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Hydrology Report

Pine Mountain Late-Successional Reserve Habitat Protection and Enhancement Project

Upper Lake Ranger District, Mendocino National Forest
Lake County, California

For Information Contact: Hilda Kwan
10025 Elk Mountain Road
Upper Lake, Ca 95485
707-275-1413
[Webpage]

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Executive Summary

The purpose of this document is to characterize hydrology resources of the Pine Mountain Late-Successional Reserve Habitat Protection and Enhancement Project area and analyze any potential effects from implementing the no action and action alternatives.

Potential effects to hydrology resources include impacts to water quality, riparian reserves, and cumulative watershed effects.

Methodology

The analysis of alternatives is based on field observations (including surveys) and an assessment of the Cumulative Watershed Effects (CWE) resulting from activities planned or expected to occur under each of the alternatives.

Spatial boundaries for the CWE analyses include 7th field (HUC 14, approx. 3,500-8,000 acres) and 8th field watersheds (HUC 16, approx. 1,500-2,500 acres). These watersheds are 2nd to 4th order streams. Temporal Bounding of the CWE analysis considers all ground-disturbing activities in the past (up to ten years prior), present, and reasonably foreseeable future.

Affected Environment

The Planning area is approximately 10,200 acres, encompassing public and private lands within the border of the Mendocino National Forest (MNF). The project is located within the Dashiell, Benmore, Packsaddle, Lower Bucknell, and Upper Bucknell 7th field watersheds.

The majority of streams within the project area are low-order (1-3) intermittent and ephemeral streams with gradients of 10% or higher and side slopes greater than 45%. These lower order streams support little to no phreatophytic vegetation. True riparian vegetation, where it exists, is limited to about five to ten feet from the channel. These streams are typically step-pool systems with bedrock and boulder stream beds. They are vertically stable and are not very sensitive to changes in land use.

Portions of Benmore and Packsaddle Creeks, as well as an unnamed tributary to Packsaddle Creek, are perennial within the project boundary. These streams tend to have over-steepened and unstable side slopes with high sediment loads in the upstream portions. Packsaddle and its tributary flow into Lake Pillsbury, while Benmore Creek flows directly into the Eel River. Although Benmore Creek has elevated sediment levels due to natural instabilities, it supports Steelhead for approximately its lower 2 miles.

The project area encompasses about 5105 acres of Riparian Reserves (RRs) and 1,913 acres of Streamside Management Zones (SMZs). RRs and SMZs constitute a hierarchy of areas designated to protect water quality, aquatic and riparian habitats. The highest level of protection occurs within the SMZ, where no ground-based mechanized equipment is allowed to operate except at designated crossings.

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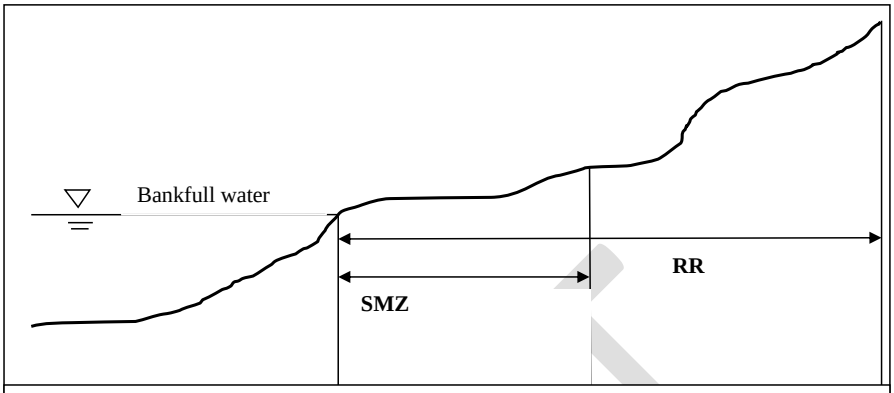

RR and SMZ width for each streamclass:		
Streamclass	Riparian Reserve Buffer	Streamside Management Zone Buffer
Perennial	300’	The greater of 100’ slope distance or to the slope break
Intermittent	150’	The greater of 50’ slope distance or to the slope break
Ephemeral	100’	20’ (non-anadromous)
		50’ (anadromous)

Environmental Consequences

Direct, indirect, and cumulative effects of the action alternatives (2 through 5) are fairly similar. It is assumed that these effects would be short term.

<u>Alternative 1 – No Action</u>

Direct Effects and Indirect Effects

Direct and indirect effects associated with not treating the units and roads in the project would result in continued sedimentation from roads and further accumulation of forest material; increasing the potential for catastrophic fire.

Cumulative Effects

The analysis of No Action Alternative is the same as the existing condition. Analysis of the No Action Alternative indicates that potential for cumulative effects is minimal to moderate.

Alternatives 2 through 5

Direct Effects and Indirect Effects (Summary)

Alternative	Direct and Indirect Effects
2	Temporary effects due to removal of vegetation, slash piling, creation of temporary roads, and burning. Use of heavy equipment may affect soil compaction.
3	Similar effects as Alt 2, but less potential negative effects because 0.25 mile of temporary road would not be created. May have indirect effect of needing to use more skid trails to haul out timber.
4	Similar effects of Alt 2, but less disturbance within Riparian Reserves. Indirect effect would include the exclusion of heavy fuels removed from RR's , which can lead to negative soil and watershed effects in an event of a wildfire.
5	Similar effects of Alt 2, but less disturbance within known Norther Spotted Owl nesting sites. Indirect effect would include the exclusion of heavy fuels removed from these areas, which can lead to negative soil and watershed effects in an event of a wildfire.

Cumulative Effects

All alternatives proposed as part of this project do not exceed the "Threshold of Concern" when analyzed with the Cumulative Watershed Effects model. Each alternative approaches the threshold at varying levels.

Watershed	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Willow	1.56	1.66	-	-	-
Packsaddle	2.31	4.11	-	3.66	4.09
Upper Bucknell	1.48	2.32	-	2.13	-
Lower Bucknell	1.23	2.28	-	2.15	-
Benmore	4.14	7.75	7.74	5.99	7.56
Dashiell	1.8	2.2	-	2.14	-
"-" denotes same value as Alternative 2 All analysis results remain below Threshold of Concern of 12%					

Summary of Effects

The effects resulted from all alternatives proposed in this project do not exceed the Threshold of Concern. While some alternatives may have less of a cumulative effect, there may be negative

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indirect effects as a result. Alternative 1 has the least cumulative effects, but is the most susceptible to catastrophic wildfires. Similarly, Alternatives 4 and 5 will have less of a cumulative impact compared to Alternative 2, but do not address the heavy fuels problem in the excluded treatment areas. Alternative 2 would have the most cumulative effects (though not above threshold), but will have the most impact in reduction of fuels; thus reducing the possibility of catastrophic wildfires.

Compliance with law, regulation, policy, and the Forest Plan

Compliance for this project include: Clean Water Act (1977), Executive Order 11988 (Floodplain Management,1977), National Forest Management Act (1976), Mendocino National Forest Land and Resource Management Plan (1996), Porter-Cologne Water Quality Control Act (1999), Executive Order 11990 (Protection of Wetlands, 1977) . The following were excluded because they are not affected by the project or do not apply:, Coastal Zone Management Act (1972; 16 USC 1451), Wild and Scenic Rivers (1508.27 (b)(3)).

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Hydrology Report

Introduction

The purpose of this document is to characterize hydrology within the Pine Mountain Late-Successional Reserve Habitat Protection and Enhancement Project (Project) area and analyze any potential effects from implementing the no action and action alternatives.

Discussions will include regulations related to hydrological resources, the affected environment, current conditions, environmental effects, and design features.

Potential effects to hydrologic resources include impacts to water quality, riparian reserves, and cumulative watershed effects. Water quality impacts will include sediment and temperature as these are parameters listed in the Total Maximum Daily Load (TMDL) and have the most potential to impact aquatic habitat. Water quantity (amount of stream flow) is not addressed since the level of thinning proposed in a water-stressed environment is not expected to have any measurable impact to the timing or magnitude of stream flows. It is expected that any additional soil moisture available will be utilized by remaining vegetation.

Proposed Actions and Alternatives Analyzed

Five alternatives from the Pine Mountain project have been analyzed for watershed impacts. Please see Chapter 2 of the EIS for detailed descriptions of each alternative and how they were developed.

Alternative 1- No Action

Alternative 2- Proposed Action- The primary proposed activities include fuels reduction treatments on approximately 7,830 acres southwest of Lake Pillsbury in the Pine Mountain vicinity. The Planning Area is 10,200 acres in size and comprises both Late Successional Reserve (LSR) and Matrix land designations. Of approximately 7,830 acres to be treated, ~5,690 acres are within the Pine Mountain LSR and ~2,140 acres are in Matrix lands. The project emphasizes fuel reduction activities and habitat management for the protection and enhancement of late-successional species. The project area was chosen for treatment based on past fire history and the existing conditions that pose a threat to late-successional habitat. Connected activities include road maintenance, temporary road construction, and motorized trail management. A detailed description of the Proposed Action can be found in Chapter 2 of the Environmental Impact Statement (EIS).

Alternative 3- No New Temporary Road Construction
This alternative would follow actions proposed in Alternative 2, with the exception of creating new temporary roads.

Alternative 4- No commercial thinning in Riparian Reserves
This alternative would follow all the actions proposed in Alternative 2, with the exception of no commercial thinning.

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Alternative 5- No commercial thinning in known Northern Spotted Owl nesting habitat
This alternative would follow all the actions proposed in Alternative 2, with the exception of no commercial thinning.

Methodology

The analysis of alternatives is based on Field Observations and an assessment of the Cumulative Watershed Effects (CWE).

Detailed Methodology

Cumulative Watershed Effects

Watershed effects as a result of the 5 different alternatives have been analyzed using the Cumulative Watershed Effect (CWE) process (as required by USDA FSH 2509.22, Soil and Water Conservation Handbook, Chapter 20- Cumulative Off-Site Watershed Effects Analysis). This analysis considers all ground-disturbing activities (past, present, and foreseeable future) including: past wildfire, prescribed fire, vegetation treatments, grazing, and roads.

Scores for the CWE analysis is based on the Equivalent Roaded Acre (ERA); one unit of ERA is equal to one acre of land that is completely roaded. In calculating ERA's, all ground disturbing activities are assigned an activity coefficient. This is due to the fact that most disturbances are a fraction of an ERA and have a recovery period. For example, a partial cut with tracked skidder has an activity coefficient of 0.18 and recovery period of 10 years. Permanent disturbances that have little to no recovery (e.g. roads and landings) have a coefficient of 1.

Initial ERA= acres of activity * activity coefficient

For subsequent years, to account for recovery:

Projected ERA= Initial ERA * 0.5^ (recovery years/ recovery half-life)

A percent disturbance for the watershed is then calculated as the %ERA:

%ERA= ERA / watershed acres * 100

This %ERA value is compared to a pre-determined Threshold of Concern (TOC); and when the %ERA is greater than the TOC, further analysis is required to determine if water yield, erosion, or sedimentation are of concern. The TOC varies with soil erodibility, geologic stability, and drainage density and has been established on the Mendocino National Forest to be 12% ERA.

A lower TOC used generally indicates a low risk of cumulative watershed effects. Cumulative watershed effects can be affected by watershed size. Larger watersheds have a greater "dilution" factor; such that an activity has less of an impact when compared to a smaller watershed with same activity. Analysis was completed at the 7th (3,000-40,000 acres) and 8th (1,400- 3,000 acres) field watershed (HUC 14 and 16, respectively). If TOC is not exceeded by using 7th or 8th field watersheds, it is not necessary to analyze larger watersheds (e.g. 6th field or 5th field watersheds) within which they are located, for the reason of dilution effects.

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Field Observations

As part of the North Coast California Regional Water Quality Control Board's implementation of the federal Clean Water Act, the Forest Service is required to establish in-channel monitoring sites to determine whether USFS project management and Best Management Practices collectively are effective in meeting water quality objectives, protecting beneficial uses, and assessing trends in water quality at the watershed scale. Baseline in-channel monitoring following the Stream Condition Inventory (SCI) protocol have been established at two locations within the project area. More information of these SCI surveys can be found under the Existing Conditions and Appendix D of the hydrology report.

