative 2 (No Action)

DIRECT AND INDIRECT EFFECTS

Under the no action alternative, current management plans would continue to guide management of the project area and all conditions would remain the same as those shown in the Affected Environment. Hydrologic and erosional responses to the fire would continue to occur. No reforestation, deer habitat enhancement or noxious weed eradication would be implemented to accomplish the purpose and need of the Rim Reforestation Project.

Large areas of the fire where all or most of the conifers were killed would be left to recover naturally, which could take many decades.

Alternative 2 does not serve to improve the long-term watershed and riparian stability and function by enhancing and restoring the species diversity and structural composition of the forest surrounding riparian communities and adjacent hillslopes. Alternative 2 does not help restore or improve RCAs and adjacent hillslopes functions as a filtering or shading mechanism.

Erosion and Sedimentation

Soil Compaction

Under the Alternative 2, no additional soil compaction would occur. However, activities under the action alternatives designed to reduce soil compaction would also not occur. Field review and LiDAR imagery indicates an extensive skid trail network within the project area. Many of these pre-existing skid trails were not properly decommissioned in the past and thus are concentrating runoff and causing erosion and sedimentation. Under the action alternatives, existing skid trails would be re-used to the extent practicable, and then subsoiled and waterbarred, reducing compaction and the risk of erosion and sedimentation. This would not occur under Alternative 2.

Soil Displacement

Soil displacement would not be increased by proposed activities under Alternative 2.

Ground Cover

Erosion resulting from the winter of 2015/16 will be a small increment over that from the Rim Fire following the winter of 2013/14. Post-fire observations on past fires on the STF show that the most substantial amount of erosion usually occurs during the first winter after the fire. The erosion rates will continue decreasing as a result of additional needle cast and growth of live cover. Over time, trees falling would increase ground cover in many areas. Live vegetative recovery would increase over time under the no action alternative. This recovery is anticipated to be faster than under the action alternatives because disturbance by heavy equipment would not occur. Groundcover would recover the most slowly in High SBS areas, with erosion the most likely in these areas.

Mechanized Equipment Activities

Thinning and mechanical site preparation activities as proposed in the action alternatives have the potential to create more sediment transport networks to stream channels. These transport networks would not be created under Alternative 2. However, existing sediment transport networks would also not be mitigated by subsoiling under Alternative 2, as they would be under the action alternatives.

Piling and Burning

No piling and burning would occur under Alternative 2, so there is no risk of further erosion and sedimentation from these activities.

Roads

Forest roads cause hydrological effects by concentrating and channelizing surface and subsurface flow. Following wildfire, the ability of the landscape to filter runoff from roads can be reduced due to

a decrease in ground cover (Peterson et al. 2009). Any existing issues would continue to occur under Alternative 2.

The increased overland flow rates and sediment yields associated with road reconstruction and maintenance would not occur under Alternative 2. In addition, no roads would be improved through these activities, allowing existing problems to persist.

Fuel Loading

The no action alternative would allow for fuel loading to increase in the project area. Nearly all snags would be expected to fall by 20 years post-fire. The limbs and boles from these fallen trees would accumulate as surface fuels. This fuel is expected to increase each decade as trees fall over.

Increased erosion following fire is related to the amount of vegetation removed. Prescribed fires, by design, do not consume extensive areas of organic matter (Baker 1990). Therefore, they have little impact on erosion and sedimentation, whereas intense wildfires may have substantial impacts (Brooks et al. 1997). Higher fuel loadings, projected to occur under Alternative 2, would not be maintained with prescribed fire. A future reburn under higher fuel loadings would likely lead to soil erosion and sedimentation more severely than that caused by the reduction of fuel loading during site preparation activities under the action alternatives and maintaining these reduced loadings in the future by utilizing prescribed fire.

Riparian Vegetation

Under Alternative 2, riparian vegetation would not be disturbed. However, the thinning of trees in riparian areas would increase sunlight to these species, and this would not occur under Alternative 2.

Stream Condition

Stream Flow

Under Alternative 2, there would be no measurable changes in stream flow. Soil compaction from management activities, which can reduce infiltration and increase runoff to streams, would not occur. However, activities under the action alternatives designed to reduce soil compaction would not occur either. There would be no hydrologic changes in canopy throughfall, plant transpiration and uptake processes from removing, shredding and burning vegetation.

Stream Morphology

No changes in stream morphology are anticipated. Bank stability would increase over time as live vegetation continued to recover.

Large Woody Debris

Levels of large woody debris (LWD) in streams would be high under Alternative 2 as existing snags and dying trees would be retained and over time many near-stream snags would fall into streams. The effect of this high level of LWD on stream condition is uncertain. In streams with low levels of LWD this extra loading may be beneficial in storing stream sediment. In streams with high levels of LWD, this extra loading may be excessive. Larger rivers should be capable of transporting these high loads of LWD to downstream reservoirs.

Wild and Scenic Rivers

Alternative 2 would have no effect on the free-flowing condition of eligible or designated Wild and Scenic Rivers. Activities that may be beneficial to water quality would not occur. This includes subsoiling of existing skid trails and maintaining roads to improve drainage and reduce hydrologic connectivity. However, the high water quality needed to maintain the wild and scenic values of the Tuolumne, Clavey, and South Fork Tuolumne Rivers would be maintained under Alternative 2.

Water Quality

Water Temperature

Under Alternative 2, thinning would not occur allowing stream shading to increase, maintaining cool water temperatures over time.

Sediment-Related Parameters

Ground disturbance from mechanized equipment that could lead to stream sedimentation would not occur under Alternative 2. However, activities that could reduce stream sedimentation, such as mastication and subsoiling of existing skid trails, would not occur.

Chemicals

Herbicides would not be used under Alternative 2.

Summary

Beneficial uses of water would continue to be met.

CUMULATIVE EFFECTS

Equivalent Roaded Acres (ERAs)

Table 9 shows ERAs were calculated for 13 HUC 6 and 5 HUC 7 watersheds.

HUC 6 and 7 Watersheds

ERAs exceed the threshold of concern in 2 HUC 6 and 3 HUC 7 watersheds under the no action alternative. These high values can be attributed to the fire itself as well as past and future management activities on private and NFS lands.

Grazing

Same as Alternative 1.

Table 9 Alternative 2: Annual Percent ERA for HUC 6 and HUC 7 Analysis Watershed

HUC Level and Name	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
6 - Grapevine Creek-Tuolumne River	2.63	2.46	2.27	2.07	1.88	1.73	1.59	1.44	1.30	1.28
6 - Jawbone Creek-Tuolumne River	13.24[1]	11.51	9.84	7.97	6.21	5.11	4.02	2.93	2.02	1.67
7 - Corral Creek	22.04[1]	19.62[1]	17.03[1]	13.73[1]	10.42	8.59	6.78	4.97	3.16	2.29
7 - Lower Jawbone Creek	10.65	9.18	8.11	6.79	5.47	4.66	3.87	3.08	2.50	1.83
6 – Lower North Fork Tuolumne River	3.19	2.94	2.71	2.48	2.27	2.10	1.93	1.75	1.62	1.61
6 - Lower Clavey River	8.29	7.48	6.61	5.58	4.60	3.81	3.03	2.29	1.58	1.24
7 - Bear Springs Creek	11.79	11.06	10.19	9.13	8.19	7.56	6.93	6.41	5.93	1.39
6 - Middle Clavey River	5.29	4.87	5.19	5.40	4.73	4.15	3.58	3.03	2.50	2.11
6 - Reed Creek	8.09	7.34	6.65	5.87	4.84	4.16	3.49	2.82	2.25	1.89
7 - Lower Reed Creek	14.46[1]	12.38[1]	10.36	8.26	6.25	5.21	4.18	3.15	2.45	2.05
6 - Lower Cherry Creek	7.71	6.70	5.66	4.59	3.54	2.98	2.42	1.87	1.41	1.26
7 - Granite Creek	18.85[1]	15.91[1]	13.02[1]	10.17	7.44	6.14	4.83	3.52	2.67	2.48
6 - Miguel Creek-Eleanor Creek	1.25	1.03	0.80	0.55	0.31	0.28	0.24	0.20	0.17	0.15
6 - Poopenaut Valley-Tuolumne River	1.92	1.62	1.29	0.96	0.62	0.56	0.51	0.47	0.43	0.41
6 - Lower Middle Fork Tuolumne River	12.57[1]	11.54	10.32	8.81	7.36	6.23	5.11	4.02	2.99	2.32
6 - Upper Middle Fork Tuolumne River	1.73	1.35	0.98	0.59	0.21	0.19	0.17	0.15	0.13	0.11
6 - Lower South Fork Tuolumne River	8.37	7.78	7.23	6.26	5.37	4.68	3.99	3.31	2.65	2.21
6 - Upper South Fork Tuolumne River	1.53	1.33	1.13	0.93	0.74	0.71	0.68	0.64	0.62	0.60

[1] Denotes watersheds over the TOC

Alternative 3

Alternative 3 would not include use of herbicides. Instead, site preparation, treatment of noxious weeds and release of planted seedlings would be accomplished using manual treatments or heavy equipment.

DIRECT AND INDIRECT EFFECTS

Erosion and Sedimentation

Direct and indirect effects from all of the treatments described in Alternative 1 would be the same for Alternative 3, with the differences described below.

The effects described for the use of glyphosate, aminopyralid, clopyralid, and clethodim do not apply to Alternative 3.

Additional mechanical site preparation would increase ground disturbance and the risk of erosion and sediment delivery to streams slightly; however, because these activities would comply with all specified management requirements including BMPs, any additional impacts are expected to be minimal. Additional hand release would have no effects on watershed resources due to the localized and minor disturbance that results from this treatment. Overall effects of the array of mechanical treatments would be the same as described under Alternative 1.

Treating noxious weeds with mechanical methods would produce different effects than the use of herbicides. As part of the Integrated Pest Management Approach (IPM), 1,127 and 1,173 acres of prescribed fire would treat medusahead grass and other weed species on the Jawbone Creek-Tuolumne River and Lower Clavey River watersheds, respectively. Prescribed fire would also require fire line construction. The burn would be followed by targeted grazing or additional grubbing. The management requirements developed for these actions would minimize effects. While tilling has a greater risk of causing erosion than other mechanical treatments; however, assuming that BMPs and other management requirements are implemented, potential impacts to water quality would be minor and localized to the adjacent stream reach.

Mechanized Equipment Activities

Table 10 shows mechanical activities acres (thin/biomass, machine piling, mastication, deep tilling and forest cultivation) within 100 feet of perennial or intermittent streams and SAFs by soil burn severity.

Despite implementation of BMPs and management requirements, increased stream sedimentation is anticipated as a result of Alternative 3, particularly in areas where mechanical activities create more effective sediment transport networks to stream channels. This is more likely to occur in the Jawbone Creek-Tuolumne River, Corral Creek, Lower Cherry Creek, and Granite Creek watersheds than in other HUC 6 or HUC 7 watersheds due to the larger acreages of high soil burn severity areas near streams proposed for treatment. Under these 4 watersheds and this Alternative 3, mechanical activities acres on high soil burn severity would increment slightly when compared with Alternative 1. Jawbone Creek-Tuolumne River goes from 68 to 69 acres, Corral Creek from 32 to 33 acres, Lower Cherry Creek from 66 to 70 acres, and Granite Creek from 54 to 56 acres.

Table 10 Alternative 3: Mechanical Activities by Soil Burn Severity

HUC Level and Name	SBS HIGH	SBS MOD	SBS LOW
6. Grapevine Creek-Tuolumne River	0	26	46
6. Jawbone Creek-Tuolumne River	69	125	99
7. Corral Creek	33	47	7
7. Lower Jawbone Creek	1	27	3
6. Lower North Fork Tuolumne River	0	19	20
6. Lower Clavey River	3	59	34
7. Bear Springs Creek	3	12	5
6. Middle Clavey River	0	11	11
6. Reed Creek	13	20	16
7. Lower Reed Creek	13	18	6
6. Lower Cherry Creek	70	148	45
7. Granite Creek	56	84	3
6. Miguel Creek-Eleanor Creek	0	0	2
6. Poopenaut Valley-Tuolumne River	4	4	0
6. Lower Middle Fork Tuolumne River	26	143	53
6. Upper Middle Fork Tuolumne River	0	6	6
6. Lower South Fork Tuolumne River	5	48	48
6. Upper South Fork Tuolumne River	0	0	3

LOW=Low and Unburned; **MOD**=Moderate; **SBS**=Soil Burn Severity (percent of Fire area)

CUMULATIVE EFFECTS

Equivalent Roaded Acres (ERAs)

ERAs were calculated for 13 HUC 6 and 5 HUC 7 watersheds. Results of these analyses vary from that found under Alternative 1 since increases in mechanical treatment would create higher ERAs. Table 11 shows the ERA values for Alternative 3.

HUC 6 and 7 Watersheds

ERA values for 7 of the 13 HUC 6 watersheds were equal or slightly higher for Alternative 3 than Alternative 1. These are Grapevine Creek-Tuolumne River, Lower North Fork-Tuolumne River, Middle Clavey River, Miguel Creek-Eleanor Creek, Poopenaut Valley-Tuolumne River, Upper Middle Fork-Tuolumne River and Upper South Fork-Tuolumne River watersheds. Of those 7 watersheds, Grapevine Creek-Tuolumne River would have the higher increase with up to 0.17% in 2023 for Alternative 3. Eleven HUC 6 and HUC 7 watersheds had higher ERA values than Alternative 1. The largest increase would occur in 2021 with up to 4.61 in the Corral Creek watershed under Alternative 3. ERA increases were attributed primarily to the additional deep tilling and forest cultivation and manual grubbing treatments added under this Alternative 3.

Although there are differences in ERA values between Alternative 1 and Alternative 3, the watersheds that exceeded the TOC were the same. Therefore, cumulative effects for Alternative 3 are anticipated to be the same as described for Alternative 1.