Analysis Indicators

Analysis Indicators are discussed in the Existing Conditions section of this report.

Spatial and Temporal Bounding of Analysis Area

- Spatial boundaries for these analyses include 7th field (HUC 14, approx. 3,500-8,000 acres) and 8th field watersheds (HUC 16, approx. 1,500-2,500 acres). These watersheds are 2nd to 4th order streams,
- Temporal Bounding: The CWE analysis considers all ground-disturbing activities in the past (up to ten years prior), present, and foreseeable future.

Affected Environment

The Planning area is approximately 10,200 acres, encompassing public and private lands within the border of the Mendocino National Forest (MNF). The Project is located within the Dashiell, Benmore, Packsaddle, Lower Bucknell, and Upper Bucknell 7th field watersheds (Figure 1 and Table1). All but the Packsaddle watershed are within the Soda Creek 5th field watershed, an anadromous watershed draining to the Upper Main Eel River. The Packsaddle Watershed is in the Rice Fork 5th field watershed which drains into Lake Pillsbury. Scott dam, which impounds Lake Pillsbury, is a barrier to upstream migration of anadromous fish; therefore there are no anadromous fish in the Packsaddle portion of the project.

Table 1. Watersheds affected by the Pine Mountain project

5th Field HUC Watershed (Name/#)	6th Field HUC Watershed (Name/#)	7th Field HUC Watershed (Name/#)	8th Field HUC Watershed (Name/#)
Soda Creek 1801010303	Soda Creek- Eel River 180101030502	Benmore 18010103050201	1801010305020101
			1801010305020102
		Dashiell 18010103050202	1801010305020201
			1801010305020202
			1801010305020203
			1801010305020204
			1801010305010201

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5th Field HUC Watershed (Name/#)	6th Field HUC Watershed (Name/#)	7th Field HUC Watershed (Name/#)	8th Field HUC Watershed (Name/#)
	Bucknell Creek 180101030501	Lower Bucknell 18010103050102	1801010305010202
			1801010305010203
		Upperbucknell 18010103050101	1801010305010101
			1801010305010102
			1801010305010103
Rice Fork 1801010302	Rice Creek- Rice Fork 180101030103	Packsaddle 18010103010303	1801010301030301
			1801010301030302
			1801010301030303
		Willow 18010103010302	1801010301030201
			1801010301030202

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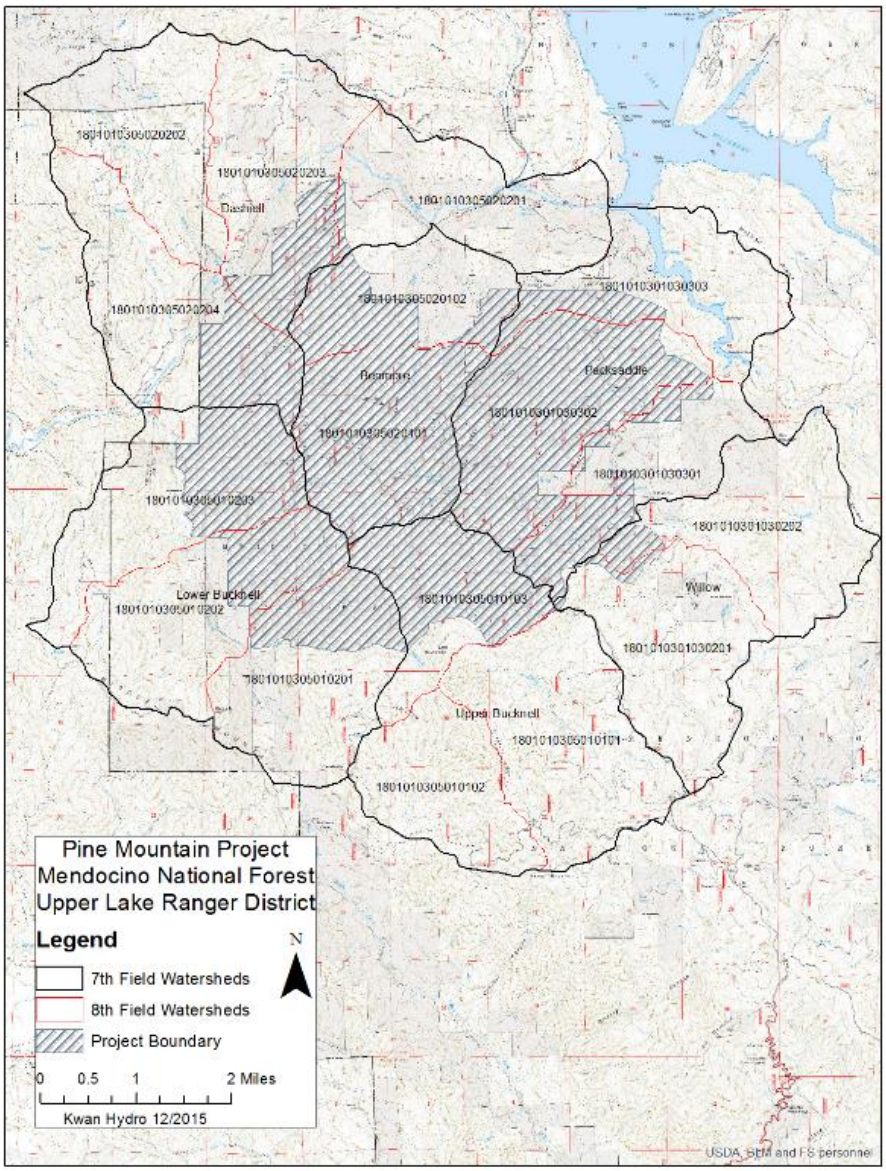

Figure 1. Treatment areas in the HUC 7 and HUC 8 watersheds.

Riparian Reserves (RRs) and Streamside Management Zones (SMZs)

RRs and SMZs constitute a hierarchy of areas designated to protect water quality, aquatic, and riparian habitats (Figure 2). The highest level of protection occurs within the SMZ, where no ground-based mechanized equipment is allowed to operate except at designated crossings. Vegetation treatments are allowed within any of these zones but are subject to more stringent management requirements. Table 2 shows the number of acres of SMZs and RRs within the planning area.

Table 2. Acres of SMZs and RRs within project area

	SMZ (acres)	RR (acres)
Perennial	325	373
Intermittent	456	1640
Ephemeral	1132	3092

The LRMP and the Northwest Forest Plan define five classes of Riparian Reserves (Table 3). The Pine Mountain Project contains four of these classes of Riparian Reserve (Figure 2, Table 3). Riparian reserves provide several functions that are important to watershed and aquatic health. They serve as filter strips to slow overland flow and trap sediment. While providing shade to regulate water temperature, they also provide for recruitment of Large Woody Debris (LWD) into the fluvial system. They can also provide micro-climates for habitat niches and connectivity corridors for wildlife. The majority of the Riparian Reserves within the Project Area are along intermittent and ephemeral streams and are composed of upland vegetation, with little to no phreatophytic vegetation present. As with the surrounding land areas, the vegetation is dense and fuel loads are very high.

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Table 3. Five classes of Riparian Reserves (USDA Forest Service, 1995).

Stream or waterbody	Extent of Riparian Reserves
Fish-bearing streams	The stream and the area on each side of the stream extending from the edges of the active stream channel to the top of the inner gorge, or to the outer edges of the 100-year floodplain, or to the outer edges of riparian vegetation, or to a distance equal to the height of two site-potential trees, or 300 feet slope distance (600 feet total, including both sides of the stream channel), whichever is greatest.
Permanently flowing nonfish-bearing streams	The stream and the area on each side of the stream extending from the edges of the active stream channel to the top of the inner gorge, or to the outer edges of the 100-year floodplain, or to the outer edges of riparian vegetation, or to a distance equal to the height of one site-potential tree, or 150 feet slope distance (300 feet total, including both sides of the stream channel), whichever is greatest.
Constructed ponds and reservoirs, and wetlands greater than 1 acre	The body of water or wetland and the area to the outer edges of the riparian vegetation, or to the extent of seasonally saturated soil, or the extent of unstable and potentially unstable areas, or to a distance equal to the height of one site-potential tree, or 150 feet slope distance from the edge of the wetland greater than 1 acre or the maximum pool elevation of constructed ponds and reservoirs, whichever is greatest.
Lakes and natural ponds (None present in the Project Area)	The body of water and: the area to the outer edges of the riparian vegetation, or to the extent of seasonally saturated soil, or to the extent of unstable and potentially unstable areas, or to a distance equal to the height of two site-potential trees, or 300 feet slope distance, whichever is greatest.
Seasonally flowing or intermittent streams (including ephemeral), wetlands less than 1 acre, and unstable and potentially unstable areas	At a minimum, the riparian reserves must include. the extent of unstable and potentially unstable areas (including earthflows): the stream channel and the area extending to the top of the inner gorge; the stream channel or wetland and the area from the edges of the stream channel or wetland to the outer edges of the riparian vegetation; and extension from the edges of the stream channel to a distance equal to the height of one site-potential tree, or 100 feet slope distance, whichever is greatest.

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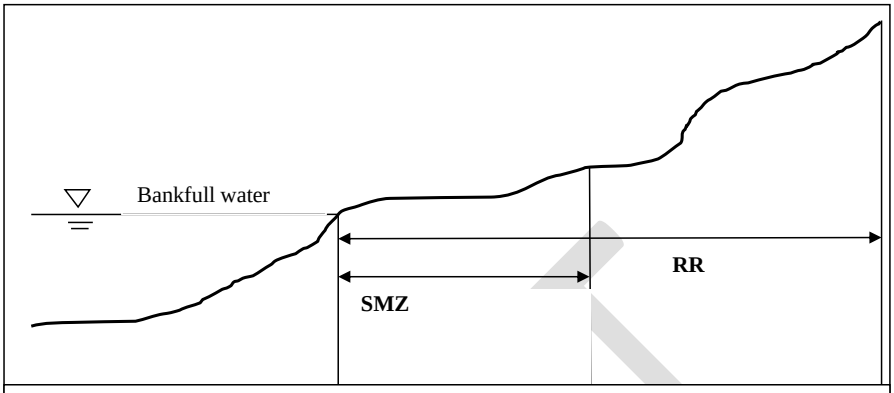

RR and SMZ width for each streamclass:		
Streamclass	Riparian Reserve Buffer	Streamside Management Zone Buffer
Perennial	300’	The greater of 100’ slope distance or to the slope break
Intermittent	150’	The greater of 50’ slope distance or to the slope break
Ephemeral	100’	20’ (non-anadromous)
		50’ (anadromous)

Figure 2. Definition sketch for Riparian Reserves (RRs) and Streamside Management Zones (SMZs)

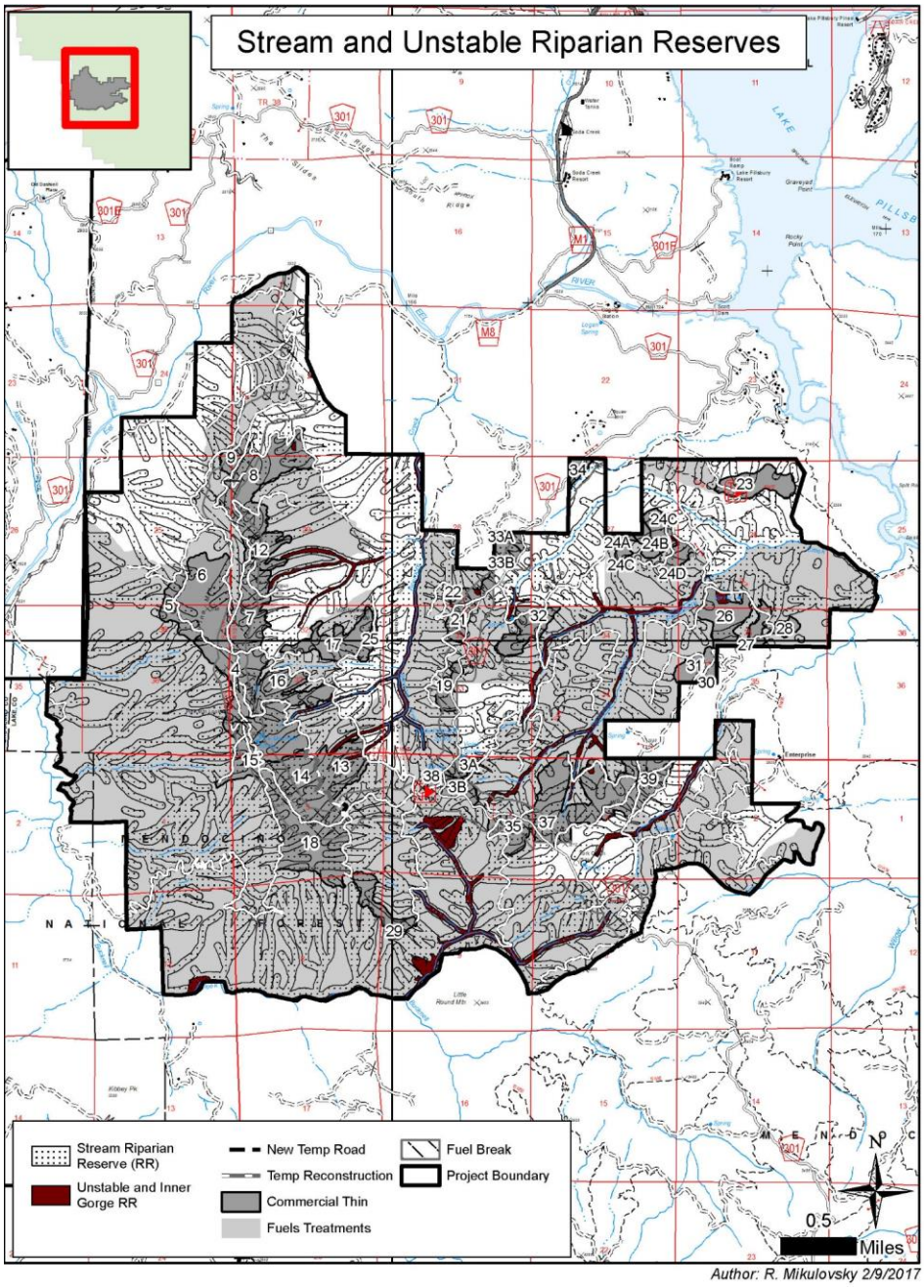

Figure 3. Riparian Reserves in the Project Area

Existing Conditions

The majority of streams within the project area are low-order (1-3) intermittent and ephemeral streams with gradients of 10% or higher and side slopes greater than 45%. These streams are typically step-pool systems with bedrock and bolder stream beds. They are vertically stable and are not very sensitive to changes in land use. However, the rapid uplift of the area and the highly fractured bedrock of the Franciscan Complex make for very steep and unstable side slopes. Slumps, slides, and other mass movements along these incised streams are a natural and common occurrence. These lower order streams support little to no phreatophytic vegetation. True riparian vegetation, where it exists, is limited to about five to ten feet from the channel.

Portions of Benmore and Packsaddle Creeks, as well as an unnamed tributary to Packsaddle creek, are perennial within the project boundary. These streams tend to have over-steepened and unstable side slopes with high sediment loads in the upstream portions. Packsaddle and its tributary flow into Lake Pillsbury, while Benmore flows directly into the Eel River. Although Benmore Creek has elevated sediment levels due to natural instabilities, it supports Steelhead for approximately its lower 2 miles (USDA, 2011a).

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Surveys

1) Channel Stability Evaluations (Pfankuch Surveys)

Stream channel stability evaluations (Pfankuch, 1975) have been evaluated in the project area dating back to 1976. These surveys evaluate the resistive capacity of mountain stream channels to the detachment of bed and bank materials, and to provide information about the capacity of streams to adjust and recover from potential changes in flow and/or increase in sediment production. There are a total of 15 items in the evaluation that are broken up into 3 major physical attributes (Table 4); Upper Banks, Lower Banks and Bottom.

Table 4. Pfankuch variables.

Upper Banks (above active channel)	Landform Slope
	Mass Wasting Potential
	Debris Jam Potential
	Vegetative Bank Protection
Lower Banks (summer low flow to annual flow)	Channel Capacity
	Bank Rock Content
	Obstructions to Flow
	Cutting
	Deposition
Bottom (submerged portion of the channel)	Rock Angularity
	Brightness
	Consolidation of Particles
	Bottom Size Distribution
	Scouring and Deposition

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	Aquatic Vegetation

Evaluations for Packsaddle Creek show the channel to be in fair condition (overall evaluation results unchanged from 1976 to 2014). Past and present surveys note steep slopes and a large potential for mass wasting within the upper banks.

Evaluations for Benmore Creek show the channel to be in good condition (overall evaluation results unchanged from 1978 to 2014). The most recent survey shows a lack of vegetative bank cover in the upper banks.

2) Stream Condition Inventory (SCI)

Stream Condition Inventory (SCI) plots monitor stream features, or attributes, that are useful in classifying channels, evaluating the condition of stream morphology and aquatic habitat, and making inferences about water quality (Frazier et al., 2005). In-channel monitoring at Benmore Creek and Packsaddle Creek was completed in early 2014. Attributes collected include: cross sections, particle counts, longitudinal profile, streambank stability, bank angles, shading, macroinvertebrates, basic water chemistry and large woody debris counts.

Both creeks are classified as Rosgen B4 channels (Packsaddle is B4a for steeper slope). These channels are dominate in gravel material and are characterized as a series of rapids with irregular pools (Rosgen, 1996). These types of streams are considered relatively stable and are not a high sediment supply stream channel. They are also moderate in their sensitivity to disturbance and have excellent recovery potential (Rosgen, 2006). Survey details can be found in Appendix D of the Hydrology Report.

Macroinvertebrate sampling from both streams contain aquatic insects that are intolerant to water pollution. Some of these include: mayflies, stoneflies, caddisflies, salmonflies, riffle beetles, penny beetles, and dobsonflies. Aquatic insects tolerant to water pollution include craneflies, midges, dragonflies, snails and damselflies. Table 5 show a sample of what was collected in Benmore Creek and Packsaddle Creek.

Table 5. Macroinvertebrate samples from SCI surveys

Packsaddle Creek	Benmore Creek
Stonefly	Stonefly
Riffle Beetle	Cranefly
Water Penny	Caddisfly
Cranefly	Salmonfly
Caddisfly	Midges
Mayfly	

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The presence of aquatic insects intolerant to water pollution infers that water quality in these two creeks are fairly good.

Basic water chemistry taken at SCI survey locations:

Table 6. Basic Water Chemistry

	Benmore 2/4/2014	Packsaddle 3/10/2014	Packsaddle 6/30/2014
Temperature (ºC)	1.9	9.6	15.6
pH	8.55	7.95	7.96
Conductivity (µs)	178	-	134
Salinity (ppm)	87	33.6	70
Total Dissolved Solids (ppm)	127	46.8	95.7

Other Considerations

3) Water Quality and Water Quality Control Board

Water quality within the project area is managed under the North Coast Regional Water Quality Control Board Basin Plan (NCWQCB, 2011). All of the project area drains to the Upper Main Eel and is therefore subject to the requirements of the Upper Main Eel TMDL. The Basin Plan designates the beneficial uses and water quality objectives (Table 7).

Table 7. Designated beneficial uses for the Lake Pillsbury Hydrologic Sub-area.

Beneficial Use	Established	Potential
Municipal or domestic supply	X	
Agricultural supply	X	
Industrial service supply	X	
Industrial process supply		X
Groundwater recharge	X	
Freshwater replenishment	X	
Navigation	X	
Hydropower generation	X	
Water contact recreation	X	
Non-contact water recreation	X	
Commercial and sport fishing	X	
Warm freshwater habitat	X	
Cold freshwater habitat	X	
Wildlife habitat	X	
Rare, threatened or endangered species	X	
Migration of aquatic organisms	X	

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Table 7. Designated beneficial uses for the Lake Pillsbury Hydrologic Sub-area.

Beneficial Use	Established	Potential
Spawning, reproduction, and/or early development	X	
Aquaculture	X	
Subsistence Fishing	X	

Hydropower generation occurs downstream through the Potter Valley Project which diverts water from the Eel to the Russian River through a PG&E power plant in Potter Valley. Water recreation (both contact and non-contact) occurs downstream along the Eel River and in Lake Pillsbury.

Water quality objectives listed in the Basin Plan are mostly narrative but some have numeric limits designed to protect beneficial uses of water. The Basin Plan prohibits turbidity increases of more than 20% above background levels and temperature increases of 5 degrees for any water body that is listed as providing cold freshwater habitat. For sediment, the Basin Plan requires that "amounts shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses." More specific requirements are included in the Upper Main Eel River Total Maximum Daily Load (TMDL) for both natural and management related sediment (EPA, 2004). The TMDL divides sediment sources into large and small features (<3,000 yd^3). Small features are further divided into sources from roads, timber harvest, and agriculture/grazing. The TMDL also provides shade requirements designed to meet the intent of the Basin Plan and protect cold water habitat (Table 8).

Table 8. Applicable TMDL allocations and historic loads for sediment and temperature (EPA 2004)

Pollutant		Allocation	Historic loads 1940-2004
Natural Sources of Sediment (tons/mi^2/yr)		310	310
Land Management related sources of Sediment (tons/mi^2/yr)	Large features (>3,000 yds^3)	36	71
	Road related	14	28
	Timber harvest	20	38
	Agriculture/Grazing	8	16
Total		**388**	**463**
Water Temperature	Shade	49-50%	N/A
	Heat (langleys/day)	289	N/A

The Upper Main Eel is within the EPA's 303(d) list of impaired water bodies for sediment and temperature. Lake Pillsbury is 303(d) listed for Mercury, but TMDLs have not been established.

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A Memorandum of Understanding (MOU) between the State Water Quality Control Board and the Forest Service designated the Forest Service as the Water Quality Management Agency on National Forest System Lands. This MOU establishes a system for implementing Best Management Practices (BMPs) as the mechanism for meeting water quality requirements. The North Coast Regional Water Quality Control Board, in Resolution R1-2004-0015, established rules for issuing Waivers of Waste Discharges Related to Timber Harvest Activities on Federal Lands. However, this resolution was superseded by Resolution R1-2010-0029 in June 10, 2010, which this project will operate under.

4) Sediment

Sediment is the primary threat to water quality and aquatic habitat on the Mendocino National Forest. The Eel River TMDL reports historic basin-wide sediment loading of 463 tons/mi^2/yr between 1940 and 2004. Approximately 67% was attributed to natural sources and 33% to land management activities (includes private and public). On public lands these percentages are 78% of the natural sources and 22% land management activities.

Sedimentation in the Rice Fork arm of Lake Pillsbury averaged 576 tons/mi^2/yr from 1960 to 1984, and 256 tons/mi^2/yr from 1984-1988 (DWR 1991). Although not directly comparable due to different time periods, short-term changes in climate, land-use changes, and different methods of estimation, these numbers do provide a representation of the variability inherent in sediment loading. For this reason, the Environmental Protection Agency (EPA) specifically states that they do not expect each square mile within a particular source category to necessarily meet the allocation; rather, EPA expects the average for the entire source category to meet the allocation across the basin for that category (EPA, 2004).

Commented [KH-2]: Need to find this reference....Frank??

4a) Roads

Roads can be a significant source of non-point pollution to watersheds. Forest Service roads were originally designed for hauling timber off National Forest lands. These roads were routinely maintained with profits through timber sales. With the decline of the timber industry and reduced federally appropriated dollars, road maintenance activities have been less frequent, resulting in poor drainage, culvert failures, and increased sediment load to aquatic systems. Unmaintained or improperly designed roads can contribute a significant amount of sediment into streams through erosion of the road bed, fill slope, or inside ditch, as well as washouts caused by culvert failure (Best et al., 1995; Roni et al., 2008; Switalkski et al., 2004).

4b) Road surveys

Surveys for road Hydrologic Connectivity were performed within boundaries of the Project Area in 2015; most road segments were surveyed (Table 9). The purpose of this analysis is to determine what percent of the road network is directly connected to the stream system and delivering sediment without the filtering effect of a buffer strip. A reduction in percent hydrologic connectivity represents decreased sediment contribution from the roads and a return to more “natural” drainage system. Road segments that are disconnected from the stream system return surface flow to subsurface flow by dispersing it onto a buffer strip where it can percolate back into the ground.