Grazing

Same as Alternative 1.

Table 11 Alternative 3: Annual Percent ERA for HUC 6 and HUC 7 Analysis Watershed

HUC Level and Name	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
6 - Grapevine Creek-Tuolumne River	2.63	2.46	2.34	2.27	2.24	2.12	1.99	1.80	1.64	1.59
6 - Jawbone Creek-Tuolumne River	13.41[1]	12.52[1]	12.43[1]	10.92	9.40	8.49	7.29	5.32	3.48	2.69
7 - Corral Creek	22.37[1]	23.25[1]	25.02[1]	22.87[1]	19.81[1]	17.60[1]	15.21[1]	10.45	5.93	4.02
7 - Lower Jawbone Creek	10.65	9.96	11.30	10.63	9.52	8.65	7.71	5.55	3.68	2.55
6 - Lower North Fork- Tuolumne River	3.19	2.94	2.79	2.60	2.36	2.19	2.02	1.84	1.71	1.69
6 - Lower Clavey River	8.46	8.17	7.67	6.79	6.20	5.68	4.84	3.91	3.04	2.48
7 - Bear Springs Creek	12.23[1]	12.37[1]	11.86	10.99	10.08	9.44	8.36	7.41	6.69	1.95
6 - Middle Clavey River	5.29	4.95	5.30	5.56	4.90	4.32	3.75	3.20	2.71	2.31
6 - Reed Creek	8.12	7.75	7.25	6.48	5.46	5.06	4.34	3.54	3.00	2.63
7 - Lower Reed Creek	14.55[1]	13.74[1]	12.33[1]	10.24	8.26	8.00	6.79	5.36	4.64	4.15
6 - Lower Cherry Creek	7.71	6.92	6.37	5.43	4.50	4.66	4.19	3.35	2.57	2.25
7 - Granite Creek	18.85[1]	17.20[1]	16.99[1]	14.93[1]	12.49[1]	11.20	9.58	6.51	4.11	3.37
6 - Miguel Creek-Eleanor Creek	1.25	1.03	0.80	0.55	0.31	0.34	0.30	0.27	0.23	0.21
6 - Poopenaut Valley-Tuolumne River	2.04	1.77	1.49	1.16	0.81	0.74	0.62	0.52	0.46	0.43
6 - Lower Middle Fork Tuolumne River	13.78[1]	13.57[1]	13.74[1]	13.48[1]	12.40[1]	11.57	9.60	7.63	5.59	4.02
6 - Upper Middle Fork Tuolumne River	1.76	1.40	1.03	0.66	0.28	0.26	0.22	0.18	0.15	0.14
6 - Lower South Fork Tuolumne River	8.47	8.04	7.84	7.28	7.22	6.98	6.14	5.29	4.69	3.75
6 - Upper South Fork Tuolumne River	1.54	1.35	1.15	0.98	0.82	0.78	0.75	0.72	0.69	0.66

[1] Denotes watersheds over the TOC

Alternative 4

Under Alternative 4, considerably fewer planted acres and trees are proposed in comparison with Alternative 1. Alternative 4 would reforest no more than 20% of each unit proposed in Alternative 1. Site preparation treatments would be the same as in Alternative 1, but on only 2,867 acres. Alternative 4 includes similar noxious weed eradication as Alternative 3 on 3,131 acres.

DIRECT AND INDIRECT EFFECTS

The direct and indirect effects of Alternative 4 are the same as those for Alternative 1 with the exception of those described below.

Erosion and Sedimentation

Ground disturbance from mechanized equipment would be reduced dramatically under Alternative 4 due to the reduction of treated areas in comparison to Alternative 1. Thousands of acres would not have initial mechanical site preparation treatments which would result in increased fuel loading. Alternative 4 proposes the reintroduction of early and frequent use of prescribed fire within the stands. Increased erosion following fire is related to the amount of vegetation removed. Prescribed burns, by design, do not consume extensive areas of organic matter (Baker 1990). Therefore, prescribed fires would have little impact on erosion and sedimentation, whereas intense wildfires may have substantial impacts (Brooks et al. 1997). Reducing fuel loading through site preparation and thinning followed by maintenance with prescribed fire has less potential for erosion and sedimentation than allowing fuel loading to increase as snags fall and having another large stand-replacing wildfire in the future. Although BMPs are expected to protect stream channels and water quality from treatment actions, there would be less overall impact with fewer treated acres.

The effects described for the use of aminopyralid, clopyralid, and clethodim for noxious weed eradication do not apply to Alternative 4. Instead the effects of manual noxious weed eradication are the same as Alternative 3.

The effects of glyphosate for site preparation and release of planted seedlings on 2,867 acres are similar to those described under Alternative 1, but on fewer acres.

Mechanized Equipment Activities

Table 12 describes mechanical activity acres (feller buncher and mastication) within 100 feet of perennial or intermittent streams and special aquatic features (SAFs) by soil burn severity. No machine pilling treatments falls within the 100 feet buffer of any hydrological feature. Under Alternative 4, no deep tilling and forest cultivation is proposed for site preparation purposes on any of the units. The potential to create more effective sediment transport networks to stream channels is reduced dramatically under Alternative 4. Table 12 shows that almost all of the watersheds have zero mechanical treatment acres within the high soil burn severity areas with the exception of the Lower Cherry Creek and Granite Creek watersheds having 6 and 2 acres respectively. This is a reduction of mechanical activities on 91% and 96%, respectively, of these two watersheds' acres when compared to Alternative 1.

Table 12 Alternative 4: Mechanical Activities by Soil Burn Severity

HUC Level and Name	SBS HIGH	SBS MOD	SBS LOW
6. Grapevine Creek-Tuolumne River	0	13	44
6. Jawbone Creek-Tuolumne River	0	16	82
7. Corral Creek	0	0	1
7. Lower Jawbone Creek	0	0	1
6. Lower North Fork Tuolumne River	0	8	12
6. Lower Clavey River	0	16	29
7. Bear Springs Creek	0	0	1
6. Middle Clavey River	0	6	4
6. Reed Creek	0	9	11
7. Lower Reed Creek	0	7	6
6. Lower Cherry Creek	6	59	39
7. Granite Creek	2	22	2
6. Miguel Creek-Eleanor Creek	0	0	0
6. Poopenaut Valley-Tuolumne River	0	0	0
6. Lower Middle Fork Tuolumne River	0	5	10
6. Upper Middle Fork Tuolumne River	0	0	0
6. Lower South Fork Tuolumne River	0	7	14
6. Upper South Fork Tuolumne River	0	0	3

LOW=Low and Unburned; **MOD**=Moderate; **SBS**=Soil Burn Severity (percent of Fire area)

CUMULATIVE EFFECTS

Equivalent Roaded Acres (ERAs)

ERAs were calculated for 13 HUC 6 and 5 HUC 7 watersheds. Table 13 shows the ERA values for Alternative 4.

HUC 6 and 7 Watersheds

ERA values for 6 of the 13 HUC 6 watersheds were equal or slightly lower for Alternative 4 than Alternative 1. These are Grapevine Creek-Tuolumne River, Lower North Fork-Tuolumne River, Middle Clavey River, Miguel Creek-Eleanor Creek, Upper Middle Fork-Tuolumne River, and Upper South Fork-Tuolumne River watersheds. The remaining 12 HUC 6 and HUC 7 watersheds had lower ERA values than Alternative 1. The largest decrease would occur in 2018 with up to a 5.27% decrease in ERA in the Corral Creek watershed under Alternative 4. ERA decreases were attributed primarily due to the large reduction of treated areas under Alternative 4. The contribution on ERAs under Alternative 4 is very small ranging from 0 to 0.75%. Less disturbance is beneficial to watersheds. However, the post-fire response would still dominate at all scales (project area, HUC 7, and HUC 6).

Table 13 Alternative 4: Annual Percent ERA for HUC 6 and HUC 7 Analysis Watershed

HUC Level and Name	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
6 - Grapevine Creek-Tuolumne River	2.63	2.46	2.34	2.27	2.20	1.95	1.76	1.58	1.42	1.38
6 - Jawbone Creek-Tuolumne River	13.25[1]	11.57	10.02	8.12	6.40	5.53	4.40	3.26	2.28	1.88
7 - Corral Creek	22.05[1]	19.90[1]	17.74[1]	14.29[1]	10.89	9.07	7.37	5.45	3.48	2.59
7 - Lower Jawbone Creek	10.66	9.21	8.18	6.87	5.51	4.75	3.92	3.16	2.55	1.84
6 - Lower North Fork-Tuolumne River	3.19	2.94	2.79	2.60	2.35	2.15	1.96	1.78	1.65	1.63
6 - Lower Clavey River	8.30	7.70	7.10	6.11	5.35	4.41	3.61	2.85	2.08	1.63
7 - Bear Springs Creek	11.84	11.20	10.41	9.35	8.46	7.77	7.14	6.60	6.09	1.51
6 - Middle Clavey River	5.29	4.87	5.21	5.46	4.78	4.20	3.62	3.06	2.53	2.13
6 - Reed Creek	8.09	7.34	6.67	5.89	4.87	4.28	3.60	2.92	2.33	1.95
7 - Lower Reed Creek	14.46[1]	12.39[1]	10.41	8.32	6.32	5.48	4.43	3.38	2.62	2.18
6 - Lower Cherry Creek	7.71	6.71	5.67	4.60	3.62	3.47	2.82	2.21	1.69	1.50
7 - Granite Creek	18.88[1]	15.95[1]	13.08[1]	10.24	7.59	6.48	5.07	3.76	2.86	2.62
6 - Miguel Creek-Eleanor Creek	1.25	1.03	0.80	0.55	0.31	0.28	0.24	0.21	0.17	0.15
6 - Poopenaut Valley-Tuolumne River	1.92	1.62	1.30	0.96	0.63	0.57	0.52	0.47	0.43	0.41
6 - Lower Middle Fork Tuolumne River	12.58[1]	11.60	10.42	8.92	7.66	6.43	5.32	4.17	3.09	2.39
6 - Upper Middle Fork Tuolumne River	1.73	1.35	0.98	0.60	0.23	0.20	0.17	0.15	0.13	0.11
6 - Lower South Fork Tuolumne River	8.39	7.81	7.28	6.36	5.59	4.88	4.16	3.46	2.75	2.28
6 - Upper South Fork Tuolumne River	1.53	1.33	1.13	0.96	0.79	0.74	0.71	0.67	0.64	0.62

[1] Denotes watersheds over the TOC

Although there are differences in ERA values between Alternative 1 and Alternative 4, the watersheds that exceeded the TOC were the same with the exception of Bear Springs Creek that fell back below TOC in year 2016. Therefore, cumulative effects for Alternative 4 are anticipated to be slightly less than Alternative 1 and Alternative 3.

Grazing

Same as Alternative 1.

Alternative 5

Alternative 5 is the same as Alternative 1 except for the deletion of prescribed fire in new plantations and it includes thinning at age 7 to create the desired ICO and fuel structure. This PCT would be accomplished using hand cutting, piling and burning treatments or lop and scatter if fuels are not an issue.

DIRECT AND INDIRECT EFFECTS

Same as Alternative 1.

CUMULATIVE EFFECTS

Equivalent Roaded Acres (ERAs)

ERAs were calculated for 13 HUC 6 and 5 HUC 7 watersheds. Results of these analyses were similar to that found under Alternative 1. Table 14 shows the ERA values for Alternative 5.

Grazing

Same as Alternative 1.

Table 14 Alternative 5: Annual Percent ERA for HUC 6 and HUC 7 Analysis Watershed

HUC Level and Name	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
6 - Grapevine Creek-Tuolumne River	2.63	2.46	2.34	2.27	2.24	2.02	1.84	1.63	1.48	1.42
6 - Jawbone Creek-Tuolumne River	13.41[1]	12.32[1]	11.38	9.44	7.53	6.62	5.32	4.08	2.87	2.36
7 - Corral Creek	22.37[1]	23.03[1]	23.01[1]	19.36[1]	15.27[1]	12.99[1]	10.63	8.27	5.61	4.19
7 - Lower Jawbone Creek	10.65	9.35	8.64	7.43	5.83	5.14	4.20	3.52	2.78	1.96
6 - Lower North Fork-Tuolumne River	3.19	2.94	2.79	2.60	2.36	2.17	1.98	1.79	1.66	1.64
6 - Lower Clavey River	8.41	7.92	7.26	6.15	5.52	4.73	3.93	2.97	2.17	1.79
7 - Bear Springs Creek	12.09[1]	11.76	10.93	9.76	8.86	8.12	7.48	6.82	6.25	1.72
6 - Middle Clavey River	5.29	4.88	5.22	5.47	4.78	4.20	3.63	3.08	2.55	2.16
6 - Reed Creek	8.12	7.51	6.90	6.06	5.07	4.52	3.95	3.23	2.56	2.26
7 - Lower Reed Creek	14.55[1]	12.95[1]	11.17	8.88	6.99	6.25	5.54	4.35	3.33	3.12
6 - Lower Cherry Creek	7.71	6.79	6.09	5.05	4.00	4.05	3.35	2.71	2.08	1.82
7 - Granite Creek	18.85[1]	16.45[1]	15.40[1]	12.72[1]	9.66	8.45	6.71	5.30	4.04	3.48
6 - Miguel Creek-Eleanor Creek	1.25	1.03	0.80	0.55	0.31	0.29	0.25	0.22	0.18	0.16
6 - Poopenaut Valley-Tuolumne River	2.04	1.73	1.40	1.05	0.70	0.63	0.57	0.51	0.46	0.43
6 - Lower Middle Fork Tuolumne River	13.23[1]	12.47[1]	11.67	10.68	9.29	7.95	6.72	5.27	4.08	3.17
6 - Upper Middle Fork Tuolumne River	1.76	1.38	1.01	0.63	0.25	0.22	0.19	0.16	0.14	0.12
6 - Lower South Fork Tuolumne River	8.40	7.84	7.47	6.72	6.13	5.40	4.62	3.84	3.14	2.69
6 - Upper South Fork Tuolumne River	1.54	1.35	1.15	0.97	0.81	0.76	0.73	0.69	0.66	0.64

[1] Denotes watersheds over the TOC

Summary of Effects Analysis across All Alternatives

Beneficial Uses of Water

All alternatives are expected to result in maintenance of the applicable beneficial uses of water in the Water Quality Control Plan (Basin Plan) for the California Central Valley Water Quality Control Board (CVRWQCB 2011). Water temperature, sediment, and water quality following herbicide use are not expected to be adversely altered. Domestic and municipal water supplies and power are not adversely affected by the proposed action or alternatives. Recreational contact and non-contact waters are suitable for human use. Warm and cold freshwater habitat and wildlife habitat are not adversely affected by the proposed action or alternatives

Erosion and Sedimentation

Under Alternatives 1, 3, and 5 sedimentation increases, due to mechanical activities, are anticipated to be highest in 2 HUC 6 and 2 HUC 7 watersheds with treatments proposed within 100 feet of streams in high soil burn severity areas (Jawbone Creek-Tuolumne River, Corral Creek, Lower Cherry Creek, and Granite Creek). Of the piling and burning activities, dozer piling has the highest potential for sedimentation and could occur in any of the treatment units. Under this project, the management requirement is to maintain a minimum of 60% well distributed ground cover within the 100 feet and to exclude dozer operations within 50 feet of a perennial stream, intermittent stream, or SAF. Although it is anticipated that some sediment could reach streams as a result of machine piling, streamside buffers, needle cast and/or resprouting vegetation should minimize this. Although minimal road work is proposed (just associated with thinning of the existing plantations), some erosion and sedimentation is anticipated along maintained and reconstructed roads. Implementation of BMPs and management requirements are expected to minimize these effects. Road reconstruction and maintenance may reduce erosion and sedimentation that is currently occurring as these treatments would involve improving road drainage features.

Under Alternative 2, new sediment transport networks would not be created. However, reductions in soil compaction on existing skid trails would also not occur. With no piling and burning, no risk of erosion and sedimentation would occur. Road reconstruction and maintenance would not occur, so hydrologic connectivity of roads and streams currently occurring would remain.

Under Alternative 4, ground disturbance from mechanized equipment would be reduced dramatically in comparison to Alternative 1, due to the reduction of treated areas and no deep tilling and forest cultivation for site preparation. No machine piling treatment falls within the 100 feet buffer of any hydrological feature. Effective sediment transport networks to stream channels is reduced dramatically under Alternative 4.

In summary, the Rim Fire Reforestation project will not cause significant impacts to water resources. In the short-term project work would involve negligible and very localized soil disturbance due to planting and the release of young conifers. In the long-term (decades) the project would accelerate a return to conifer forest, stabilizing soils and improving water quality.

Fuel Loading

Alternatives 1, 3 and 5 site preparation activities would reduce fuel loading to 20 tons per acre of surface fuels, allowing for direct attack of future wildfires and maintenance of reduced fuel loading with prescribed fire.

Under Alternative 4, thousands of acres proposed in Alternative 1 would not have initial mechanical site preparation which could result in a higher risk of increased fuel loading through time. Alternative 4 proposes the reintroduction of early and frequent use of prescribed fire within the stands. Reducing fuel loading through site preparation and thinning followed by maintenance with prescribed fire has less potential for erosion and sedimentation than allowing fuel loading to increase as snags fall and having another large stand-replacing wildfire in the future.

Under Alternative 2, fuel loading is expected to increase over time. This would not allow for direct attack of wildfires or use of prescribed fire. A future reburn under higher fuel loadings would likely lead to soil erosion and sedimentation more severely than that caused by the reduction of fuel loading during site preparation activities under the action alternatives and maintaining these reduced loadings in the future by utilizing prescribed fire.

Riparian Vegetation

Under Alternatives 1, 3, 4 and 5, thinning of trees in riparian areas (where prescribed) may provide slight increases in sunlight, benefitting regrowth of riparian obligate trees and shrubs. Management requirements would prevent disturbance to riparian vegetation and the numerous meadows.

Under Alternative 2, no thinning of trees would occur, so no beneficial increase in sunlight would occur. There would be no disturbance to riparian vegetation.

Stream Condition

Under the action alternatives, measurable changes in stream flow or channel incision are not anticipated. BMPs and management requirements under all alternatives would involve maintaining ground cover and minimizing compaction. Therefore, measurable changes in stream flow are not anticipated to change beyond what already occurred as a result of the fire.

Under Alternative 2, no changes in stream flow or channel incision are anticipated. The erosion rates will continue decreasing as a result of additional needle cast and growth of live cover. Over time, trees falling would increase ground cover in many areas. Live vegetative recovery would increase over time under the no action alternative. This recovery is anticipated to be faster than under the action alternatives because disturbance by heavy equipment would not occur. Groundcover would recover the most slowly in High SBS areas, with erosion the most likely in these areas. The burned riparian areas would be left to recover naturally. Alternative 2 does not serve to improve the long-term watershed and riparian stability and function by enhancing and restoring the species diversity and structural composition of the forest surrounding riparian communities. Alternative 2 does not serve to restore or improve riparian RCA functions as a filtering or shading mechanism.

Wild and Scenic Rivers

There are not proposed activities within the ¼ mile buffer of eligible and designated Wild and Scenic Rivers under this project. Therefore, none of the alternatives are anticipated to affect their free-flowing condition. While some sedimentation could occur, it is anticipated to be minimal and of short duration and is not expected to affect the Outstandingly Remarkable Values of these rivers.

Under Alternative 2, the free flowing condition and high water quality needed to maintain wild and scenic values would be maintained.

Water Quality

Under the action alternatives, water temperature is not expected to be affected. Under Alternatives 1, 3 and 5, some sedimentation would likely occur, particularly in areas having high soil burn severity adjacent to streams. That sedimentation potential would be reduced dramatically under Alternative 4. The potential for herbicides to contaminate surface water under Alternatives 1, 4 and 5 is limited. Herbicides are not applied in Alternative 3. Adverse effects to beneficial uses of water are not anticipated.

Under Alternative 2, no changes to water temperature, stream sedimentation or water quality related to herbicide applications are anticipated. Adverse effects to beneficial uses are not anticipated.

Compliance with the Forest Plan and Other Direction

Standards and Guidelines

Table 15 lists Standards and Guidelines (S&Gs) applicable to watershed resources, as well as how the S&Gs would be met under the action alternatives.

Table 15 Standards and Guidelines Applicable to Watershed Resources

Standards and Guidelines	Supporting Information/Discussion
Design projects to reduce potential soil erosion and the loss of soil productivity caused by loss of vegetation and ground cover. Examples are activities that would: (1) provide for adequate soil cover in the short term; (2) accelerate the dispersal of coarse woody debris; (3) reduce the potential impacts of the fire on water quality; and (4) carefully plan restoration/salvage activities to minimize additional short- term effects.	Project management requirements are designed to maintain ground cover to reduce soil erosion and allow for filtering of sediment.
Implement water quality Best Management Practices (BMPs) as needed for all Forest management activities. BMPs are a system of nearly 100 practices designed to minimize or prevent water pollution from Forest management activities. They cover such activities as timber harvest, road construction, mining, recreation, fire management and grazing. See Appendix K of the EIS for a discussion and listing of the water quality BMPs.	Applicable BMPs are described in the Management Requirements section of the Watershed Report (Appendix B).
Monitor the implementation and effectiveness of BMPs in selected areas to determine if they are being carried out and if they are accomplishing their objectives.	The implementation and effectiveness of BMPs would be monitored following the Regional BMPEP and National Core BMP monitoring guidelines.
Analyze cumulative watershed effects (CWE) on all applicable proposed Forest management activities to determine off-site effects on the beneficial uses of water.	A CWE analysis was conducted.
Implement the following watershed recovery practices following major wildfires, except in Wilderness in most cases: (1) Restore ground cover as soon as possible when necessary to reduce flood flows to protect life and property, to maintain soil productivity and/or to minimize	Emergency ground cover restoration was conducted soon after the fire (Nov 2013) by the BAER watershed stabilization effort. Activities include straw mulch application as well as mastication treatments. Reforestation efforts are proposed under this project and

Standards and Guidelines	Supporting Information/Discussion
stream sedimentation and cumulative watershed effects. (2) Conduct reforestation activities in a manner which reduces the potential for cumulative watershed effects, such as dispersing site preparation adequately over time and space and/or using techniques which minimize land disturbance.	are being dispersed through time and space to minimize cumulative watershed effects. This project proposes a combination of techniques for site preparation/release purposes such as the use of herbicide, heavy equipment, and hand work with the purpose to minimize land disturbance.
Designate riparian conservation area (RCA) widths as described above. The RCA widths displayed may be adjusted at the project level if a landscape analysis has been completed and a site-specific RCO analysis demonstrates a need for different widths.	RCA widths for the Rim Fire Reforestation Project were designated based on direction from the STF Forest Plan Direction (2010) and were used in the analysis of each alternative.
Evaluate new proposed management activities within CARs and RCAs during environmental analysis to determine consistency with the riparian conservation objectives at the project level and the AMS goals for the landscape. Ensure that appropriate mitigation measures are enacted to (1) minimize the risk of activity-related sediment entering aquatic systems and (2) minimize impacts to habitat for aquatic- or riparian-dependent plant and animal species.	Proposed management activities were developed as part of an interdisciplinary process. Management requirements incorporate a range of BMPs and were designed to ensure consistency with AMS/RCOs during project implementation.
As part of project-level analysis, conduct peer reviews for projects that propose ground-disturbing activities in more than 25 percent of the RCA or more than 15 percent of a CAR.	Ground-disturbing activities do not exceed these thresholds, so no peer review is required. Percentages of ground disturbing activities in RCAs and CARs are displayed in the project record.
Ensure that management activities do not adversely affect water temperatures necessary for local aquatic- and riparian-dependent species assemblages.	Water temperatures are not expected to be affected by the removal of the near-stream dead or live conifer trees on existing plantation as the effect of this action is expected to be minimal and localized. Conversely, the action of planting trees would help to restore the shading component that was lost by the fire in many riparian corridors.
Limit pesticide applications to cases where project level analysis indicates that pesticide applications are consistent with riparian conservation objectives.	The project proposes the use of herbicide for site preparation and release as well as for weed eradication purposes. The Watershed report includes BMPs and Management Requirements specific for this activity that would achieve consistency with RCOs.
Prohibit storage of fuels and other toxic materials within RCAs and CARs except at designated administrative sites and sites covered by a Special Use Authorization. Prohibit refueling within RCAs and CARs unless there are no other alternatives. Ensure that spill plans are reviewed and up-to-date.	Fuels and other toxic materials would not be stored in any RCAs or CARs. Servicing and refueling would be only at designated and approved sites. BMP 2.11 Equipment Refueling and Servicing would address handling of fueling and servicing operations. A spill plan would be provided where applicable.
Maintain and restore the hydrologic connectivity of streams, meadows, wetlands, and other special aquatic features by identifying roads and trails that intercept, divert, or disrupt natural surface and subsurface water flow paths. Implement corrective actions where necessary to restore connectivity.	Road work under this project is limited since the bulk of road work was done under the BAER emergency stabilization efforts and through previous projects. However, the project incorporated management requirements for road maintenance/reconstruction activities and are designed to enhance hydrologic function of roads within the project area.
Ensure that culverts or other stream crossings do not create barriers to upstream or downstream passage for aquatic-dependent species. Locate water drafting sites to avoid adverse effects to in stream flows and depletion of pool habitat. Where possible, maintain and restore the timing, variability, and duration of floodplain inundation and water table elevation in meadows, wetlands, and other special aquatic features.	BMP 2.8 Stream Crossings addresses barriers to aquatic-dependent species. BMP 2.5 Water Source Development and Utilization addresses the location of water drafting sites and methods of water removal, including limits on drafting based on stream flows. Ground cover maintenance, stream buffers, and compaction mitigations are designed to maintain/restore flood flows.
Prior to activities that could adversely affect streams, determine if relevant stream characteristics are within	This project is within the Rim Fire area and due to the wildfire some areas are near or out of the range of