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Table 9. Road connectivity within Project Area

Road	Total Length (ft)	Connection (ft)	% Connected
17N23	13592.78	2704	20
17N23A	2989.9	568	19
17N35	11499.9	6064	53
17N40	6264.3	5120	82
17N45	5252.7	787	15
18N05	34029.6	14248	42
18N05E	1050	0	0
18N05J	2175	207	10
18N05M	2150	312	15
18N05N	660	0	0
18N05P	2159	713	33
18N29	20701	2046	10
18N37	4468.8	845	19
18N69	10908.7	0	0
18N69A	1132.3	0	0
18N69B	4439	413	9
18N69C	1254.7	100	8
18N70	8421.2	2231	26
18N77B	1987.3	1589	80
17N72A	476	286	60
17N72	6891.9	2527	37
17N72B	1429	554	39
17N73	14779.1	5469	37
Total	**158,712.18**	**46,783**	**29.48 (avg)**

Several roads within the project area have been "storm-proofed", in other words: bladed, outsloped where possible, and had drainage structures cleaned out. These activities have reduced the amount of sediment entering project area streams and have restored hillslope drainage to a more natural state. Overall road connectivity within the Project Area is about 29%.

5) Temperature

The temperature loading allocation for the Upper Main Eel and its tributaries is set by the TMDL at 289 langleys per day (EPA, 2004). Although it is possible to measure langleys, the heat component in the streams includes solar radiation and point sources. Since there are no point sources, heat is mainly derived from solar radiation. Stream shading of at least 50% was determined to be adequate for attaining the temperature allocation.

Measurements with a Solar Pathfinder were taken along the length of Benmore Creek and Packsaddle Creek SCI reaches. Shade varied from 63% to 96% and averaged 85% in Benmore

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Creek. Shade varied from 30% to 71% and averaged 58% in Packsaddle Creek. Data loggers were also deployed at the surveyed locations in early 2014 to monitor for temperature.

Environmental Consequences

Alternative 1 – No Action

Direct Effects and Indirect Effects

Direct and indirect effects associated with not treating the units and roads in the project would result in continued sedimentation from roads and further accumulation of forest material; increasing the potential for catastrophic fire. The lost opportunity to reduce fuel loading on the ground has the potential to affect riparian habitat and water quality. It has been documented that wildfires can produce accelerated erosion to the watershed (Shakesby et. Al., 1993; Benvaides-Solorio and MacDonalds, 2001). Additionally, suppression activities related to fighting fire also can have a wide effect on watersheds (Backer et al. 2004). The most commonly documented effect is soil disturbance through creation of fire lines, temporary roads, fire camps, and helibases. Fuel spillage and application of fire retardant could also cause soil contamination and alter water chemistry.

Cumulative Effects

A description of the Cumulative Watershed Effect analysis can be found in the Methodology Section of the Hydrology Report.

The analysis of No Action Alternative is the same as the existing condition. Analysis of the No Action Alternative indicates that potential for cumulative effects is minimal to moderate. Watersheds in the project area currently all less than 7 percent TOC used (Table 10 and 11).

Table 10. 7th field Watershed CWE

HUC 7 Code	HUC 7 Name	Watershed Acres	ERA's Available	ERA's used	% ERA Used
18010103010302	**Willow**	**4059**	487.08	**63.3204**	**1.56**
18010103010303	Packsaddle	5676	681.12	**131.1156**	2.31
18010103050101	Upper Bucknell	5358	642.96	**79.2984**	1.48
18010103050102	Lower Bucknell	6289	754.68	**77.3547**	1.23
18010103050201	Benmore	3414	409.68	**141.3396**	4.14
18010103050202	Dashiell	8270	992.4	**148.86**	1.80
Threshold of Concern is ≥12% ERA, compared with "% ERA Used" column					

Table 11. 8th Field Watershed CWE

Watershed	Watershed Acres	ERAs Available	ERAs Used	% ERAs Used
1801010301030201	2032	243.84	53.6448	2.64
1801010301030202	2027	243.24	16.216	0.8
1801010301030301	1550	186	45.105	2.91
1801010301030302	2328	279.36	79.3848	3.41
1801010301030303	1799	215.88	31.4825	1.75
1801010305010101	2426	291.12	34.9344	1.44
1801010305010102	1475	177	11.21	0.76
1801010305010103	1457	174.84	49.538	3.40
1801010305010201	2025	243	24.5025	1.21
1801010305010202	2105	252.6	39.574	1.88
1801010305010203	2159	259.08	31.5214	1.46
1801010305020101	1780	213.6	118.726	6.67
1801010305020102	1634	196.08	43.301	2.65
1801010305020201	1966	235.92	60.7494	3.09
1801010305020202	1808	216.96	22.0576	1.22
1801010305020203	2235	268.2	57.4395	2.57
1801010305020204	2262	271.44	58.1334	2.57
Threshold of Concern is ≥12% ERA, compared with "% ERA Used" column				

Alternative 2 – Proposed Action

The proposed action includes a series of mechanical harvest, fuels reduction through hand thinning or mastication, and prescribed burning. Burning within units will be achieved through low-intensity piling and burning, under-burning or jackpot burning. See section ___ of the EIS for detailed prescriptions of this Alternative.

Direct and Indirect Effects

Sediment - The proposed action has the potential to temporarily affect aquatic resources through removal of vegetation, slash piling, creation of temporary roads, and burning following treatment. Each activity has the potential to disturb soil. Soil displacement, compaction, or change in ground cover could cause an effect on watershed condition and aquatic habitat. Conservation measures incorporated into the project would be implemented to control erosion and sedimentation. The implementation of BMP's would avoid or minimize potential increases in sediment loads to streams during project implementation. Long term effects on hydrologic resources are expected to be minor and substantially less than the effects of an uncontrollable wildfire.

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The largest potential for sediment increase into streams comes from initiating mass movements on unstable ground. These areas could be mobilized by either direct impact from heavy equipment, increasing pore-water pressure, reducing sheer strength provided by root systems, or removing all or part of the toe. Pore-water pressure can be increased by draining roads and trails onto an unstable area or by removing too much vegetation. This acts to transpire water out of the subsurface. While every unit in the project has been visited by an earth scientist, the corporate GIS database and aerial photos were also used for further interpretation. No large active deep slides were identified in the project area; unstable areas found were mostly small slumps or ground exhibiting signs of creep. These areas were mapped and will be flagged for avoidance. Additional precautions include a 50 foot setback (buffer) from the top of an unstable area where no trees > 4 inches DBH will be removed and no mechanized equipment allowed. Skid trails and temporary roads will not be located on or within 50 feet from these areas, nor will cross drains drain onto them.

Steep road cuts in this area also have the potential to fail when trees at the top are cut or die and the root system decays. These failures can contribute sediment to an inside ditch (if present) and onto the road surface, which can then be transported to a nearby stream. For this reason, a design feature has been incorporated into the proposed action that limits the removal of trees within 50 feet of the top of steep road cuts. Steep road cuts are defined as being a minimum of 10 feet high with 65% and greater slopes.

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Commented [MRP-4R3]: 50 feet is reasonable. Conifer roots (especially P-Pine) can extend significant distances downslope, conferring stability to roadcuts.

The second largest potential for increased sediment comes from roads and skid trails. Complete ground cover removal and compaction of the soil along roads and skid trails increases the potential for erosion much more than the removal of vegetation and reduction in canopy cover.

Whenever a road crossing is removed or installed, the potential for destabilizing the stream banks exists. Design features and BMPs have been built into the proposed action to minimize the potential for increased sediment. Temporary road crossings will be kept to the minimum needed to reduce adverse skidding, and all crossings of intermittent and ephemeral streams will be reviewed by a hydrologist. All skid trails and temporary roads will be hydrologically stabilized and erosion control put in place as the unit is finished, or on a weekly basis outside the normal operating period, or prior to anticipated storms.

Maintaining a ground cover of at least 50% evenly distributed across the units, with additional ground cover on steep slopes (> 50%) in RRs will provide sufficient ground cover to minimize erosion and potential sediment delivery from burning or vegetation removal activities (see soils section below). In addition, future litter cast will provide increased ground cover in as little as one year.

An indirect effect of these proposed actions resulting in increased sediment is the temporary increase of turbidity. It is expected that any direct increase in sediment will be short-term (1-2 years) and within the natural variability of the system.

A wide range of activity-specific BMP's are designed to minimize detrimental soil disturbance, protect water quality, and maintain physical stability and hydrologic connectivity or riparian and aquatic habitats (see appendix 1 for a list of applicable BMP's). There is little potential for the proposed action to adversely affect the geomorphic, hydrologic, or riparian characteristics and

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aquatic habitats in the watersheds. This is due to the low-impact characteristics of the proposed stand treatments, limitations imposed on operations within SMZ's and RR's, and use of activity-specific BMP's.

Temperature – There are no anticipated direct or indirect effects to water temperature. Canopy cover will not be reduced below 70% within the SMZs of perennial streams, or 50% along intermittent and ephemeral SMZs. Within the RRs and the treatment units, canopy cover will not be reduced below 40% within foraging/dispersal units or 60% in nesting/roosting units. The prescriptions also provide for retaining vertical and horizontal heterogeneity in the adjacent forested stands, therefore no noticeable increase in direct or angular solar radiation is expected.

Riparian Reserves - Treatment prescriptions within the RRs is the same as that of the unit within which the RR is located, except for the specific design features and BMPs applicable to RRs. All riparian vegetation will remain and effective ground cover will be retained. The proposed treatments will leave snags in sufficient levels for Large Woody Debris recruitment. The prescription also calls for favoring retaining all large trees as well as co-dominate trees and trees with defects; thereby ensuring continued availability for LWD recruitment in the future. Prescribed burning will be done in such a manner as to leave currently down large wood in the RRs and SMZs.

Cumulative Effects

Cumulative effects of past and proposed management activities were calculated using the ERA method described above (Tables 8 and 9). None of the project HUC 7 or HUC 8 watersheds exceed the TOC. The highest %TOC occurs in the Benmore watersheds due the majority of the treatment acres being within these watersheds. The ERAs in Tables 8 and 9 are considered to be conservative as it is assumed in the ERA calculation that all treatments are done in 2018 and 2019. More likely, the thinning over 10" DBH (commercial thinning) will happen over two years while thinning under 10" DBH, fuels thinning, fuel break, and prescribed burning will happen implemented over several years. This will result in lower %ERAs and %TOC since the watersheds will have recovery time. The CWE analysis also incorporates all potential landings and skid routes. Comparison of ERA scores can be seen in Table 12 and 13 of the Summary of Effects section.

Alternative 3 – No New Temporary Roads

Direct Effects and Indirect Effects

The direct and indirect effects would essentially be the same as alternative 2. However, without the addition of 0.25 mile of new temporary road, there would be less soil disturbance and potential negative effects to water quality. An indirect effect may be the need to use more of the identified skid trails to haul out timber.

Cumulative Effects

Cumulative effects for this alternative are the same for all watersheds in alternative 2 with the exception of 1801010305020101 (8th Field, Benmore 7th Field). Without the creation of new

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temporary roads, there are less ERA's used (a decrease from 11.53 to 11.51). All watersheds remain below Threshold of Concern. See Summary of Effects for a comparison of Alternative 2 and Alternative 3. Comparison of ERA scores can be seen in Table 12 and 13 of the Summary of Effects section.

Alternative 4- No commercial thinning in RRs

This alternative would eliminate approximately 700 acres of commercial thinning within riparian reserves.

Direct Effects and Indirect Effects

Since logging equipment would not be needed in Riparian Reserves under this alternative, there would be less anticipated ground disturbance as a direct result. This also decreases soil disturbance and negative effects to water quality within Riparian Reserves. However, the indirect effect of this treatment would leave heavy fuels, which can lead to a host of negative soil and watershed effects in an event of a large wildfire (see indirect effects of Alternative 1).

Cumulative Effects

With the reduction commercial thinning acres for this alternative, cumulative effects also decrease. See comparison to alternative 2 and 3 in Summary of Effects. All watersheds remain under TOC for this alternative. Comparison of ERA scores can be seen in Table 12 and 13 of the Summary of Effects section.

Alternative 5- No commercial thinning in NSO nesting areas

This alternative would eliminate approximately 60 acres of commercial thinning.