Standards and Guidelines	Supporting Information/Discussion
the range of natural variability. If characteristics are outside the range of natural variability, implement mitigation measures and short-term restoration actions needed to prevent further declines or cause an upward trend in conditions. Evaluate required long-term restoration actions and implement them according to their status among other restoration needs.	natural variability. The project has included numerous BMPs and Management Requirements to mitigate or prevent further declines or cause an upward trend in conditions, including the maintenance of ground cover. Planting trees would accelerate the return to a conifer forest and serve to restore or improve hillslope and riparian RCA functions in many areas.
Prevent disturbance to streambanks and natural lake and pond shorelines caused by resource activities (for example, livestock, off-highway vehicles, and dispersed recreation) from exceeding 20 percent of stream reach or 20 percent of natural lake and pond shorelines. Disturbance includes bank sloughing, chiseling, trampling, and other means of exposing bare soil or cutting plant roots. This standard does not apply to developed recreation sites, sites authorized under Special Use Permits and designated off-highway vehicle routes.	The project includes BMPs and Management Requirements for mechanized equipment operation activities within RCAs, including exclusion zones and restrictions on the number of stream crossings.
At either the landscape or project-scale, determine if the age class, structural diversity, composition, and cover of riparian vegetation are within the range of natural variability for the vegetative community. If conditions are outside the range of natural variability, consider implementing mitigation and/or restoration actions that will result in an upward trend. Actions could include restoration of aspen or other riparian vegetation where conifer encroachment is identified as a problem.	This project is within the Rim Fire area and due to the wildfire some areas are near or out of the range of natural variability. The project has included numerous BMPs and Management requirements to mitigate effects, including equipment exclusion zones. Planting trees would accelerate the return to a conifer forest and serve to restore or improve hillslope and riparian RCA functions in many areas. This project will also promote riparian vegetation by: removing conifers 20 feet from riparian obligate vegetation along perennial and intermittent stream within existing plantations, and all conifers less than 24 inches dbh within 25 feet of meadow edges.
Cooperate with Federal, Tribal, State and local governments to secure in stream flows needed to maintain, recover, and restore riparian resources, channel conditions, and aquatic habitat. Maintain in stream flows to protect aquatic systems to which species are uniquely adapted. Minimize the effects of stream diversions or other flow modifications from hydroelectric projects on threatened, endangered, and sensitive species.	The project does not propose to create flow modifications. The project does propose to use approved water sources for watering roads, dust abatement, and road surface protection. Management requirements for water drafting are designed to maintain in stream flows needed to protect riparian resources, channel conditions and aquatic habitat.
Determine if the level of coarse large woody debris (CWD) is within the range of natural variability in terms of frequency and distribution and is sufficient to sustain stream channel physical complexity and stability. Ensure proposed management activities move conditions toward the range of natural variability.	Based on stream survey data and visual observations of stream channels within the project area, levels of CWD appear to be adequate and within the range of natural variability. In addition, previous projects (Rim Fire Recovery and Rim Fire HT) were designed to retain an adequate recruitment source for CWD by retaining snags in near- stream areas as well as by leaving in place existing downed trees that are in perennial or intermittent stream channels. This project doesn't propose to remove any existing downed trees that are in perennial or intermittent stream channels.
Design prescribed fire treatments to minimize disturbance of ground cover and riparian vegetation in RCAs. In burn plans for project areas that include, or are adjacent to RCAs, identify mitigation measures to minimize the spread of fire into riparian vegetation. In determining which mitigation measures to adopt, weigh the potential harm of mitigation measures, for example fire lines, against the risks and benefits of prescribed fire entering riparian vegetation. Strategies should recognize	This project proposes to use broadcast burning, pile burning and jackpot burning. BMPs and Management Requirements specific to these activities include ground cover requirements, restrictions on pile placement to protect riparian vegetation, restriction on the construction of fire lines within RCAs, and to avoid direct ignition within RCAs.

Standards and Guidelines	Supporting Information/Discussion
the role of fire in ecosystem function and identify those instances where fire suppression or fuel management actions could be damaging to habitat or long-term function of the riparian community.	
Post-wildfire management activities in RCAs and CARs should emphasize enhancing native vegetation cover, stabilizing channels by non-structural means, minimizing adverse effects from the existing road network, and carrying out activities identified in landscape analyses. Post-wildfire operations shall minimize the exposure of bare soil.	All proposed actions are designed to minimize impacts to aquatic- and riparian-dependent resources while meeting project objectives. This project will also enhance riparian vegetation by: removing conifers 20 feet from riparian obligate vegetation along perennial and intermittent stream within existing plantations, and all conifers less than 24 inches dbh within 25 feet of meadow edges. Adverse effects from roads on this project would be minimized via numerous BMPs in the watershed management requirements. Bare soil would be minimized by following ground cover management requirements and BMPs. Restoration activities are outside the scope for this project.
Allow hazard tree removal within RCAs or CARs. Allow mechanical ground disturbing fuels treatments, salvage harvest, or commercial fuelwood cutting within RCAs or CARs when the activity is consistent with RCOs. Utilize low ground pressure equipment, helicopters, over the snow logging, or other non-ground disturbing actions to operate off of existing roads when needed to achieve RCOs. Ensure that existing roads, landings, and skid trails meet Best Management Practices. Minimize the construction of new skid trails or roads for access into RCAs for fuel treatments, salvage harvest, commercial fuelwood cutting, or hazard tree removal.	Low ground pressure equipment such as feller bunchers, or non-ground disturbing methods such as hand cutting would be employed. Numerous BMPs have been included in the project to minimize effects of the transportation system, as well as for landings and skid trails.
Prohibit or mitigate ground-disturbing activities that adversely affect hydrologic processes that maintain water flow, water quality, or water temperature critical to sustaining bog and fen ecosystems and plant species that depend on these ecosystems. During project analysis, survey, map, and develop measures to protect bogs and fens from such activities as trampling by livestock, pack stock, humans, and wheeled vehicles. Criteria for defining bogs and fens include, but are not limited to, presence of: (1) sphagnum moss (Spagnum spp.), (2) mosses belonging to the genus Meessia, and (3) sundew (Drosera spp.)	No fens are within treatment areas and would therefore not be affected.

Water Quality Best Management Practices (BMPs)

Alternatives 1, 3, 4 and 5 comply with the intent and procedural requirements of BMPs (USDA 2011, USDA 2012). If any of the action alternatives are implemented, or a combination thereof, applicable BMPs would be followed. BMPs would not be implemented under Alternative 2, as no project activities would occur under this alternative.

REFERENCES

Baker, M.B. 1990. Hydrologic and Water Quality Effects of Fire. In: Krammes, J.S., Proceedings, Effects of Fire Management of Southwestern Natural Resources. Gen. Tech. Rep. RM-GTR-191. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 31-42.

Bakke, D. 2001. A review and assessment of the results of water monitoring for herbicide residues for the years 1991 to 1999. Unpublished document. USDA Forest Service, Vallejo, CA.

Bakke, D. 2007. Analysis of issues surrounding the use of spray adjuvants with herbicides. 61p. Unpublished document. On file with: USDA Forest Service, Stanislaus National Forest, 19777 Greenley Road, Sonora, CA 95370.

Berenbrock, C. 2014. United States Geological Survey. Sacramento, CA. Magnitude and Frequency of Floods. Personal Communication.

Beschta, R.L., J.J. Rhodes, J.B. Kauffman, R.E. Gresswell, G.W. Minshall, J.R. Karr, D.A. Perry, F.R. Haeur, and C.A. Frissell. 2004. Postfire management on forested public lands of the western United States. Conservation Biology 18: 957-967.

Berg, N., A. Carlson, and D. Azuma. 1998. Function and dynamics of woody debris in stream reaches in the central Sierra Nevada, California. Can. J. Fish. Aquat. Sci. 55:1807-1820.

Brooks, K.N., P.F. Ffolliott, H.M. Gregersen, and L.F DeBano. 1997. The role of fire in riparian, wetland, and aquatic systems. In: Hydrology and the Management of Watersheds. 2nd ed. Ames, IA: Iowa State University Press: 358-360.

CDFW. 2014. Definition of Heritage and Wild Trout Waters. http://www.dfg.ca.gov/fish/REsources/WildTrout/WT_WaterDef.asp

Connaughton, J.L. 2005 (24 June). Memorandum to heads of federal agencies from the Council ofEnvironmental Quality. Guidance on the consideration of past actions in cumulative effects analysis.

CREP. 2008. Clavey River Watershed Assessment. Volume I (Assessment) and Volume II (Appendices). Clavey River Ecosystem Project. Sonora, CA.

CVRWQCB. 2010. California Regional Water Quality Control Board, Central Valley Region. TheIntegrated Report – 303(d) List of Water Quality Limited Segments and 305(b) Surface Water Quality Assessment. http://www.swrcb.ca.gov/rwqcb5/water_issues/tmdl/impaired_waters_list/index.shtml

CVRWQCB. 2011. California Regional Water Quality Control Board, Central Valley Region. The water quality control plan (basin plan) for the California Regional Water Quality Control Board, Central Valley Region: The Sacramento River Basin and the San Joaquin River Basin. 4th ed., rev. Sacramento, CA. 131p. http://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/index.shtml

CVRWQCB. 2014. California Regional Water Quality Control Board, Central Valley Region. Implementation, Forensic and Effectiveness Monitoring and Reporting Program. Order No. R5-2014-0144 for Individual Discharges Under Waiver of Waste Discharge Requirements for Discharges Related to Timber Harvest Activities. Sacramento, CA.http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/waivers/r5-2014-0144.pdf

DiTomaso, J.M.; Miller, J.R.; Kyser, G.J.; Hazebrook, A.W.; Trumbo, Joel, Valcore, David, et al. 2004. Aerial application of clopyralid demonstrates little drift potential and low toxicity to toads. California Agriculture. 58(3). http://www.escholarship.org/uc/item/4sd088gq

Dow AgroSciences. 2011. Transline Concentrate Specimen Label. Revised 08-26-11.

Dow AgroSciences. 2014. Rodeo Concentrate Specimen Label. Revised 02-10-14.

Dwire, K.A. and J.B. Kauffman. 2003. Fire and riparian ecosystems in landscapes of the western USA. Forest Ecology and Management 178(1-2):61-74.

Ellis, L.M. 2001. Short-term response of woody plants to fire in a Rio Grande riparian forest, Central New Mexico, USA. Biological Conservation, 97, 159-170.

EPA 2005. Pesticide Fact Sheet: Aminopyralid. US Environmental Protection Agency: Office of Pesticide Programs. Ariel Rios Building, 1200 Pennsylvania Ave, N.W., Washington D.C. 20460

EPA 2010. Basic information about glyphosate in drinking water. United States Environmental Protection Agency. http://water.epa.gov/drink/contaminants/basicinformation/glyphosate.cfm

Frazier, J.W. and S.L. Grant. 2003. Water quality monitoring for herbicide residue, Stanislaus National Forest, 1995-2002. A synthesis report: water quality monitoring of reforestation projects following wildfires between 1987-1996. Unpublished document. On file with: USDA Forest Service, Stanislaus National Forest, Resource Management Program Area, 19777 Greenley Road, Sonora, CA 95370.

Frazier, J. 2006. Mechanized Equipment Operations in Riparian Conservation Areas. Unpublished document . On file with: USDA Forest Service, Stanislaus National Forest Resource Program Area, Sonora, CA.

Frazier, J.W., S.J. Holdeman, and S.L. Grant. 2008. StreamScape Inventory Technical Guide. Version 3. USDA Forest Service, Stanislaus National Forest, Resource Management Program Area. Sonora, CA. 32p.

Frese, Adam. 2013-2014. CalFire. Sonora, CA. Timber Harvest Activities on Private Land. Personal Communication. 10/30/2013, 11/5/2013, 11/7/2013, 1/2/2014, 1/9/2014, 1/11/2014, 1/13/2014, 1/14/2014.

Gotvald, A.J., N.A. Barth, A.G. Veilleux, and C. Parrett. 2012. Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl., http://pubs.usgs.gov/sir/2012/5113/

Hatchett, B., M. P. Hogan, and M. E. Grismer. 2006. Mechanical mastication thins Lake Tahoe forest with few adverse impacts. California Agriculture 60(2):77-82.

Hawkins, C.P, R.H. Norris, J.N. Hogue, and J.W. Feminella. 2000. Development and evaluation of predictive models for measuring the biological integrity of streams. Biological Applications. 10(5): 1456-1477.

Hubbert, K., M. Busse, and S. Overby. 2013. Effects of Pile Burning in the LTB on Soil and Water Quality. SNPLMA 12576 Final Report. 66p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5441924.pdf

Janicki, A. 2010. Soil Quality Monitoring Report, Groveland Ranger District, Stanislaus National Forest, Long Shannahan Unit. 1p. Unpublished document. On file with: USDA Forest

Service, Stanislaus National Forest, Resource Management Program Area, 19777 Greenley Road, Sonora, CA 95370.

Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel. 2006. World Map of Koppen-Geiger Climate Classification. Meteorologische Zeitschrift. 15(3): 259–263.

Lacey, S.T. 2000. Runoff and sediment attenuation by undisturbed and lightly disturbed forest buffers. Water, Air, and Soil Pollution. 122: 121-138.

Leitch, C., and P. Fagg. 1985. Clopyralid herbicide residues in streamwater after aerial spraying of a Pinus radiata plantation. New Zealand Journal of Forestry Science. 15(2): 195-206

MacDonald, L.H., and J.D. Stednick. 2003. Forests and water: a state-of-the art review for Colorado. CWRRI Completion Report No. 196. Colorado State University, Fort Collins, CO.

MacDonald, L.H., D. Coe and S. Litschert. 2004. Assessing cumulative watershed effects in the Central Sierra Nevada: hillslope measurements and catchment-scale modeling. Proceedings, Sierra Nevada Science Symposium, October 7-10, 2002, Kings Beach, CA. PSW-GTR-193: 149-157.

Markman, S. 2010. Hydrologist, Eldorado National Forest, Placerville, CA, 95667, personal communication.

Moghaddas, Emily E.Y., and S.L. Stephens. 2007. Mechanized fuel treatment effects on soil compaction in Sierra Nevada mixed-conifer stands. Forest Ecology and Management, 255(2008): 3098-3106.

Peterson, D.L., J.K. Agee, G.H. Aplet, D.P. Dykstra, R.T. Graham, J.F. Lehmkuhl, D.S. Pilliod, D.F. Potts, R.F. Powers, and J.D. Stuart. 2009. Effects of timber harvest following wildfire in western North America. Gen. Tech. Rep. PNW-GTR-776. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 51 p.

Reeves, G.H., P.A. Bisson, B.E. Rieman, and L.E. Benda. 2006. Postfire Logging in Riparian Areas. Conservation Biology: 20(4): 994-1004.

Reid. 2010. Cumulative effects of fuel treatments on channel erosion and mass wasting. Chapter 6 in: Elliot, W.J., I.S. Miller, and L. Audin, eds., Cumulative watershed effects of fuel management in the western United States. RMRS-GTR-231, Fort Collins, CO. 299p. http://www.fs.fed.us/rm/pubs/rmrs_gtr231.html

Robichaud, P.R., L.H. MacDonald, and R.B. Foltz. 2010. Fuel management and erosion. Chapter 5 in: Elliot, W.J., I.S. Miller, and L. Audin, eds., Cumulative watershed effects of fuel management in the western United States. RMRS-GTR-231, Fort Collins, CO. 299p. http://www.fs.fed.us/rm/pubs/rmrs_gtr231.html

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, CO.

Rutherford, J.C., N.A. Marsh, P.M. Davies, and S.E. Bunn. 2004. Effects of Patchy Shade on Stream Water Temperature: How Quickly do Small Streams Heat and Cool? Marine and Freshwater Research 55: 737-748.

Rutten, L. and S.L. Grant. 2008. Cumulative Watershed Effects Excel Based Analysis Model. Version 2.0. USDA Forest Service, Stanislaus National Forest, Resource Management Program Area. Sonora, CA.

Schuette, J. 1998. Environmental fate of glyphosate. Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, Sacramento, CA 95814-5624. http://www.cdpr.ca.gov/docs/emon/pubs/fatememo/glyphos.pdf

SERA. 1997. Use and Assessment of Marker Dyes Used with Herbicides. December 21, 1997. SERA TR 96-21-07-03b. Submitted by Syracuse Environmental Research Associates (SERA). Michelle Pepling, Phillip H. Howard, and Patrick R. Durkin. Fayeteville, NY. 47 pages.

SERA. 2004. Clopyralid – Human Health and Ecological Risk Assessment - Final Report, December 5, 2004. SERA TR 04-43-17-03c. Prepared for USDA Forest Service, Forest Health Protection. Syracuse Environmental Research Associates, Inc., Fayetteville, NY. 154 pages.

SERA. 2014. Clethodim – Scoping/Screening Level Risk Assessment - Final Report, October 30, 2014. SERA TR 056-08-02b. Submitted to Dr. Harold Thistle for USDA Forest Service, Forest Health Technology Enterprise Team. Syracuse Environmental Research Associates, Inc., Manlius, NY. 246 pages.

Smith, H.G. G.J. Sheridan, P.N.J. Lane, and L.J. Bren. 2011. Wildfire and Salvage Harvesting Effects on Runoff Generation and Sediment Exports from Radiata Pine and Eucalypt Forest Catchments, South-Eastern Australia. Forest ecology and Management 261:570-581.

STF 1992-1998. Water quality best management practices evaluation program, BMPEP V28 monitoring data sheet. 6p. Unpublished document. On file with: USDA Forest Service, Stanislaus National Forest, Resource Management Program Area, 19777 Greenley Road, Sonora, CA 95370.

STF 2004. Water quality best management practices evaluation program, BMPEP. Brown Darby. 59p. Unpublished document. On file with: USDA Forest Service, Stanislaus National Forest, Resource Management Program Area, 19777 Greenley Road, Sonora, CA 95370.

STF 2007. Water quality best management practices evaluation program, report of BMPEP monitoring 2006. 4p. Unpublished document. On file with: USDA Forest Service, Stanislaus National Forest, Resource Management Program Area, 19777 Greenley Road, Sonora, CA 95370.

STF 2008. Water quality best management practices evaluation program, report of BMPEP monitoring 2007. 5p. Unpublished document. On file with: USDA Forest Service, Stanislaus National Forest, Resource Management Program Area, 19777 Greenley Road, Sonora, CA 95370.

STF 2009. Water quality best management practices evaluation program, report of BMPEP monitoring 2008. 5p. Unpublished document. On file with: USDA Forest Service, Stanislaus National Forest, Resource Management Program Area, 19777 Greenley Road, Sonora, CA 95370.

STF 2010. Water quality best management practices evaluation program, report of BMPEP monitoring 2009. 6p. Unpublished document. On file with: USDA Forest Service, Stanislaus National Forest, Resource Management Program Area, 19777 Greenley Road, Sonora, CA 95370.

STF 2011. Water quality best management practices evaluation program, report of BMPEP monitoring 2010. 7p. Unpublished document. On file with: USDA Forest Service, Stanislaus National Forest, Resource Management Program Area, 19777 Greenley Road, Sonora, CA 95370.

STF 2012. Water quality best management practices evaluation program, report of BMPEP monitoring 2011. 10p. Unpublished document. On file with: USDA Forest Service, Stanislaus National Forest, Resource Management Program Area, 19777 Greenley Road, Sonora, CA 95370.

STF 2013. Water quality best management practices evaluation program, report of BMPEP monitoring 2012. 10p. Unpublished document. On file with: USDA Forest Service, Stanislaus National Forest, Resource Management Program Area, 19777 Greenley Road, Sonora, CA 95370.

USDA 1990. Cumulative off-site watershed effects analysis. Soil and water conservation handbook. R-5 FSH 2509.22 Amend. 2 7/88. San Francisco, CA. Chapter 20.

USDA 2002. Investigating water quality in the pacific southwest region: best management practices evaluation program user's guide. USDA Forest Service Pacific Southwest Region. Vallejo,California.

USDA 2004. Sierra Nevada Forest Plan Amendment. Final Supplemental Environmental Impact Statement. Record of Decision. Pacific Southwest Region. Vallejo, CA.

USDA 2007. USDA Forest Service Strategic Plan: 2007-2012. USDA Forest Service. FS-880. 38p.

USDA 2010. Forest Plan Direction. Stanislaus National Forest. Sonora, CA. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5154788.pdf

USDA 2011. FSH 2509.22 Soil and Water Conservation Handbook, Chapter 10 Water Quality Management Handbook, Best Management Practices. USDA Forest Service Pacific Southwest Region.

USDA 2012. National Best Management Practices for Water Quality Management on National Forest System Lands, Volume 1-National Core BMP Technical Guide. FS-990a. Washington, DC. April. Available at: http://www.fs.fed.us/biology/resources/pubs/watershed/FS_National_Core_BMPs_April2012.pdf

USDA 2013. Science Synthesis to Promote Resilience of Social-ecological Systems in the Sierra Nevada and Southern Cascades (Draft). Pacific Southwest Research Station. January 2013. 504 p.

USDA 2014. Rim Fire Recovery Environmental Impact Statement. Forest Service, Stanislaus National Forest. Sonora, CA. August 2014.

USDA 2015. Human Health and Ecological Risk Assessment Worksheet for Glyphosate. Version 6.00.13. Prepared by dbakke for Rim Fire Meeting June 10, 2015. On file with: USDA Forest Service, Stanislaus National Forest. 19777 Greenley Road, Sonora, CA 95370.

USDA 2015a. Human Health and Ecological Risk Assessment Worksheet for Clopyralid. Version 6.00.13. Prepared by dbakke for Rim Fire Meeting June 10, 2015. On file with: USDA Forest Service, Stanislaus National Forest. 19777 Greenley Road, Sonora, CA 95370.

USDA 2015b. Human Health and Ecological Risk Assessment Worksheet for Aminopyralid. Version 6.00.13. Prepared by dbakke for Rim Fire Meeting June 10, 2015. On file with: USDA Forest Service, Stanislaus National Forest. 19777 Greenley Road, Sonora, CA 95370.

USDA 2015c. Human Health and Ecological Risk Assessment Worksheet for Clethodim. Version 6.00.13. Prepared by dbakke for Rim Fire Meeting June 10, 2015. On file with: USDA Forest Service, Stanislaus National Forest. 19777 Greenley Road, Sonora, CA 95370.

USGS 2013. Federal Standards and Procedures for the National Watershed Boundary Dataset (WBD) (4 ed.): Techniques and Methods 11–A3, 63 p., http://pubs.usgs.gov/tm/11/a3/.

APPENDICES

A. Cumulative Watershed Effects Analysis Methodology

The process for analyzing cumulative watershed effects (CWE) consists of two steps: (1) an office evaluation which consists of determining the risk of cumulative effects using a predictive model and researching watershed history, and (2) field evaluation of streamcourse indicators of cumulative effects.

Step 1, the risk of cumulative effects, is evaluated using the Forest Service equivalent roaded acreage (ERA) methodology, which has been adopted by Region 5 as a method of addressing cumulative watershed effects (USDA 1990). ERA values are calculated using a computer model developed on the Stanislaus National Forest (Rutten and Grant 2008). The model is designed as a preliminary indicator for managers to determine whether or not past and present land management disturbances in a given watershed approach or exceed a threshold of concern (TOC). The TOC for each watershed was determined based on the watershed's relief ratio, geology, precipitation regime, and stream channel classification. The ERA model is intended to predict risk of cumulative effects, not actual effects. As such, it is an initial screen for focusing field evaluation priorities.

Understanding watershed history (i.e. past management activities, hydrologic events, wildfire) is important to build a temporal context of past impacts, current condition and potential future effects. Analysis of watershed history, including land disturbance history, is essential to help predict effects of future management activities on water quality and watershed condition. This history is considered in the ERA model spreadsheets. The temporal scope analyzed is based upon the estimated time of recovery from each past activity or event. It varies by activity and ranges from 1 to 10 years. The temporal scope for known future activities also varies by activity and ranges from 1 to10 years into the future. Not all future activities used to calculate ERA values have a defined proposed action. Therefore, assumptions were made about when and where activities would likely occur. These assumptions were documented in this appendix.

Step 2, field evaluation, is necessary for comparing the modeled ERA prediction with actual and expected future field conditions. Project-related water quality parameters and watershed condition are evaluated via in-stream and near-stream indicators of condition. This evaluation is essential to help interpret cumulative effects of past projects and potential cumulative effects given proposed activities and other reasonably foreseeable future activities. Field review was used to verify that the geographic and temporal extent of analysis was adequate for evaluation of cumulative watershed effects (Connaughton 2005).

The CWE ERA analysis for the Rim Fire Reforestation EIS was conducted on all lands within the affected watersheds (public and private lands). GIS analysis was used to calculate acreages of activities in the watersheds. CalFire was contacted regarding timber harvest activities on private land and maps of activities on private lands were digitized for the GIS analysis (Frese 2013-2014). ERA values for all activities described below were summed and then were compared to a TOC. These TOCs were determined for each individual watershed based on the natural watershed sensitivity (USDA 1990, USDA 1998).

Watersheds Analyzed

The Rim Fire Reforestation project area includes 18 HUC 6 analysis watersheds. Two watersheds, West Fork Cherry Creek and Big Creek, were not analyzed further since there are not any proposed treatments within them. The percent of watershed acres proposed for treatment varies greatly between

watersheds. Table A-1 displays the soil burn severity and percent of watershed acres proposed for treatment for each action alternative.

Table A-1 Percent of HUC 6 Watershed Acres Burned at High or Moderate Soil Burn Severity and Percent of Watershed Acres Proposed for Treatment by Alternative

HUC 6 Watershed Name	Percent of Watershed Burned at High or Moderate Soil Burn Severity[1]	Percent of Watershed Acres Proposed for Treatment			
		Alternative 1	Alternative 3	Alternative 4	Alternative 5
Grapevine Creek-Tuolumne River	27%	13%	12%	12%	13%
Jawbone Creek-Tuolumne River	70%	35%	29%	29%	35%
Lower North Fork-Tuolumne River	7%	5%	5%	5%	5%
Lower Clavey River	49%	35%	26%	26%	35%
Middle Clavey River	13%	4%	4%	4%	4%
Reed Creek	23%	15%	14%	14%	15%
Lower Cherry Creek	53%	20%	18%	18%	20%
Miguel Creek-Eleanor Creek	35%	0.4%	0.4%	0%	0.4%
Poopenaut Valley-Tuolumne River	39%	1%	1%	1%	1%
Lower Middle Fork Tuolumne River	63%	47%	43%	43%	47%
Upper Middle Fork Tuolumne River	29%	1%	1%	1%	1%
Lower South Fork Tuolumne River	46%	28%	26%	26%	28%
Upper Cherry Creek	0%	0.1%	0%	0%	0.1%
Upper South Fork Tuolumne River	25%	2%	2%	2%	2%
Bull Creek	2%	1%	1%	1%	1%
Bean Creek-North Fork Merced River	4%	4%	3%	3%	4%

[1] This includes Forest Service and non-Forest Service lands.

As seen in Table A-1, three of the 16 analysis watersheds had a maximum of 4% of their watershed acreage burned at high or moderate soil burn severity. These watersheds (Upper Cherry Creek, Bull Creek, and Bean Creek-North Fork Merced River) also all had a maximum of 4% of their acreage proposed for treatment under any action alternative. Therefore, these watersheds were not analyzed in detail following the ERA methodology. The effects of the small acreage of high or moderate soil burn severity and the small acreage of proposed treatments on these watersheds made it very unlikely to have measurable cumulative watershed effects, leading to the determination that ERA calculations were unnecessary.

The focus of the ERA evaluations is on the following 13 HUC 6 watersheds:

- Grapevine Creek-Tuolumne River
- Jawbone Creek-Tuolumne River
- Lower North Fork-Tuolumne river
- Lower Clavey River
- Middle Clavey River
- Reed Creek
- Lower Cherry Creek
- Miguel Creek-Eleanor Creek
- Poopenaut Valley-Tuolumne River
- Lower Middle Fork Tuolumne River

- Upper Middle Fork Tuolumne River
- Lower South Fork Tuolumne River
- Upper South Fork Tuolumne River

Tables A-2, A-3, and A-4 below shows project proposed action acres by watershed. Noxious weed eradication columns show treatment acres outside of project units.