Direct Effects and Indirect Effects

Since logging equipment would not be needed in these NSO nesting sites under this alternative, there would be less anticipated ground disturbance as a direct result. This also decreases soil disturbance and negative effects to water quality within these areas. However, the indirect effect of this treatment would leave heavy fuels, which can lead to a host of negative soil and watershed effects in an event of a large wildfire (see indirect effects of Alternative 1).

Cumulative Effects

Cumulative effects for this alternative are the same for all watersheds in alternative 2 with the exception of 1801010305020101 and 1801010301030302 (Benmore and Packsaddle 7th field). All watersheds remain below Threshold of Concern. See Summary of Effects a comparison of Alternative 2 and Alternative 5. Comparison of ERA scores can be seen in Table 12 and 13 of the Summary of Effects section.

Summary of Effects

Alternative 1 (no action) would have the least direct and cumulative effect. However, this alternative has the most potential for indirect effect is an uncontrolled wildfire were to happen.

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Direct and Indirect effects for alternatives 2 through 5 are expected to be minor and substantially less than the effects of an uncontrolled wildfire.

All alternatives proposed as part of this project do not exceed the Threshold of Concern. While some alternatives may have less of a cumulative effect, there may be negative indirect effects as a result. Alternative 1 has the least cumulative effects, but is the most susceptible to catastrophic wildfires. Similarly, Alternatives 4 and 5 will have less of a cumulative impact compared to Alternative 2, but do not address the heavy fuels problem in the excluded treatment areas. Alternative 2 would have the most cumulative effects (though not above threshold), but will have the most impact in reduction of fuels; thus reducing the possibility of catastrophic wildfires.

Table 12. 7th Field Watershed CWE analysis

Watershed	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**
Willow	1.56	1.66	-	-	-
Packsaddle	2.31	4.11	-	3.66	4.09
Upper Bucknell	1.48	2.32	-	2.13	-
Lower Bucknell	1.23	2.28	-	2.15	-
Benmore	4.14	7.75	7.74	5.99	7.56
Dashiell	1.8	2.2	-	2.14	-
"-" denotes same value as Alternative 2 All analysis results remain below Threshold of Concern of 12%					

Table 13. 8th Field Watershed CWE analysis

8th Field Watershed	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**
1801010301030201	2.64	2.72	-	-	-
1801010301030202	0.8	0.89	-	-	-
1801010301030301	2.91	4.34	-	4.14	-
1801010301030302	3.41	6.15	-	5.44	6.11
1801010301030303	1.75	2.15	-	2.08	-
1801010305010103	3.4	6.38	-	5.71	-
1801010305010201	1.21	1.93	-	1.88	-
1801010305010202	1.88	3.03	-	2.81	-
1801010305010203	1.46	2.71	-	2.58	-
1801010305020101	6.67	11.53	11.51	9.07	11.2
1801010305020102	2.65	4.07	-	3.42	-
1801010305020201	3.09	3.09	-	-	-
1801010305020203	2.57	3.19	-	3.18	-
1801010305020204	2.57	3.65	-	3.46	-
"-" denotes same value as Alternative 2					

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All analysis results remain below Threshold of Concern of 12%

Compliance with law, regulation, policy, and the Forest Plan

Clean Water Act, 1977, was created to restore and maintain the chemical, physical and biological integrity of the Nation's waters (Section 101 (a)). It also regulates discharge of dredged or fill material into navigable waters (waters of the U.S.) (Section 404).

Executive Order 11988 (Floodplain Management), 1977, requires all federal agencies to take actions to reduce the risk of flood loss, restore and preserve the natural and beneficial values in floodplains, and minimize the impacts of floods on human safety, health, and welfare. Executive Order 11990 (Wetlands Management), 1977, requires each federal agency to provide leadership and to take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for acquiring, managing, and disposing of federal lands and facilities.

Forest Service Manual. Title 2500 provides directives for the planning and protection of soil, water, and air resources on National Forest lands.

National Forest Management Act 1976, which ensures that forest planning and management activities provide for the conservation and sustained yield of soil and water resources. It facilitates the development of sound vegetation manipulation practices based on watershed conditions and land capability rather than decisions based solely on silvicultural characteristics and the public demand for goods.

The Mendocino National Forest Land and Resource Management Plan (LRMP). The LRMP provides objectives, standards and guidelines for implementing the NFMA on the Mendocino National Forest. These standards and guidelines have been incorporated into the Proposed Action as design features and/or BMPs (Appendix B & C). Land Resource Management Plan (LRMP) compliance is detailed in Appendix A.

The Porter-Cologne Water Quality Control Act The California State Water Resources Control Board (SWRCB or "State Board") and the nine Regional Water Quality Control Boards (RWQCBs or "Regional Boards") have the authority in California to protect and enhance water quality. This authority is derived through the state's primary water-pollution control legislation, the Porter-Cologne Act, as well as through the designation of the Boards as the lead agencies in implementing the Section 319 non-point source program of the federal Clean Water Act. The North Coast Regional Water Quality Control Board (NCRWQCB) has developed the Water Quality Control Plan for the North Coast (Basin Plan ((NCRWQCB, 2011)), which designates beneficial uses to be protected, water quality objectives, and an implementation program for achieving objectives.

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Appendix A- Compliance Check with LRMP

Standards and Guides

The following checklist covers the LRMP Standards and Guides with which projects and activities must comply regarding the resources normally evaluated by the hydrologist~~ and soil scientist~~. Information is provided regarding project design elements and resource conditions which affect the project's or activity's compliance with the Standards and Guides.

Watershed & Water Quality (Pages IV - 40, 41)		
S&G #	**Requirement**	**Project Compliance**
~~**Soils and Geology (Page IV—33)**~~		
~~**S&G**~~	~~**Requirement**~~	~~**Project Compliance**~~
~~1~~	~~Develop specific soil evaluation and mitigation measures for each project that has the potential to impact soil resources.~~	~~Design features for the protection of soil resources have been included in the proposed action.~~

Watershed & Water Quality (Pages IV - 40, 41)		
S&G #	**Requirement**	**Project Compliance**
1a.	Within all watersheds, identify depleted watershed areas during the project environmental assessment process. Incorporate improvement activities as a part of the project.	During the development of this project, a separate NEPA project was completed to storm proof roads within the Pine Mountain project area, including the reroute of 18N69 away from an intermittent creek. Several sections of roads within the project have also been identified for decommissioning for watershed improvement as a part of the project.
1c.	Within all watersheds, analyze projects that propose land disturbing activities for their effects on the appropriate level of watershed (normally second to fourth order watersheds) in order to prevent excessive cumulative watershed effects on stream channel condition and water quality. Cumulative watershed effects (CWE) analysis will be used to gauge impacts of past, present, and proposed management activities on a watershed.	CWE's were analyzed according to the ERA methodology (which includes past, present, and proposed activities). Cumulative activities within 7th field and 8th field watersheds remain below Threshold of Concern.
1d.	Within all watersheds, implement Best Management Practices (BMP) to meet water quality objectives and maintain and improve the quality of surface water on the Forest. Identify methods and techniques for applying the BMPs during project level environmental analysis and incorporate them into the associated project plan and implementation documents.	BMPs prescribed in Appendix B of the Hydrology report are based on field review of the units. These are also explained in the Erosion Control Plan, Appendix C of the Hydrology Report.

Riparian and Aquatic Ecosystems Pages (IV 30-33)		
	Requirement	**Project Compliance**
1a.	Maintain and restore the distribution, diversity and complexity of watershed and landscape-scale features to ensure protection of the aquatic systems to which species, populations and communities are uniquely adapted.	Alternatives 2 through 5 will help achieve these values and objectives by reducing fuels and

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Watershed & Water Quality (Pages IV - 40, 41)		
S&G #	**Requirement**	**Project Compliance**
		returning fire to areas where fire has been suppressed.
1b.	Maintain and restore spatial and temporal connectivity within and between watersheds. Lateral, longitudinal, and drainage network connections include floodplains, wetlands, upslope areas, headwater tributaries, and intact refugia. These network connections must provide chemically and physically unobstructed routes to areas critical for fulfilling life history requirements of aquatic and riparian-dependent species.	This project is not anticipated to have a negative effect on spatial or temporal connectivity between watersheds. Alternatives 2 through 5 will have limited activities within Riparian Reserves while no mechanized equipment would be allowed within Streamside Management Zones.
1c.	Maintain and restore the physical integrity of the aquatic system, including shorelines, banks, and bottom configurations.	There are no anticipated negative effects to these values by alternatives 2 through 5. Heavy equipment would be buffered from streams during thinning, while prescribed burning effects are anticipated to be much less than what would occur during a summer wildfire.
1d.	Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality must remain within the range that maintains the biological, physical, and chemical integrity of the system and benefits survival, growth, reproduction, and migration of individuals composing aquatic and riparian communities.	Decommissioning of 1.14 road miles within the project area would help restore water quality in several small streams (Alternatives 2 through 5). Other activities from these alternatives will not have a negative effect on water quality. Heavy equipment would be buffered from streams, while prescribed burning effects are anticipated to be much less than what would occur during a summer wildfire.
1e.	Maintain and restore the sediment regime under which aquatic ecosystems evolved. Elements of the sediment regime include the timing, volume, rate, and character of sediment input, storage, and transport.	Decommissioning of 1.14 road miles within the project area would help restore the natural sediment regime in several small streams (Alternatives 2 through 5). There are no activities that are anticipated to negatively affect the sediment regime. Heavy equipment would be buffered from streams, while prescribed burning effects are anticipated to be much less than

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Watershed & Water Quality (Pages IV - 40, 41)		
S&G #	**Requirement**	**Project Compliance**
		what would occur during a summer wildfire.
1h.	Maintain and restore the species composition and structural diversity of plant communities in riparian areas and wetlands to provide adequate summer and winter thermal regulation, nutrient filtering, appropriate rates of surface erosion, bank erosion, and channel migration and to supply amounts and distributions of coarse woody debris sufficient to sustain physical complexity and stability.	These values would be maintained and/or restored. The work would not take the RR vegetation outside the natural range, but rather help reduce (and prevent) future wildfire effects. Alternatives 2 through 5 will help achieve these values and objectives by reducing fuels and returning fire to areas where fire has been suppressed through several fire return intervals. Alternative 1 "No Action" would fail to yield these benefits.
1i.	Maintain and restore habitat to support well-distributed populations of native plant, invertebrate and vertebrate riparian-dependent species.	The purpose of this project will maintain the limited true riparian habitat within the project boundaries and help protect it from future wildfire. Project activities (Alternatives 2 through 5) along streams and around springs are expected to result in improved riparian habitat.
3b.(2)	In Riparian Reserves, do not use mitigation or planned restoration as a substitute for preventing habitat degradation.	Mitigation is not being substituted for prevention of habitat degradation; there are no proposed actions to degrade habitat in Riparian Reserves.

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Appendix B- Best Management Practices (BMPs)

Forest management and associated road building in the steep rugged terrain of forested mountains has long been recognized as sources of non-point water quality pollution. Non-point pollution is not, by definition, controllable through conventional treatment means. It is controlled by containing the pollutant at its source, thereby precluding delivery to surface water. Sections 208 and 319 of the Federal Clean Water Act, as amended, acknowledge land treatment measures as being an effective means of controlling non-point sources of water pollution and emphasize their development.

Working cooperatively with the California State Water Quality Control Board, the Forest Service developed and documented non-point pollution control measures applicable to National Forest System lands. These measures were termed "Best Management Practices" (BMPs). BMP control measures are designed to accommodate site specific conditions. They are tailor-made to account for the complexity and physical and biological variability of the natural environment. The implementation of BMP is the performance standard against which the success of the Forest Service's non-point pollution water quality management efforts is judged.
The Clean Water Act provided the initial test of effectiveness of the Forest Service non-point pollution control measures where it required the evaluation of the practices by the regulatory agencies (State Board and EPA) and the certification and approval of the practices as the "BEST" measures for control. Another test of BMP effectiveness is the capability to custom fit them to a site-specific condition where non-point pollution potential exists. The Forest Service BMPs are flexible in that they are tailor-made to account for diverse combinations of physical and biological environmental circumstances. A final test of the effectiveness of the Forest Service BMP is their demonstrated ability to protect the beneficial uses of the surface waters in the State. Best Management Practices, as described in this document have been effective in protecting beneficial uses within the affected watersheds. These practices have been applied in other projects within the Mendocino National Forest. Where proper implementation has occurred there have not been any substantive adverse impacts to cold water fisheries habitat conditions or primary contact recreation (etc.) use of the surface waters. The practices specified herein are expected to be equally effective in maintaining the identified beneficial uses. Stream condition inventory (SCI) plots have been established on Benmore Creek and Packsaddle Creek to monitor the effectiveness of the prescribed BMPs.