Table A-2 Alternative 1 and 5 Proposed Action Acreage by Watershed

HUC Level and Name	Watershed Size (ac)	Proposed Action Footprint (ac)						
		Natural Regeneration	Reforestation	Thin Only	Thin & Reforestation	Deer Broadcast Burn	Noxious Weeds Eradication	Total
6 - Grapevine Creek-Tuolumne River	23,817	0	158	2,063	661	0	306	3,188
6 – Jawbone Creek-Tuolumne River	27,629	276	5,382	1,590	785	76	1,694	9,803
7 - Corral Creek	4,581	12	2,469	202	0	3	1,054	3,740
7 - Lower Jawbone Creek	5,670	59	1,570	13	13	73	52	1,780
6 - Lower North Fork Tuolumne River	34,210	14	98	1,333	272	0	30	1,747
6 - Lower Clavey River	17,871	202	890	1,379	1,722	405	1,710	6,308
7 - Bear Springs Creek	7,090	202	703	164	181	125	166	1,541
6 - Middle Clavey River	26,912	453	130	216	254	0	57	1,110
6 - Reed Creek	24,526	632	2,046	390	410	0	191	3,669
7 - Lower Reed Creek	7,495	470	2,046	250	277	0	191	3,234
6 - Lower Cherry Creek	24,383	79	1,348	912	1,996	0	479	4,814
7 - Granite Creek	4,126	26	1,113	244	274	0	470	2,127
6 - Miguel Creek-Eleanor Creek	15,798	0	43	0	22	0	0	65
6 - Poopenaut Valley-Tuolumne River	18,232	17	239	0	0	0	0	256
6 – Lower Middle Fork Tuolumne River	14,928	961	4,656	531	315	0	530	6,993
6 – Upper Middle Fork Tuolumne River	31,707	79	121	189	0	0	50	439
6 – Lower South Fork Tuolumne River	19,989	1,187	2,796	261	1,006	0	269	5,519
6- Upper Cherry Creek	16,344	0	0	22	0	0	0	22
6 - Upper South Fork Tuolumne River	37,866	99	97	426	17	0	296	935
6 - Bull Creek	21,064	0	0	94	24	0	0	118
6 - Bean Creek-North Fork Merced River	36,739	34	233	701	155	0	427	1,550

Table A-3 Alternative 3 Proposed Action Acreage by Watershed

HUC Level and Name	Watershed Size (ac)	Proposed Action Footprint (ac)						
		Natural Regeneration	Reforestation	Thin Only	Thin & Reforestation	Deer Broadcast Burn	Noxious Weeds Eradication	Total
6 - Grapevine Creek-Tuolumne River	23,817	0	158	2,063	661	0	1	2,883
6 – Jawbone Creek-Tuolumne River	27,629	276	5,382	1,590	785	76	23	8,132
7 - Corral Creek	4,581	12	2,469	202	0	3	15	2,701
7 - Lower Jawbone Creek	5,670	59	1,570	13	13	73	0	1,728
6 - Lower North Fork Tuolumne River	34,210	14	98	1,333	272	0	0	1,717
6 - Lower Clavey River	17,871	202	890	1,379	1,722	405	135	4,733
7 - Bear Springs Creek	7,090	202	703	164	181	125	2	1,377
6 - Middle Clavey River	26,912	453	130	216	254	0	0	1,053
6 - Reed Creek	24,526	632	2,046	390	410	0	0	3,478
7 - Lower Reed Creek	7,495	470	2,046	250	277	0	0	3,043
6 - Lower Cherry Creek	24,383	79	1,348	912	1,996	0	5	4,340
7 - Granite Creek	4,126	26	1,113	244	274	0	0	1,657
6 - Miguel Creek-Eleanor Creek	15,798	0	43	0	22	0	0	65
6 - Poopenaut Valley-Tuolumne River	18,232	17	239	0	0	0	0	256
6 – Lower Middle Fork Tuolumne River	14,928	961	4,656	531	315	0	5	6,468
6 – Upper Middle Fork Tuolumne River	31,707	79	121	189	0	0	0	389
6 – Lower South Fork Tuolumne River	19,989	1,187	2,796	261	1,006	0	6	5,256
6- Upper Cherry Creek	16,344	0	0	22	0	0	0	22
6 - Upper South Fork Tuolumne River	37,866	99	97	426	17	0	0	639
6 - Bull Creek	21,064	0	0	94	24	0	0	118
6 - Bean Creek-North Fork Merced River	36,739	34	233	701	155	0	0	1,123

Table A-4 Alternative 4 Proposed Action Acreage by Watershed

HUC Level and Name	Watershed Size (ac)	Proposed Action Footprint (ac)				
		Reforestation	Thin	Deer Broadcast Burn	Noxious Weeds Eradication	Total
6 - Grapevine Creek-Tuolumne River	23,817	0	2,362	0	1	2,363
6 – Jawbone Creek-Tuolumne River	27,629	1,347	1,888	1,256	23	4,514
7 - Corral Creek	4,581	657	202	3	15	877
7 - Lower Jawbone Creek	5,670	404	14	73	0	491
6 - Lower North Fork Tuolumne River	34,210	0	1,493	0	0	1,493
6 - Lower Clavey River	17,871	186	2,170	734	135	3,225
7 - Bear Springs Creek	7,090	181	246	125	2	554
6 - Middle Clavey River	26,912	36	392	0	0	428
6 - Reed Creek	24,526	432	649	0	0	1,081
7 - Lower Reed Creek	7,495	432	404	0	0	836
6 - Lower Cherry Creek	24,383	208	1,942	0	5	2,155
7 - Granite Creek	4,126	193	268	0	0	461
6 - Miguel Creek-Eleanor Creek	15,798	0	22	0	0	22
6 - Poopenaut Valley-Tuolumne River	18,232	67	0	0	0	67
6 – Lower Middle Fork Tuolumne River	14,928	1,183	696	0	5	1,884
6 – Upper Middle Fork Tuolumne River	31,707	34	189	0	0	223
6 – Lower South Fork Tuolumne River	19,989	626	774	0	6	1,406
6- Upper Cherry Creek	16,344	0	22	0	0	22
6 - Upper South Fork Tuolumne River	37,866	13	438	0	0	451
6 - Bull Creek	21,064	0	111	0	0	111
6 - Bean Creek-North Fork Merced River	36,739	0	785	0	0	785

Land Ownership in the Watersheds

The CWE ERA analysis for the Rim Fire Reforestation EIS was conducted on both public (US Forest Service, National Park Service, or Bureau of Land Management administered) and private lands in the watersheds. While it is harder to know activities on private land, GIS analysis can cover constant features such as roads and activities such as wildfire. In addition, CalFire was contacted regarding timber harvest activities on private land (Frese 2013-2014). Ownership patterns in the watersheds appear to be relatively stable.

Land ownership in the watersheds is as follows:

- Grapevine Creek-Tuolumne River: 74% USFS, 4% BLM, 22% Private
- Jawbone Creek-Tuolumne River: 73% USFS, 27% Private
- Lower North Fork-Tuolumne River: 59% USFS, 6% BLM, 35% Private
- Lower Cherry Creek: 81%USFS, 2%NPS, 17% Private
- Lower Clavey River: 85% USFS, 15% Private
- Lower Middle Fork Tuolumne River: 95% USFS, 5% Private
- Lower South Fork Tuolumne River: 96% USFS, 4% Private
- Middle Clavey River: 91% USFS, 9% Private
- Miguel Creek-Eleanor Creek: 6% USFS, 94% NPS

- Poopenaut Valley-Tuolumne River: 28% USFS, 70%NPS, 2% Private
- Reed Creek: 90% USFS, 10% Private
- Upper Middle Fork Tuolumne River: 3% USFS, 97% NPS
- Upper South Fork Tuolumne River: 8% USFS, 91% NPS, 1% Private

ERA Coefficients

The Annual ERA value is calculated in Excel using a linear decay of the ERA coefficient. The basic equation is:

ERA = Acres*(ERACoef-((Year-ActivityYear/Recovery)*ERACoef)))

However, if the activity is in the future, no ERA will be calculated until the first year of the activity. Also, if Year-ActivityYear is greater than or equal to the Recovery, then the Annual ERA is zero because the recovery time has been exceeded.

TIMBER HARVEST/FUELS TREATMENT/SITE PREPARATION/HERBICIDES

The ERA coefficient and recovery timeframe vary depending on the activity type. All coefficients are additive. For example, salvage on private land with ground based salvage plus biomass plus machine pile and burn would equal an ERA of 0.22 (0.14+0.04+0.04). See Table A-5 below for a description of ERA coefficients.

Assumptions related to the Watershed CWE Analysis

Due to unknowns in implementing this large project, the following assumptions were made:

Rim Fire Reforestation:

- Other projects or foreseeable actions were assumed to be approved and implemented.
- Reforestation herbicide use was analyzed as prescribed (one site prep and three releases) even though release applications are subject to meet some thresholds (release when greater than 20% of the land is vegetated with grass or shrubs). Also, it was assumed the total acreage would be treated for all treatment periods.
- All prescribed treatments under the Natural Regeneration units were assumed to be implemented in order to analyze for the worst case scenario.
- Hand cut treatment was assumed to have no effects on ERAs due to the smaller areas treated, less intense vegetation modification, and lack of soil disturbance.
- It was assumed that all ground based salvage has been completed under both the Rim Recovery and the Rim Hazard Tree Projects. But, fuel reduction treatments under these projects are still undergoing or still planned to happen (i.e. biomass, jackpot burning, and machine piling).
- Grazing: Previous analyses on the forest have indicated that the effects of livestock grazing at the watershed scale are low. Ground disturbance from livestock grazing is essentially a site issue rather than a watershed scale issue. This is because impacts of livestock grazing tend to be higher in low gradient stream channels through meadows than in upland areas, and these low gradient areas make up a small percentage of the watershed acreage. This results in little change to ERA values. Because of this, impacts of grazing are considered narratively for this project, but not quantitatively.

Rim Fire Recovery Salvage:

- Under Rim Recovery Alt 4, all helicopter salvage was dropped and all skyline logging was assumed to occur on the 1st year of implementation (2014).
- Approximately a third of the ground-based logging acreage assumed to be completed in 2014 and the remaining in 2015. The units which burned the hottest were assumed to be treated first because the economic value of the trees may be lost more quickly in these areas.

- Ground-based salvage units with less than 75% canopy cover mortality (determined in GIS) were assumed to have a 2nd entry to treat future die off. This 2nd entry was assumed to occur in 2015.
- Ground-based salvage units with more than 75% canopy cover mortality would only have one entry because it was assumed that the first entry would be comparable to a clearcut.
- No 2nd entries would occur on skyline logging units (cost prohibitive).

Table A-5 ERA Coefficient by Activity Type

Treatment	Coefficient	Recovery (Years)	Notes
Deep till and Forest Cultivation	0.18	10	Deep till is designated to reduce soil compaction, improve planting quality, and reduce vegetation. Forest cultivation is used to uproot competing vegetation.
Hand cut, hand pile, and burn	0.01	2	Hand cut trees that cannot be treated mechanically. In plantation remove both dead and live trees to reduce live conifer density and promote desired ICO structure.
Biomass/feller buncher	0.04	10	Mechanically remove material as firewood, shavings logs, pulpwood, or chipped biomass, or pile material for burning.
Machine pile and burn	0.04	10	This assumes use of a dozer
Jackpot burning	0.01	2	Burning of fuel concentrations
Broadcast fire	0.02	2	Low intensity underburn
Shred/mastication	0.03	3	Shred small trees, brush, and large downed woody debris.
Herbicide site prep and release, and noxious weeds	0.01	2	
Hand pull and dig weeds	0.03	2	
Green tree sale on private land – clearcut	0.18	10	
Green tree sale on private land – non-clearcut	0.15	10	This includes shelterwood seed cut, shelterwood removal cut, shelterwood prep cut, seed tree seed cut, seed tree removal cut, group selection, selection, commercial thin, sanitation salvage, rehab understocked, alternative prescription, transition, fuelbreaks
Green tree sale on private land – conversion	0.22	10	Conversion of land to a different use
Ground based salvage	0.14	10	
Salvage sale on private land – clearcut	0.22	10	Assumes ground based salvage + biomass + machine pile and burn (0.14+0.04+0.04)
Salvage sale on private land – clearcut with subsoiling	0.18	10	Coefficient was reduced due to erosion control benefits of subsoiling.
Helimulch burned area	-0.02	2	Coefficient is negative because it is a treatment used to increase groundcover and filter erosion. Straw degrades quickly, so recovery period is short.
Green tree – tractor thin	0.15	10	

Roadside Hazard Trees:

- Roadside hazard trees were assumed to be completed in 2014.
- Roadside hazard trees with less than 50% canopy cover mortality (determined in GIS) would have a 2nd entry to treat future die off. This 2nd entry was assumed to occur in 2015.
- Roadside hazard trees with more than 50% canopy cover mortality (determined in GIS) would only have 1 entry because it was assumed that the first entry would be comparable to a clearcut. This percentage is different from the salvage units because the salvage units required the trees to be 100% dead, whereas the roadside hazard trees had different marking standards.
- Subsequent entries (beyond the second entry) were not evaluated for. It was assumed that after two entries any remaining die off would be treating scattered isolated trees and would not significantly affect ERA calculations.

General Assumptions used for the Rim Recovery and the Roadside Hazard Trees:

- Pile and burn fuels treatments included machine piling and burning (dozer or grapple piling), jackpot burning, and hand piling and burning. All of these fuel treatment acres were assumed to be treated by dozer piling because this would cause the greatest ground disturbance. The exception was the areas where dozer piling was prohibited (WSA). In these areas, grapple piling was assumed.
- Pile and burn fuels treatments would require an additional entry into the units.
- Pile and burn treatments would occur from 2016-2018 and are evenly distributed in time and space.
- Biomass treatments would occur in 2016.
- Mastication treatments were assumed to occur in 2014.
- All salvage harvesting on private land was assumed to be clearcuts.
- On SPI land, it was assumed that subsoiling for site prep and erosion control was completed following salvage harvesting.
- In Yosemite National Park, 50% of hazard tree acreage was treated in 2013 and 50% in 2014. Second entries to treat future die off were calculated the same as hazard trees on National Forest lands.

ENGINEERING

Activities such as road maintenance and road reconstruction are not assigned ERA values because these activities are on existing roads which already have ERA values assigned to them (constant features).