The following management requirements are designed to address the watershed management concerns. Most are BMPs from the Forest Service publication "Water Quality Management for National Forest System Lands in California" (USDA Forest Service, 2011). All applicable water quality BMPs shall be implemented. The implementation phase of the BMPs occur after a project is completed, but before the winter season. BMP monitoring of the project is done one year later after the project experiences one rainy season. A list of BMPs used within the Pine Mountain Project is as follows along with a brief summary of what each entails:

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Timber Management Best Management Practices

1.1 Timber Sale Planning Process The objective of this practice is to incorporate water quality and hydrologic consideration into the planning process.

Application: Design Features, Forest Plan Consistency report, specification of operational BMP's, interdisciplinary team discussions, and incorporation of water quality protection measures in the Timber Sale Contact constitutes the incorporation of water quality and hydrologic consideration into the Pine Mountain Project.

1.2 Timber Harvest Unit Design The objective of this practice is to ensure that unit design would secure favorable conditions of water quality and quantity while maintaining desirable stream channel characteristics and watershed conditions.

Application: The design of the units for the Pine Mountain Project were developed though interdisciplinary discussion in the field and office. The ID team was composed of specialists in the fields of Botany, Hydrology, Soils, Silviculture, Wildlife, Fisheries, Archaeology, and Biology.

1.3 Determination of Surface Erosion and Hazard for Timber Harvest Unit Design The objective of this BMP is to identify high erosion hazard areas in order to adjust treatment measures to prevent downstream water quality degradation.

Application: High and Very High erosion hazard areas have been identified and are mapped in Appendix B. Preliminary unit designs and locations were modified based on eroion hazards and have resulted in the current unit layout.

1.4 Use of Sale Area Maps (SAM) and/or Project Maps for Designating Water Quality Protection Needs. The objective of this practice is to ensure recognition and protection of areas related to water quality protection delineation on project maps

Application: The sale administrator and purchaser will review these areas on the ground prior to commencement of ground disturbing activities. Examples of water quality protection features that will be designated on the project map include:

1) Location of streamcourses and riparian reserves to be protected
2) Wetlands (meadows, lakes, springs, etc.) to be protected.
3) Unstable areas to be protected

1.5 Limiting the Operating Period of Timber Sale Activities: This practice is to ensure that the purchasers conduct their operations, including erosion control work, road maintenance, and so forth, in a timely manner, within the time frame specified in the Timber Sale Contract.

Application: The "Normal Operating Season" for planned harvest activities would be between April 15 and October 15. Operations may occur outside of this period if conducted in accordance with the Mendocino Wet Weather Operations Standards (WWOS). The Sale Administrator will close down operations due to rainy periods, high water, or other adverse operating conditions in order to protect resources.

1.6 Protection of Unstable Areas: This objective is to provide special treatment of unstable areas to avoid triggering mass slope failure with resultant erosion and sedimentation

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Application: Unstable areas have been field mapped and will be included in Sale Area Maps. Design features prevent the cutting of trees that are acting to stabilize these areas. All temorary roads have been field checked to ensure their use will not have the potential to trigger mass movements.

1.8, 1.19 Streamside Management Zone Designation & Streamcourse and Aquatic Protection

The objectives of these measures are to designate a zone along riparian areas, streams, and wetlands that would minimize potential for adverse effects from adjacent management activities. Management activities in these zones are designated to improve habitat for riparian dependent species. Additionally, objectives of SMZ's are to provide for unobstructed passage of stormflows, control sediment and other pollutants from entering streamcourses, and restore the natural course of any stream as soon as practicable, where diversion of the stream has resulted from management activities.

It is expected that development of Riparian Reserves (RRs) are included under these BMPs. RRs include aquatic and terrestrial ecosystems and lands adjacent to perennial, intermittent, and ephemeral streams, as well as around meadows. The purposes of RRs are to protect these areas as well as dependent natural resources during site-specific project planning and implementation. Forest Strategy also maintains or restores soil properties and productivity to ensure ecosystem health, soil hydrologic function and biological buffering capacity.

Application: Forest strategy provides direction to maintain or improve conditions for riparian dependent resources. Riparian dependent resources are those natural resources that owe their existence to the presence of surface or groundwater.

SMZ should not be considered replacement of RRs, but a nested zone contained in the RRs developed for the filtering capability of the streamside zone. All streamcourses would be protected and assigned SMZ's. The streamcourses mapped (Figure 3 in Hydrology Report) on the Project Area Map provides information for development of watercourse protection maps.

- Any material resulting from project activities causing obstruction of stormflows would be removed.
- All channels have designated SMZ's, which is to be treated as an equipment exclusion zones. Material may be removed from this zone however heavy equipment is excluded.
- Table 1 below provides a summary of SMZ by Stream Class.
- No Borax would be applied within RRs and SMZs.
- Within RRs, reduce as much as possible ground disturbing impacts (ie, soil compaction, vegetation disturbances, etc). See table 2 for classifications and extent.
- BMPEP form T01 would be utilized to evaluate implementation on those units with SMZ's and other aquatic protection.

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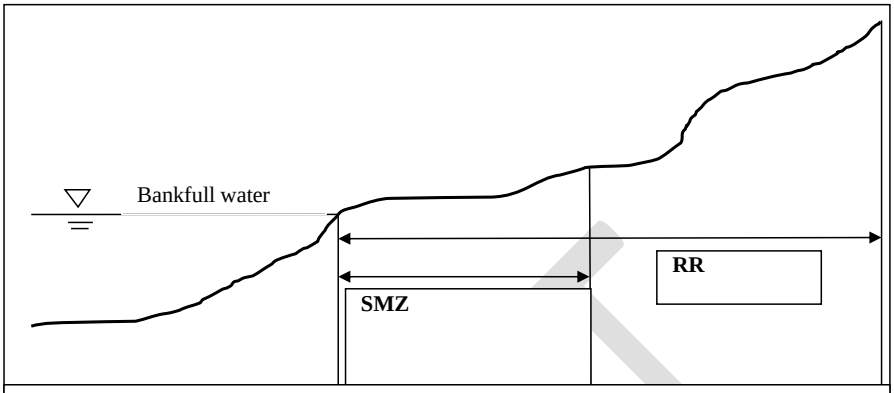

RR and SMZ width for each streamclass:		
Streamclass	Riparian Reserve Buffer	Streamside Management Zone Buffer
Perennial	300’	The greater of 100’ slope distance or to the slope break
Intermittent	150’	The greater of 50’ slope distance or to the slope break
Ephemeral	100’	20’ (non-anadromous)
		50’ (anadromous)

Figure 1. RR and SMZ buffers.

1.9 Determining Tractor Loggable Ground

The objective of this practice is to minimize erosion and sedimentation resulting from ground disturbance of tractor logging systems. Determination of tractor loggable ground considers the physical site such as steepness of slopes and soil properties.

Application: Ground skidding, mechanical piling, and masticating is limited to slopes less than 35%, with occasional operations on ground up to 40% slope for a maximum distance of 100 feet allowed.

1.10 Tractor Skidding Design

The objective of this practice is to design skidding patterns to best fit the terrain, the volume, velocity, concentration and direction of runoff water can be controlled in a manner that will minimize erosion and sedimentation.

Application: The sale administrator and purchaser will designate all skid trails prior to ground disturbing activities. Skidding would not occur in SMZ’s. Skidding would occur on

stable slopes not greater than 35%. Skidding would not occur down draws. Evidence of ruts associated or resulting from skidding pattern/path caused by the dragging of logs (or otherwise) would be water-bared. Additionally, if ground cover disturbance is reduced to amounts less than preexisting levels, these areas would be slashed through lop and scatter to 18 inches. Rutting is characterized by the sunken tracks or grooves usually made when the ground is wet or soft. Ruts for the purposes of this analysis, are at least 2 inches in depth.

- BMPEP form T02 would be utilized to evaluate implementation on those units where skidding would occur.

If uncertainty arises regarding potential resource impacts of skid trail location, consultation with an earth scientist (ie, hydrologist, geologist, or soil scientist) will be done. Existing skid trails will be used unless they are poorly located or designed.

1.11 Suspended Log Yarding in Timber Harvesting

The objective of this practice is to protect the soil mantle from excessive disturbance, maintain the integrity of the SMZ or other sensitive watershed area and to control erosion on cable corridors.

Application: Cable logging is not expected to be used in the Pine Mountain project due to project design. Endlining trees < 10 inches DBH from SMZs may be necessary and will be accomplished with one end suspended whenever feasible and with full suspension over any streamcourse.

1.12, 1.16 Log Landing Location, Log Landing Erosion Protection and Control

The objectives of this practice is to locate new landings or reuse old landings in such a way as to avoid watershed impacts and associated water quality degradation and reduce the impacts of erosion and subsequent sedimentation associated with log landings by mitigating measures.

Application: The following criteria are to be used by the Sale Administrator when evaluating landings:

a. Utilize existing landings if they are not located in an SMZ or RR. In some cases, using an existing landing located within a RR is preferable to constructing a new landing outside of it. These situations will be reviewed on a site-by-site basis by an earth science specialist (aquatics, hydrology, geology, or soils).
b. The cleared or excavated size of landings will not exceed that needed for safe and efficient skidding and loading operations. Trees considered dangerous will be removed around landings to meet the safety requirements of OSHA.
c. Selected landing locations will involve the least amount of excavation and fill possible. Landings must be located outside of SMZs.
d. Locate landings near ridges away from headwater swales in areas that will allow skidding without crossing stream channels, violating SMZs, or causing direct deposit of soil and debris to a stream.
e. Locate landings where the least number of skid roads will be required, and sidecast can be stabilized without entering drainages or affecting other sensitive areas. Keep the number of skid trails entering a landing to a minimum.

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f. Position landings such that the skid road approach will be nearly level as feasible, to promote safety and to protect soil from erosion.
g. Construct stable landing fills or improve existing landings by using appropriate compaction and drainage specifications.

Landings will be properly cross-ditched, ripped (if soils are compacted), re-contoured (as necessary), and mulched after use and before the winter precipitation period, whichever comes first. Excess material not needed for erosion control can be piled and burned. Upon completion of the project or before the onset of the winter precipitation period, consult with the hydrologist or soil scientist to determine the need for additional soil protection measures.

- BMPEP form T04 would be utilized to evaluate implementation on those units with landings.

1.13, 1.17 Erosion Prevention and Control Measures during Sale Operations, Erosion Control on Skid Trails

The objective of these practices is to ensure that the purchasers operation will be conducted reasonably to minimize soil erosion.

Application: Timber purchaser responsibilities for erosion control will be set forth in the Timber Sale Contract. Equipment will not be operated when ground conditions are such that excessive damage will result. The kinds and intensity of control work required of the purchaser will be adjusted by the sale administrator to ground and weather conditions with emphasis on controlling overland runoff, erosion, and sedimentation. Prior to October 15, erosion control work would be completed as units are completed. After October 15, erosion work is kept up weekly, or prior to anticipated storms.

Erosion control measures would be implemented on all skid trails, tractor roads, and temporary roads. Erosion control measures must include, but are not limited to, cross ditches (water bars), organic mulch, and ripping. Cross ditches will be spaced according to the guidelines in the Sale Administrators Handbook. Water bar spacing may need to be decreased in units where soils have high and very high Erosion Hazard Ratings.

Any evidence of ruts associated or resulting from skidding pattern/path caused by the dragging of logs (or otherwise) would be water-bared. Additionally, if ground cover disturbance is reduced to amounts less than preexisting levels would be slashed through lop and scatter to 18 inches. Ruts for the purposes of this analysis, are at least 2 inches in depth. Skidding would occur on ridge tops and not within draws. Standard road maintenance practices would be implemented.