WILDFIRE/SUPPRESSION ACTIVITIES

The ERA coefficient and recovery timeframe vary depending on the activity and the fire soil burn severity. See Table A-6 for a description of ERAs.

Table A-6 ERA Values for Wildfire

Treatment	Coefficient	Recovery (Years)	Notes
High Soil Burn Severity	0.33	7	
Moderate Soil Burn Severity	0.1	3	
Low Soil Burn Severity	0.02	1	
Dozer Lines	1.00	7	All dozer lines rehabbed

CONSTANT FEATURES

Constant features in a watershed are considered as part of the ERA analysis. This includes features such as roads, trails, power lines, buildings, campgrounds, dispersed recreation sites, etc. See CWE analysis spreadsheets for constant features and ERA coefficients for each watershed. Since they are constant features, they have no recovery timeframes assigned.

FUTURE ACTIVITIES

Reasonable foreseeable future land management activities were considered in the ERA calculations. This included all items listed in the 2015 SOPA that had the potential for ground disturbance as well as any other known likely future activities on public or private lands. Similar equations to those described above were used to calculate ERAs for future activities. See CWE analysis spreadsheets for each future activity, ERA coefficient, and recovery timeframe.

GRAZING

Previous analyses on the forest have indicated that the effects of livestock grazing at the watershed scale are low. Ground disturbance from livestock grazing is essentially a site issue rather than a

watershed scale issue. This is because impacts of livestock grazing tend to be higher in low gradient stream channels through meadows than in upland areas, and these low gradient areas make up a small percentage of the watershed acreage. This results in little change to ERA values. Because of this, impacts of grazing are considered narratively for this project, but not quantitatively.

ERA Analysis Results

Table A-7 summarizes ERA results for the 13 HUC 6 analysis watersheds and compares them to a TOC of 12 to14%. See the CWE analysis spreadsheets in the Project Record for specific activities in each watershed as well as details on how the TOC was determined.

Table A-7 Highest Percent ERA by Watershed and Alternative

HUC 6 Watershed Name	Highest % ERA Alternative 1	Highest % ERA Alternative 2	Highest % ERA Alternative 3	Highest % ERA Alternative 4	Highest % ERA Alternative 5	TOC Exceeded? (Y/N)
Grapevine Creek-Tuolumne River	2.63	2.63	2.63	2.63	2.63	N
Jawbone Creek-Tuolumne River	13.41	13.24	13.41	13.25	13.41	Y (Alt 1,2,3,4,5)
Lower North Fork-Tuolumne river	3.19	3.19	3.19	3.19	3.19	N
Lower Clavey River	8.41	8.29	8.46	8.30	8.41	N
Middle Clavey River	5.47	5.40	5.56	5.46	5.47	N
Reed Creek	8.12	8.09	8.12	8.09	8.12	N
Lower Cherry Creek	7.71	7.71	7.71	7.71	7.71	N
Miguel Creek-Eleanor Creek	1.25	1.25	1.25	1.25	1.25	N
Poopenaut Valley-Tuolumne River	2.04	1.92	2.04	1.92	2.04	N
Lower Middle Fork Tuolumne River	13.23	12.57	13.78	12.58	13.23	Y (Alt 1,2,3,4,5)
Upper Middle Fork Tuolumne River	1.76	1.73	1.76	1.73	1.76	N
Lower South Fork Tuolumne River	8.40	8.37	8.47	8.39	8.40	N
Upper South Fork Tuolumne River	1.54	1.53	1.54	1.53	1.54	N

The results of the HUC 6 ERA analysis indicated that 2 HUC 6 watersheds, Jawbone Creek-Tuolumne River and the Lower Middle Fork Tuolumne River, exceeded the TOC under all alternatives, including the no action alternative. There were an additional 4 watersheds that approached, but did not exceed, the TOC. These were the Lower Clavey River, Reed Creek, Lower Cherry Creek, and Lower South Fork Tuolumne River watersheds.

The 6 HUC6 watersheds which approached or exceeded the TOC were then evaluated more closely to determine if ERAs should be calculated at the HUC 7 level.

In the Jawbone Creek-Tuolumne River HUC 6 watershed, there are five HUC 7 watersheds. Of these, Corral Creek and Lower Jawbone Creek had the highest percentage of moderate and high soil burn severity and the highest percentage of acreage treated under the action alternatives. These two HUC 7 watersheds were therefore evaluated using the ERA methodology.

In the Lower Middle Fork Tuolumne River HUC 6 watershed, there are 2 HUC 7 watersheds. Both soil burn severity and treatment area percentages were fairly well distributed between these two watersheds. Because the HUC 6 watershed was over the threshold of concern for each action alternative and impacts appeared to be well distributed, TOC was not calculated for either HUC 7 watershed. It was assumed that both HUC 7 watersheds would exceed the TOC.

In the Lower Clavey River HUC 6 watershed, there are 3 HUC 7 watersheds. All had similar soil burn severity. Bear Springs Creek-Lower Clavey River had the highest percentage of watershed proposed for treatment, so this HUC 7 watershed was evaluated using the ERA methodology.

In the Reed Creek HUC 6 watershed, there are 3 HUC 7 watersheds. Of these, Lower Reed Creek had by far the highest percentage of moderate and high soil burn severity as well as the highest percentage of acreage proposed for treatment. Therefore, Lower Reed Creek was evaluated using the ERA methodology.

In the Lower Cherry Creek HUC 6 watershed, there are 4 HUC 7 level watersheds. Granite Creek had the highest percentage of moderate and high soil burn severity and the highest percentage of the watershed proposed for treatment. In addition, much of this watershed is on private land and the private land was salvage logged. Therefore, Granite Creek was evaluated using the ERA methodology.

In the Lower South Fork Tuolumne River HUC 6 watershed, there are 2 HUC 7 watersheds. Both soil burn severity and treatment area percentages were fairly well distributed between these two watersheds. Because the impacts of the action alternatives appeared to be well distributed, TOC was not calculated for either HUC 7 watershed. It was assumed that neither HUC 7 watershed would exceed the TOC.

See Table A-8 for a description of soil burn severity and treatment acres for the 5 selected HUC 7 watersheds.

Table A-8 Percent of HUC 7 Watershed Acres Burned at High or Moderate Soil Burn Severity and Percent of Watershed Acres Proposed for Treatment by Alternative

HUC 6 Watershed Name	HUC 7 Watershed Name	Percent of Watershed Burned at High or Moderate Soil Burn Severity[1]	Percent of Watershed Acres Proposed for Treatment			
			Alternative 1	Alternative 3	Alternative 4	Alternative 5
Jawbone Creek-Tuolumne River	Corral Creek	89%	82%	59%	19%	82%
	Lower Jawbone Creek	85%	31%	30%	9%	31%
Lower Clavey River	Bear Springs Creek-Lower Clavey River	50%	22%	19%	8%	22%
Reed Creek	Lower Reed Creek	62%	43%	41%	11%	43%
Lower Cherry Creek	Granite Creek	92%	52%	40%	11%	52%

[1] This includes Forest Service and non-Forest Service lands.

See Table A-9 for a summary of the ERA results for the 5 HUC 7 watersheds analyzed.

Table A-9 Highest Percent ERA by Watershed and Alternative

HUC 7 Watershed Name	Highest % ERA Alternative 1	Highest % ERA Alternative 2	Highest % ERA Alternative 3	Highest % ERA Alternative 4	Highest % ERA Alternative 5	TOC Exceeded? (Y/N)
Corral Creek	23.03	22.04	25.02	22.05	23.03	Y (Alt 1,2,3,4,5)
Lower Jawbone Creek	10.65	10.65	11.30	10.66	10.65	N
Bear Springs Creek-Lower Clavey River	12.09	11.79	12.37	11.84	12.09	Y (Alt 1,3,5)
Lower Reed Creek	14.55	14.46	14.55	14.46	14.55	Y (Alt 1,2,3,4,5)
Granite Creek	18.85	18.85	18.85	18.88	18.85	Y (Alt 1,2,3,4,5)

References

Connaughton, J.L. 2005 (24 June). Memorandum to heads of federal agencies from the Council of Environmental Quality. Guidance on the consideration of past actions in cumulative effects analysis.

Frese, Adam. 2013-2014. CalFire. Sonora, CA. Timber Harvest Activities on Private Land. Personal Communication. 10/30/2013, 11/5/2013, 11/7/2013, 1/2/2014, 1/9/2014, 1/11/2014, 1/13/2014, 1/14/2014.

Rutten, L. and S.L. Grant. 2008. Cumulative Watershed Effects Excel Based Analysis Model. Version 2.0. USDA Forest Service, Stanislaus National Forest, Resource Management Program Area. Sonora, CA.

USDA 1990. Cumulative off-site watershed effects analysis. Soil and water conservation handbook. R-5 FSH 2509.22 Amend. 2 7/88. San Francisco, CA. Chapter 20.

USDA 1998. Eldorado National Forest Cumulative Off-Site Watershed Effects (CWE) Analysis Process. Eldorado National Forest, Placerville, CA.

B. Watershed Management Requirements

Management requirements, designed to protect water quality and watershed conditions, are derived from Regional and National Best Management Practices (BMPs) (USDA 2011, USDA 2012) and Riparian Conservation Objectives (RCOs) (USDA 2004). Riparian resources within Riparian Conservation Areas (RCAs) and the Critical Aquatic Refuge (CAR) will be protected through compliance with the RCOs outlined in the Forest Plan (USDA 2010). Best Management Practices (BMPs) protect beneficial uses of water by preventing or minimizing the threat of discharge of pollutants of concern. BMPs applicable to this project are listed below with site-specific requirements and comments. Project planners and administrators (e.g., layout, Sale Administrator, Contracting Officer Representative) are responsible for consulting with a hydrologist and/or soil scientist prior to or during project implementation for interpretation, clarification, or adjustment of watershed management requirements.

MECHANIZED EQUIPMENT OPERATIONS WITHIN RCAS/CAR

On the Stanislaus National Forest, ground-based mechanized equipment operations in RCAs are divided into three zones. The exclusion zone, at the edge of streams or wetlands, prohibits mechanized equipment use. Next, the transition zone allows light mechanized activity. Last, the outer zone allows activity to increase to standard operations beyond the RCA. Together, these zones comprise a wide, graduated RCA buffer zone intended to achieve Riparian Conservation Objectives as well as vegetation management objectives.

The purpose of mechanized RCA operations is to reduce fuel loading and improve riparian vegetation community condition close to streams and wetlands. These operations are carefully conducted to prevent detrimental soil impacts and retain a high percentage of ground cover in the RCA. Where ground cover is minimal in an RCA, such as following wildfire, specialized low ground pressure vehicles become the primary type of equipment used. They minimize disturbance during timber removal operations and can be used to increase ground cover by chipping and distributing woody debris.

Forest guidance for Mechanized Equipment Operations in RCAs (Frazier 2006) as summarized above was developed for RCA vegetation management operations in unburned areas. It has since been revised to include post-wildfire operations.

Table B-1 provides a summary of the operating requirements for mechanical operations in RCAs.

Table B-1 Operating requirements for mechanized equipment operations in RCAs

Stream Type[1]	Zone	Width (feet)	MECH[2]	SKID[3]	Operating Requirements
PER/INT/SAF	Exclusion[4]	0-15	Prohibited	Prohibited	N/A
PER/INT/SAF	Exclusion	15-50	Allowed	Prohibited	N/A
PER/INT/SAF	Transition	15-50	Allowed	Prohibited	Remove operation-created debris from stream channels unless prescribed for resource benefit. Retain remaining obligate riparian shrubs and trees (e.g. willows, alder, aspen). Do not damage streambanks with equipment and retain sufficient vegetation to maintain streambank stability.
PER/INT/SAF	Transition	50-100	Allowed	Allowed	Use existing skid trails except where unacceptable impact would result.The number of crossings should not exceed an average of 2 per mile.
PER/SAF	Outer	100-300	Allowed	Allowed	Density and intensity of skid trails will gradually increase as distance increases from the Transition Zone.
INT	Outer	100-150	Allowed	Allowed	Density and intensity of skid trails will gradually increase as distance increases from the Transition Zone.
EPH	Exclusion[5]	0-15	Prohibited	Prohibited	N/A
EPH	Exclusion	15-25	Allowed	Prohibited	N/A
EPH	Transition	25-50	Allowed	Allowed	The number of crossings should not exceed an average of 3 per mile.

[1] **PER**=Perennial; **INT**=Intermittent; **EPH**=Ephemeral; **SAF**=Special Aquatics Features (lakes, meadows, bogs, fens, wetlands, vernal pools, and springs)
[2] **MECH**=Mechanical Harvesting or Shredding (low ground pressure track-laying machines such as feller bunchers and masticators)
[3] **SKID**=Skidding (rubber-tired skidders and track laying tractors)
[4] The exclusion zone for perennial/intermittent streams starts at: A. The edge of the active channel where slopes rise uniformly from the stream, or at the outer edge of the following features, whichever is the furthest from the stream. B. The first slope-break adjacent to the stream (e.g., stream bank, inner gorge). C. Flat or nearly flat ground adjacent to the channel (e.g., floodplain or terrace). D. Obligate riparian shrub and/or tree communities associated with any of the above. The exclusion zone for SAFs begins at: A. The outer edge of obligate trees, shrubs or herbaceous plants in wet meadows, bogs, fens and springs, or the high water line of lakes and vernal pools. B. The top of the first slope-break immediately adjacent to the special aquatic feature if further than the obligate vegetation or high water line.
[5] The exclusion zone begins at the edge of the channel where slopes rise uniformly or at the edge of the stream bank, whichever is furthest from the stream.

MANAGEMENT REQUIREMENTS INCORPORATING BMPS AND FOREST PLAN S&GS

Table B-2 presents management requirements pertaining to: erosion control plans; operations in RCAs; road activities; log landings; skid trails; water sources; slope and soil moisture limitations; servicing and refueling of equipment; burn piles; prescribed fire; herbicides; water quality monitoring; and cumulative watershed effects.