If the purchaser fails to perform seasonal erosion control work prior to any seasonal period of precipitation or runoff, the Forest Service may temporarily assume responsibility, complete the work, and use any unencumbered deposits as payment for the work.

- BMPEP forms T02 and T05 would be utilized to evaluate implementation on those units where skidding operations and where erosion prevention and control measures are expected to occur.

1.20 Erosion Control Structure Maintenance

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The objective of this practice is to ensure that constructed erosion control structures are stabilized and working.

Application: During the period of the Timber Sale Contract, the purchaser will provide maintenance of soil erosion control structures contracted by the purchaser until they become stabilized, but not more than one year after their construction. If the purchaser fails to do seasonal work, the Forest Service may assume responsibility and charge the purchaser accordingly. The Forest Service sale administrator is responsible for ensuring erosion control maintenance work is completed. T

- BMPEP form T05 would be utilized to evaluate implementation on those units with SMZ's and other aquatic protection.

1.21 Acceptance of Timber Sale Erosion-control Measures Before Sale Closure

The objective of this practice is to ensure the adequacy of required erosion control work on timber sales.

Application: The sale administrator must inspect erosion control measures to ensure their adequacy prior to accepting closure on the unit and/or sale.

The effectiveness of erosion control measures will be evaluated using BMPEP protocols after the sale area has been through one or more wet seasons. This evaluation is to ensure that erosion control treatments are in good repair and functioning as designed before releasing the purchaser from contract responsibility.

The purchaser is responsible for repairing erosion control treatments that fail to meet criteria in the Timber Sale Contract, as determined by the Sale Administer, for up to one year past closure of the sale.

1.22 Slash Treatment in Sensitive Area

The objective of this practice is to maintain or improve water quality by protecting sensitive areas from degradation which would likely result from using mechanized equipment for slash disposal.

Application: Locations and specifications from piling and burning in RRs and SMZs are prescribed in the design features above.

Road Management Best Management Practices

2.2 General Guidelines for the Location and Design of Roads

The objective of this practice is to locate roads to minimize problems and risks to water; aquatic, and riparian resources. Incorporate measures that prevent or reduce impacts, through design for construction, reconstruction, and other route system improvements.

Application: The following considerations are incorporated into the planning process of road location and design.

(a) The location and design of temporary roads were determined by the ID team and located to minimize potential impacts to water quality

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(b) Sensitive areas such as wetlands, inner gorges, and unstable ground were avoided.

2.3 Road Construction and Reconstruction
The objective of this practice is to minimize erosion and sediment delivery from roads during road construction or reconstruction, and their related activities.

Application: Newly constructed or reconstructed roads will be designed to reduce hydrologic connectivity and soil erosion. The sale administrator or other Forest Service representative will ensure that roads are adequately maintained during project implementation to ensure that road drainage features function as designed. Measures include construction of properly spaced cross drains, water bars or rolling dips, energy dissipaters, aprons, downspouts, debris racks, and armoring of ditches. Work will be done during the dry season, or when rain and runoff are unlikely. If possible, newly constructed "temporary" road should not be used for more than one season. Thus, this same road will be decommissioned post project according to specifications (BMP 2.7).

Construction and maintenance fill, sidecast, and end-hauled materials will be kept out of SMZ's except at designated crossing sites to minimize the effect to the aquatic environment. In-channel excavation will only be done as needed to install and remove temporary road crossings. When removed, the streambed and banks will be restored to as natural a condition as possible. In-channel activities will not occur on perennial streams without further consultation with the district hydrologist and will require a dewatering plan. Slash generated by road work will not be disposed of into any watercourse or SMZ.

- BMPEP forms E08, E09, E11, E13, E14 will be used to evaluate the overall effectiveness of proper construction and reconstruction of roads.

2.4 Road Maintenance and Operations
The objective of this practice is to maintain roads in a manner which provides for water quality protection by minimizing rutting, failures, incorporation of slash into road fills, side-casting, and blockage of drainage facilities, all of which can cause erosion and sedimentation and deteriorating watershed conditions.

Application: Roads needed for project activities will be brought to current engineering standards of alignment, drainage, and grade before use, and will be maintained through the life of the project. The purchaser and the Forest Service would agree to an Annual Road Maintenance Plan that outlines responsibilities and timing of maintenance. This would be done before the beginning of the operating season.

Road maintenance and storm proofing activities will be designed to reduce impacts of roads to aquatic systems. Water or other dust palliatives will be used to control dust during operations.

2.5 Water Source Development and Utilization
The objective of this practice is to supply water for roads and fire protection while maintaining existing water quality.

Application: Water source development is normally needed to supply water for road construction and maintenance, dust control, and fire control. At no time would downstream

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water flow be reduced to a level that would be detrimental to aquatic resources, fish passage, or other established uses, and would require review and approval by District or Forest Hydrologist and Fisheries Biologist.
All drafting devices will utilize appropriate screens to protect aquatic organisms

- BMPEP form E16 would be utilized to evaluate implementation on those areas identified for water source development.

2.7 Road Decommissioning
The objective of this practice is to stabilize, restore, and vegetate unneeded roads to a more natural state as necessary to protect and enhance NFS lands, resources, and water quality.

Application: Temporary roads will be obliterated after serving their intended purpose for this project. This includes: (1) road effectively barricaded; (2) road effectively drained by measures such as re-contouring or outsloping to return surface to near natural hydrologic function; (3) a well distributed mulch or organic cover provides at least 50% cover, or road surface is revegetated using local native species; (4) sideslopes are reshaped and stabilized to match the natural contour (as necessary); and (5) stream crossings are removed and natural channel geometry is restored.

- BMPEP form E10 would be utilized to evaluate implementation of road decommissioning and obliteration.

2.8 Stream Crossings
The objective of this practice is to minimize water, aquatic, and riparian resource disturbances and related sediment production when constructing, reconstructing, or maintaining temporary and permanent water crossings.

Application: Crossings of intermittent and ephemeral streams will be approved by the district or forest hydrologist prior to implementation. Only existing controlled crossings (bridges and culverts) of perennial streams will be used.

- BMPEP form E09 would be utilized to evaluate potential effects of stream crossings.

2.11 Equipment Refueling and Servicing
The objective of this practice is to prevent pollutants such as fuels, lubricants, bitumens and other harmful materials from being discharged into or near rivers, streams and impoundments, or into natural or man-made channels.

Application: Storage of hazardous materials (including fuels) and servicing and refueling of equipment will be conducted at pre-designated locations outside of RRs. If fueling and/or storage of hazardous materials are needed within RRs, those sites must be reviewed and approved by the Forest Hydrologist. Additional protection measures, such as containment devices, may be necessary. Refueling and servicing of chainsaws may be permitted in RRs but not in SMZs

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- BMPEP form E12 would be utilized to evaluate implementation on those areas that meet the requirements for servicing and refueling of equipment.

2.13 Erosion Control Plan
The Erosion Control Plan can be found in Appendix B.

Vegetation Manipulation Best Management Practices
5.2 Slope Limitations for Mechanical Equipment Operations
The objective of this practice is to reduce gully and sheet erosion and associated sediment production by limiting tractor use.

Application: Ground skidding, machine piling, and masticating is limited to slopes less than 35%, with occasional operations on ground up to 40% slope for a maximum distance of 100 feet allowed.

5.3 Tractor Operation Limitation in Wetlands and Meadows
The objective of this practice is to limit turbidity and sediment production resulting from compaction, rutting, runoff concentration, and subsequent erosion by excluding the use of mechanical equipment in wetland and meadows except for the purpose of restoring wetland and meadow function.

Application: Tractors or other ground based machinery are not allowed in Wetlands or Meadows. Identified wetlands or meadows have will identified and flagged within units. Should any be encountered during implementation, this BMP is to be used.

5.6 Soil Moisture Limitations for Mechanical Equipment Operations
The objective of this practice is to prevent compaction, rutting, and gullying, with resultant sediment production and turbidity.

Application: The Contract shall require winter shutdown whenever the Forest Service determines that the soil moisture or physical conditions have become unsuitable for equipment operation on any area. Soils will need to dry to acceptable levels before activities can resume. Consultation with district hydrologist or soil scientist will be as needed.

Fire Suppression and Fuels Management Best Management Practices

6.2 Consideration of Water Quality in Formulating Fire Prescriptions
This BMP provides for water quality protection while achieving management objectives through the use of prescribed fire.

Application: Prescribed burning is planned at the minimum intensity and severity necessary to achieve management objectives, and each Burn Plan will incorporate all relevant design features from this EIS.

6.3 Protection of Water Quality from Prescribed Burning Effects
The purpose of this BMP is to maintain soil productivity; minimize erosion; and minimize ash, sediment, nutrients, and debris from entering water bodies.

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Application: Burning within RR and SMZs would only occur during conditions where a low intensity burn would occur. Suppression would be required if fire intensity increases above this level. Any fire-lines created during fuels management activities would be water barred to reduce concentration of water. Active ignition utilizing broadcast burning would not be allowed within the RR, however fire would be allowed to back into the RR and SMZ. Fire will not be allowed into the SMZ of the fish-bearing portion of Benmore Creek or Bucknell Creek.

- BMPEP form F25 would be utilized to evaluate implementation of fuels management operations.

Watershed Management Best Management Practices

7.4 Oil and Hazardous Substance Spill Contingency Plan and Spill Prevention Control and Countermeasure (SPCC) Plan

The objective of this practice is to prevent contamination of water from accidental spills.

Application: A spill contingency plan and spill prevention and countermeasure plan (SPCC) must be prepared if hazardous materials (including fuels and oils) stored on the Mendocino National Forest exceed 1320 gallons, or if a single container exceeds 660 gallons.

The plan will at a minimum include: the types and amounts of hazardous materials located in the project area, pre-project identified locations for hazardous materials storage and fueling/maintenance activities (must be located outside of RRs), methods for containment of hazardous materials and contents of on-site emergency spill kit, and a contingency plan (including contact names with phone numbers) to implement in the event of a spill. The SPCC plan must be approved by the Forest Service prior to project implementation.

7.6 Water Quality Monitoring

The objective of this BMP is to collect representative water data to determine base line conditions for comparison to established water quality standards, which are related to beneficial uses for that particular watershed.

Application: This BMP is implemented through establishment of Stream Condition Inventory (SCI) sites prior to project implementation to establish pre-project condition. Two monitoring reaches were established on Benmore Creek and Packsaddle Creek. Reports of these surveys are contained in Appendix D.

7.8 Cumulative Watershed Effects

The objectives of this BMP is to protect the identified beneficial uses of water from the combined effects of multiple management activities which individually may not create unacceptable effects, but collectively may result in degraded water-quality conditions.

Application: See the Cumulative Watershed Effects discussion in the Environmental Consequences section of the Hydrology Report.

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Appendix C. Erosion Control Plan and Design Features

This Erosion Control Plan provides detailed considerations and mitigations applicable to the completion of the project to reduce off site erosion. The plan is broken up into three sections which are pre-project, project implementation, and post project. These sections will contain information regarding, but not limited to: mitigation measures, anticipated ground-disturbing activities, maps, and waste management strategies.

Pre-Project Implementation

Prior to implementing the Pine Mountain Project, several attributes of the Erosion Control Plan must be in place. These include mitigation measures developed through project analysis, requirements to meet Best Management Practices (BMP), project plans and specifications, and required State and Federal permits.

Ground disturbing activities are expected to occur as a result of the Pine Mountain Project. These include: opening and closing skid roads/temp roads, creating temporary roads, ground based logging, and mastication. Opening old access roads and landings will require removal of debris and brush along these areas. Creating temporary roads identified by the project and all road maintenance activities will follow Forest road maintenance specifications. Roads that intercept ground water and are wet during implementation will be rocked prior to use.

Best Management Practices have been identified for the Pine Mountain Fuels Project. These are discussed in the Hydrology report and itemized in Appendix B. Some BMP's required during the planning stages are:

BMP 2.13 Erosion Control Plan
BMP 7.6 Water Quality Monitoring

California's North Coast Water Quality Control Board (WQCB) adopted Order No. R1-2010-0029 "Waiver of Waste Discharge Requirements for Nonpoint Source Discharges Related to Certain Federal Land Management Activities on National Forest System Lands" on June 10, 2010. A Category B waiver from the North Coast WQCB is required prior to project implementation.