Table B-2 Management requirements incorporating BMPs and Forest Plan S&Gs

Management Requirements	BMPs/Forest Plan[1]/Locations
Erosion Control Plan - Prepare a project area Erosion Control Plan (USDA 2011) approved by the Forest Supervisor prior to the commencement of any ground-disturbing project activities. Prepare a BMP checklist before implementation.	**Regional BMPs** 2-13 Erosion Control Plans (roads and other activities) 1-13 Erosion Prevention and Control Measures During Operations 1-21 Acceptance of Timber Sale Erosion Control Measures before Sale Closure **National Core BMPs** Veg-2 Erosion Prevention and Control **Forest Plan S&Gs** 194 (RCO 4) **Locations**: all areas where ground-disturbing activities occur.
Operations in Riparian Conservation Areas - Delineate riparian buffers within RCAs around all streams and special aquatic features within project treatment units. Riparian buffer widths are described in Table B-1. - Fell trees harvested within RCAs directionally away from stream channels and SAFs unless otherwise recommended by a hydrologist or biologist.	**Regional BMPs** 1-4 Using Sale Area Maps and/or Project Maps for Designating Water Quality Protection Needs 1-8 Streamside Zone Designation 1-10 Tractor Skidding Design

Management Requirements	BMPs/Forest Plan[1]/Locations
- A minimum of 60% well distributed ground cover is desired within 100 feet of perennial and intermittent streams and SAFs. - Project administrator shall coordinate with a hydrologist prior to operating in units BB035, BB050, and BB036 to protect the Bear Gully restoration site, the stream channel downstream of the site, and the alluvial flat. - Exclude mechanized equipment between the near-stream roads that closely parallel both sides of Corral Creek in Units R037 and T005 (1N01 and 1N08 on the west, and 1N74 and 1N74C on the east) unless otherwise recommended by a hydrologist or soil scientist. - Planting: For perennial and intermittent streams, do not plant within 15 feet of the streambank or 20 feet of their associated riparian vegetation, whichever is more. - Exclude dozer operations within 50 feet from the start of the exclusion zone for all perennial and intermittent and SAFs and 25 feet from the start of the exclusion zone for all ephemerals.	1-18 Meadow Protection During Timber Harvesting 1-19 Streamcourse and Aquatic Protection 5-3 Tractor Operation Limitations in Wetlands and Meadows 5-5 Disposal of Organic Debris 7-3 Protection of Wetlands **National Core BMPs** Aq Eco-2 Operations in Aquatic Ecosystems Plan-3 Aquatic Management Zone Planning Veg-1 Vegetation Management Planning Veg-2 Erosion Prevention and Control Veg-3 Aquatic Management Zones Veg-4 Ground-Based Skidding and Yarding Operations **Forest Plan S&Gs** 193 (RCO 2) 194 (RCO 3) 194 (RCO 4) 195 (RCO 5) **Locations**: All units containing RCAs and SAFs, and specifically the portions of units mentioned in this section.
Road Construction and Reconstruction - Maintain functioning erosion-control measures during road construction and reconstruction and in accordance with the erosion control plan. - Stabilize disturbed areas with mulch, erosion fabric, vegetation, rock, large organic material, engineered structures, or other measures according to specifications in the erosion control plan.	**Regional BMPs** 2-2 General Guidelines for the Location and Design of Roads 2-3 Road Construction and Reconstruction 2-8 Stream Crossings 2-13 Erosion Control Plans (roads and other activities) **National Core BMPs** Road-3 Road Construction and Reconstruction **Forest Plan S&Gs** 62 193 (RCO 2) 194 (RCO 4) **Locations**: all roads to be reconstructed.
Road Maintenance and Operations - Maintain road surfaces to dissipate intercepted water in a uniform manner along the road by outsloping with rolling dips, insloping with drains or crowning with drains. Where feasible and consistent with protecting public safety, utilize outsloping and rolling the grade (rolling dips) as the primary drainage technique. - Adjust surface drainage structures to minimize hydrologic connectivity by: discharging road runoff to areas of high infiltration and high surface roughness, armoring drainage outlets to prevent gully initiation, and increasing the number of drainage facilities within RCAs.	**Regional BMPs** 2-4 Road Maintenance and Operations 2-13 Erosion Control Plans (roads and other activities) **National Core BMPs** Road-4 Road Operations and Maintenance Veg-2 Erosion Prevention and Control **Forest Plan S&Gs** 193 (RCO 2) 194 (RCO 4) **Locations**: all roads with maintenance or project use.
Log Landings - Re-use log landings to the extent feasible. - Do not construct new landings within 100 feet of perennial or intermittent streams and SAFs or 50 feet of ephemeral streams. - Deep till all landings when biomass operations are complete.	**Regional BMPs** 1-12 Log Landing Location 1-16 Log Landing Erosion **National Core BMPs** Veg-6 Landings Veg-2 Erosion Prevention and Control **Forest Plan S&Gs** 194 (RCO 4) **Locations**: Biomass Removal: all landings.
Skid Trails - Use existing skid trails wherever possible, except where unacceptable resource damage may result. Locate skid trails at least 50 feet from perennial and intermittent streams and SAFs and 25 feet from ephemeral streams. - Install waterbars and other erosion control measures as needed on skid trails immediately following completion of biomass operations. - Remove skid trails berms that concentrated flows to improve surface drainage	**Regional BMPs** 1-10 Tractor Skidding Design 1-17 Erosion Control on Skid Trails **National Core BMPs** Veg-2 Erosion Prevention and Control Veg-4 Ground-Based Skidding and Yarding Operations **Forest Plan S&Gs**

Management Requirements	BMPs/Forest Plan[1]/Locations
following use.	194 (RCO 4) **Locations**: all ground-based yarding system units.
Water Sources - For water drafting on fish-bearing streams: do not exceed 350 gallons per minute for streamflow greater than or equal to 4.0 cubic feet per second (cfs); do not exceed 20 percent of surface flows below 4.0 cfs; and, cease drafting when bypass surface flow drops below 1.5 cfs. - For water drafting on non-fish-bearing streams: do not exceed 350 gallons per minute for streamflow greater than or equal to 2.0 cfs; do not exceed 50 percent of surface flow; and, cease drafting when bypass surface flow drops below 10 gallons per minute.	**Regional BMPs** 2-5 Water Source Development and Utilization 2-13 Erosion Control Plans (roads and other activities) **National Core BMPs** WatUses-3 Administrative Water Developments AqEco-2 Operations in Aquatic Ecosystems **Forest Plan S&Gs** 193 (RCO 2) 194 (RCO 4) **Locations**: all water drafting sites.
Slope and Soil Moisture Limitations - See Soils report for specific slope limitations for operation of ground-based equipment. - See Soils report for wet weather operating restrictions.	**Regional BMPs** 5-2 Slope Limitations for Mechanical Equipment Operation 5-6 Soil Moisture Limitations for Mechanical Equipment Operations **National Core BMPs** Veg-2 Erosion Prevention and Control Veg-4 Ground-Based Skidding and Yarding Operations **Locations**: all ground-based equipment units.
Servicing, Refueling, and Cleaning Equipment and Parking/Staging Areas - Allow temporary refueling and servicing only at approved sites located outside of RCAs. - Rehabilitate temporary staging, parking, and refueling/servicing areas immediately following use. - A Spill Prevention and Containment and Counter Measures (SPCC) plan is required where total oil products on site in above-ground storage tanks exceed 1320 gallons or where a single container exceeds 660 gallons. Review and ensure spill plans are up-to-date. - Report spills and initiate appropriate clean-up action in accordance with applicable State and Federal laws, rules and regulations. The Forest Service's hazardous materials coordinator's name and phone number shall be available to Forest Service personnel who administer or manage activities utilizing petroleum-powered equipment. - Remove contaminated soil and other material from NFS lands and dispose of this material in a manner according to controlling regulations.	**Regional BMPs** 2-10 Parking and Staging Areas 2-11 Equipment Refueling and Servicing **National Core BMPs** Road-9 Parking and Staging Areas Road-10 Equipment Refueling and Servicing Fac-7 Vehicle and Equipment Wash Water **Forest Plan S&Gs** 193 (RCO 1) **Locations**: designated temporary refueling, servicing and cleaning sites and parking/staging areas.
Burn Piles - Place burn piles a minimum of 50 feet away from perennial and intermittent streams and SAFs and 25 feet from ephemeral streams. Locate piles outside areas that may receive runoff from roads. - Avoid disturbance to obligate riparian vegetation. - Do not dozer pile in sensitive watershed areas and on areas where mastication or drop and lop were prescribed under the Rim Recovery Project. Grapple piling[2] is allowed in these areas, but is subject to the mechanized equipment restrictions for RCAs. When grapple piling in sensitive watershed areas, consult a hydrologist or soil scientist if less than 70% ground cover would be retained. **Prescribed Fire** - Avoid damage to obligate riparian vegetation (e.g., willows, alders, cottonwoods). - Do not burn over Bear Gully restoration site (contained in parts of units BB035, BB050, and BB036). - In order to maintain the wood component or temporary fences proposed under the Rim Fire Rehabilitation Project and the Rim Fire Habitat Improvement Project, coordinate with a hydrologist prior to conducting prescribed fire on the following units: M024, M021, M019, M016, R025, R033, I062, I063, I067, N019, T017, T022, S004, Y030, Y027, BB011, I131, I132, I137, M008, R041, R042, R034, Z011, AA001. - Maintain a minimum of 60% ground cover within 100 feet of perennial and intermittent streams and 50 feet of ephemeral streams. - Avoid direct ignition within RCAs, including ephemeral channels; fire may back into the riparian area as long as ground cover is maintained.	**Regional BMPs** 6-2 Consideration of Water Quality in Formulating Fire Prescriptions 6-3 Protection of Water Quality from Prescribed Burning Effects **National Core BMPs** Fire-1 Wildland Fire Management Planning Fire-2 Use of Prescribed Fire **Forest Plan S&Gs** 194 (RCO 4) **Locations**: all pile burning areas, sensitive watershed areas. All units that are planned for prescribed fire.

Management Requirements	BMPs/Forest Plan[1]/Locations
- Avoid constructing fire lines within RCAs unless there is no alternative. Do not construct new dozer lines within 100 feet of perennial and intermittent streams and 50 feet of ephemeral streams. - Restore constructed fire lines upon completion of prescribed burning and/or prior to each winter when fire lines are exposed to the potential for erosion. - Restoration should consist of water barring hand and dozer lines, re-contouring of benched trails, and deep tilling of detrimentally compacted dozer lines. - No debris or soil that might impede water flow or cause stream bank degradation will be placed in any stream. - Do not bulldoze the surface within SMZs or near streams. Favor hand tools and equipment on steep slopes, fragile soils and in sensitive areas such as Streamside Management Zones. - Install fire lines on the contour as much as possible.	
Vegetation Manipulation/Herbicide Use - Comply with all label and other applicable legal requirements for herbicide use and cleaning and disposal of pesticide equipment and containers. Incorporate a spill contingency plan into the project safety plan and have on site during herbicide application. - To protect streams and special aquatic features, do not apply Glyphosate within the following designated buffers zones: 10 feet from the edge of perennial, intermittent or ephemeral streams; special aquatic features such as springs, seeps and fens; and obligate riparian vegetation. The 10-foot buffer does not apply if any intermittent stream or ephemeral stream is dry at the time of application. - Do not apply Clopyralid, Aminopyralid and Clethodim within the following designated buffer zones: 50 feet from the edge of perennial, intermittent or ephemeral stream; special aquatic features; and wet areas with standing water at the time of application; 10 feet from the edge of obligate riparian vegetation; 15 feet from the edge of any intermittent or ephemeral stream, or special aquatic features dry at the time of application. - Do not apply Clopyralid, Aminopyralid and Clethodim to areas with high surface runoff potential such as road surfaces, roadside ditches, shallow soils, and rocky or compacted slopes adjacent to perennial or intermittent streams. To avoid excessive leaching, soils should not be saturated at time of application. Soil moisture should be drier than field capacity. - Storage of Herbicides: No storage of herbicides will be allowed on RCAs other than what will be carried in the contractor(s) vehicle to complete each day's work. Mixing and loading will be done in areas where accidental spills will not contaminate streams or other water. Mixing sites will be predetermined by the COR and should be as far from water and on ground as level as possible. Include spill cleanup procedures in all project plans.	**Regional BMPs** 5-7 Pesticide Use Planning Process 5-8 Pesticide Application According to Label Directions and Applicable Legal Requirements 5-11 Cleaning and Disposal of Pesticide Containers and Equipment 5-12 Streamside Wet Area Protection During Pesticide Spraying **National Core BMPs** Chem-1 Chemical Use Planning Chem-2 Follow Label Directions Chem-3 Chemical Use Near Waterbodies Chem-5 Chemical Handling and Disposal **Forest Plan S&Gs** 193 (RCO 1) **Locations**: all units with applications in RCAs.
Water Quality Monitoring - Conduct implementation and effectiveness monitoring using the Best Management Practices Evaluation Program (BMPEP) (USDA 2002) and the National Core Monitoring Protocols (FS-990b) (USDA 2012).	**Regional BMPs** 7-6 Water Quality Monitoring **Locations**: Monitoring locations will be detailed in a project monitoring plan.
Cumulative Watershed Effects (CWE) Analysis - CWE analysis will be conducted for the project.	**Regional BMPs** 7-8 Cumulative Off-Site Watershed Effects **Locations**: All activities within the project watersheds will be analyzed

[1] Forest Plan S&Gs indicate page number from Forest Plan Direction (USDA 2010).

[2] Grapple piling is a site preparation technique that uses tracked excavator type equipment with an articulating arm equipped with a clam type pincher head that lifts and piles brush and logs. Usually followed by jackpot burning.