Flagging will be used to identify project perimeter, avoidance areas, location of access road and staging area, fuel storage and equipment servicing locations. Blue and white stripped flagging or orange paint will be used to identify Streamside Management Zones. Riparian Reserves will be identified on contract (Sale Area Maps) and force account maps. Thinning activities in the RRs will be conducted to make these buffers more resilient to disturbance (ie fire and insects). Contact personnel on the Pine Mountain Fuels Project are listed below:

Name	Position	Phone number/ email
Hilda Kwan	Zone Hydrologist	707-275-1413 hkwan@fs.fed.us
April Hargis	District Planner	707-275-1410 ahargis@fs.fed.us
Gary Urdahl	Silviculturist	707-275-1417 gurdahl@fs.fed.us
TBD	COR	TBD

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Frank Aebly	District Ranger	707-275-1401 faebly@fs.fed.us

Project Implementation

The Project Implementation portion of the Erosion Control Plan discusses the when, where, why, and how the project activities will be implemented while minimizing or preventing erosion.

Design Features Applicable to All Management Activities

The design standards listed below are needed to assure that the proposed activities do not result in unacceptable levels of erosion and sediment delivery to streams. This, in turn, will assure that the proposed activities will comply with State and Federal clean water laws and regulations. They also contribute to meeting R5 soil quality standards.

- All road maintenance activities will follow Forest road maintenance specifications.
- Any water bars installed post-harvest that are damaged by fuels activities will be repaired before the next precipitation event.
- Roads that intercept ground water and are wet at the time of operations will be rocked prior to use.
- Prior to October 15, erosion control work would be completed as units are completed, or if the National Weather Service forecast for the project area predicts that a precipitation even is likely (greater than 30% chance). After October 15, erosion work is kept up weekly, or prior to anticipated storms.
- Ground-based heavy equipment will be limited to stable slopes less than 35%. Occasional use on stable slopes up to 40% for a distance not to exceed 100 feet is acceptable.
- Mechanical operations would occur during dry soil conditions; typically May 15-October 15. Operating during these times will minimize impact and reduce the potential for increased erosion. However, dust abatement will most likely be needed to minimize dust. The hydrologist or soil scientist would be consulted if any question concerning soil operability arises.
- On road cut-slopes steeper than 65% ~~70%~~ and higher than 10 ft., no trees > 8 inches DBH will be removed from the cut slope or within 20 feet of the upper edge of the cutbank. Pruning trees for access/road safety and visibility, or to meet fuels objectives would be allowed. **Exception:** if it is determined that a tree poses a safety hazard or would be subject to blow down, the tree may be removed.
- Several small slides and slumps have been identified in the treatment units (See Geology Report, Figure 2 in Appendix A for map and Table 3 in Appendix C for table of units with active landslides). These areas will be flagged on the ground and no thinning of trees > 4 inches DBH will be allowed within 50 feet from the top edge of these areas. Pruning of trees and removal of ladder fuels to attain fuels objectives is permissible.
- Retain at least 50% ground cover (litter/duff/rock) across all treatment areas. Retention and even distribution of fine vegetation (rather than rocks) should be favored for ground cover and nutrient cycling.

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Commented [MRP-7]: Let's make this 65% since these "cut-slopes" could actually be inner gorge at some crossings.

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Activities within the **Riparian Reserves** will be subject to the following requirements:

- Within the outer portion of the riparian reserves, which is from the SMZ out to the edge of the RR, the thinning prescriptions would be the same as the stand-specific prescriptions but no riparian associated vegetation will be removed.

- Retain all riparian-associated vegetation within the RRs of seeps, springs, and unstable areas

- Tractor piling is not permitted within the RRs on slopes > 25%; however, mastication or grapple piling is permissible outside of the SMZs on slope <35%.

- On slopes <50% retain at least 50% ground cover (litter/duff/rocks) evenly distributed across the treatment area.

- On slopes >50% retain at least 70% ground cover (littler/duff/rocks) evenly distributed across the treatment area.

- Cover bared soil areas that exceed 50 sq. ft. with mulch or slash to the ground cover percent appropriate for the slope class (see above) if the area is likely to deliver sediment to the stream.

- There are a number of perennial springs/seeps within the project area, where the riparian reserve width would extend 50 feet (for seeps < 1 acre in size) or 150 feet (for seeps > 1 acre) from the extent of water-dependent vegetation, or the break in slope, whichever is greater. No riparian would be cut within the water-dependent vegetation zone. Within the remainder of the riparian reserve trees < 8 inches in DBH would be hand thinned on a 20-25 foot spacing, retaining at least 70% canopy cover. There would be no ignition or burning of thinning slash within 50 feet of the flagline that marks the extent of water-dependent vegetation (BMPs 1.8, 1.18, 1.19, 7.3).

The following restrictions apply to all **Streamside Management Zones** (**SMZs**):

- No ground-based mechanized equipment or commercial harvest will be allowed in SMZ except in designated crossings. Crossings of intermittent and ephemeral streams will be approved by the district or forest hydrologist prior to implementation. Only existing controlled crossings (bridges and culverts) of perennial streams will be used.
- Within SMZs only trees < 10 inches DBH would be thinned on a 20-25 foot spacing. No trees > 4 inches DBH will be cut within the lower 10 feet of the SMZs.

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- Trees cut in the SMZ must be felled toward the outer part of the RR. If it is necessary to remove the tree it should be end lined or grapple skidded from outside the SMZ, suspending one end where feasible and requiring full suspension over stream courses.
- Retain all riparian associated vegetation.
- Maintain a canopy cover of at least 7~~5~~0% in all perennial, intermittent and ephemeral SMZs
- ~~Maintain a canopy cover of at least 70% in all perennial SMZs~~
- Cover bare soil areas that exceed 50 sq. ft. with mulch or slash if the area is likely to deliver sediment to a stream.

Design Features Specific to Commercial Thinning:

The following design features apply to commercial harvesting activities, and are ***in addition to*** those listed above for all actions

- Waterbar spacing will follow the Sale Administration handbook
- Reuse existing skid trails and landings unless they are poorly placed (i.e. in a Riparian Reserve or through an unstable area) or designed (i.e. over steepen).
- Uphill skidding would be allowed on slopes up to 35% slope and sections shorter than 100 feet on slopes up to 40%
- Any soil displacement caused by the mechanical equipment greater than 4 inches in depth would be back bladed or waterbarred to prevent water concentration
- Not more than 15% of any harvest unit would be occupied by skid trails and landings. Units found to be above this limit would have the most heavily compacted skid trails sub-soiled or ripped such that the unit would be under the 15%.
- Grooves greater than 4 inches in depth left by ripping or sub-soiling would be back bladed or waterbarred
- Ripping/subsoiling would occur to a minimum depth of 18 inches or to bedrock whichever is less
- Temporary stream crossings will be removed, cleaned, and stabilized prior to the onset of the wet season (typically October 15).
- No commercial harvest will be done within any SMZs.
- Portions of units 23 and 24 (both "thin over 10-inches DBH) are underlain by soils with a high or very high erosion hazard rating. If tractor operations occur on these soils than special erosion control prevention measures will be required. These measures may include the use of additional ground cover by 10%.

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Design Features Specific to Fuels and Pre-commercial treatments:

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The following design features apply to commercial harvesting activities, and are ***in addition to*** those listed above for all actions

- Prescribed burning will be conducted in such a way as to result in a low to moderate intensity fire
- In units previously harvested the masticating/shredding equipment would reuse the existing travel ways within the unit
- Masticators should walk on slash as much as possible
- Mechanical piling would be limited to the minimum necessary
- Mechanical piles would be clean (i.e. less than 10% soil in them)
- Any soil displacement caused by the mechanical equipment greater than 4 inches in depth would be back bladed or water-barred to prevent water concentration
- No ground based equipment will be allowed in the fish-bearing RR of Benmore Creek or Bucknell Creek.
- No equipment or mechanical tree removal would be allowed within unstable areas.
- No tree > 8 inches DBH will be cut within 25 feet of the top of the inner gorge of Benmore Creek
- Prescribed Burning may be conducted within Riparian Reserve, SMZ, and unstable areas, but active ignition is prohibited. Burning may "back into" the RR, SMZ, and unstable areas; however fire would be suppressed if intensity is such that riparian vegetation or overstory canopy mortality would occur.
    - **EXCEPTION:** Fire will not be allowed within 300 feet of the fish-bearing reach of Benmore Creek and Bucknell Creek

- Pile burning in SMZs is restricted as follows
    - On slopes <40%, no pile burning would occur within 25 feet of the channel high water line.

      Exception – hand piles may be located within 10-25 feet of the channel high water line if there is a topographic break (flat or bench with slope <20%). During burning, fire would not be allowed to creep outside the perimeter of the piled material, and the downhill perimeter of burn piles would remain unlit in order to retain some slash for ground cover and to function as a sediment trap.

    - On slopes 40-60%, no hand pile burning would occur within 25 feet of the high water line, and shall include the following requirements:
        - Piling should utilize topographic features (flats, benches, or areas of least slope (10-20%), where available, to stabilize piles.
        - Slash should be piled with stems oriented with the slope to prevent rollout.

      Exception – hand piles may be located within 10-25 feet of the channel high water line if there is a topographic break (flat or bench with slope <20%). During

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burning, fire would not be allowed to creep outside the perimeter of the piled material, and the downhill perimeter of burn piles would remain unlit in order to retain some slash for ground cover and to function as a sediment trap.

- On slopes >60% *slash is to be lopped and scattered, and within the lower 10 feet of the SMZ the slash is to be moved upslope >10 feet from the channel high water line.*

Once the project is completed, Best Management Practices protocol requires all header and implementation portions of the BMP evaluation forms be completed. The Contracting Officer assigned to the project will be responsible for completing all required BMP forms. Submission of these forms will go to the Zone Hydrologist in Upper Lake.

Post Project Implementation

Post project procedures include removal of heavy equipment, removal of any items stored in the staging area, waste management and disposal, and post project water management. The staging area may contain waste generated during project implementation. The contractor will be responsible for removing any and all waste from the site in accordance to all applicable laws. The goal of waste management and disposal is to return the project area, as much as possible, to pre-project conditions. Once those items are removed, the old access road used will need post project water management.

Post Project Water Management is described within BMP 2.13 as a way of implementing water control structures and management practices to minimize pollutants, in this case erosion, after project activities have been completed at the site (pre-project and project implementation). Skid roads opened for the project will be ripped, slashed, and have water bars installed. These actions would minimize the chances for excess erosion and reduce soil compaction created during project implementation. Water bars would be installed in accordance with Forest Service Handbook 2409.15 R5 supplement 2409.215_2012-01 Chapter 60. Waterbar spacing is expected to use the **Erosion Rating of High** for skid roads.

Post project monitoring will occur as required by BMP protocol. BMPs used during pre and project implementation would be evaluated the following year. A Forest Service hydrologist is required during post project BMP monitoring.

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Appendix D. Stream Condition Inventory (SCI)

Benmore Creek
Prepared by Hilda Kwan, West Zone Hydrologist (MNF)

A Stream Condition Inventory (SCI) (Frazier et. al, 2005) survey was performed on Benmore Creek between 2/4/2014-2/5/2014. Location of this survey is adjacent to PG&E land on Section 28 of Township 18N, Range 10W. Drainage area above this survey is 3.28 mi^2, or approximately 2100 acres. The surveyed reach itself is 321.8 feet.

A variety of physical data were collected, including: Longitudinal Profile, Cross Sections, Particle Size Distribution, Shading, Bank Stability, Bank Angle, Large Woody Debris, and Pool Tail Fine Sediment. Basic water chemistry data collected include: Total Dissolved Solids, pH, Conductivity, Water Temperature, and Salinity. A Temperature Data Logger was deployed to monitor continuous water temperature and will be retrieved at a later date for data analysis. Macroinvertebrate samples were also collected and will be sent to the Utah Bug Lab for further analysis.

Longitudinal Profile
The longitudinal profile characterizes water surface gradient and depths of riffles, pools, runs, glides, rapids and step pools. The average water surface slope is required for delineating stream types. At the broadest resolution level, fluvial geomorphologists recognize fast water (riffles, runs, and glides) and slow water (pools) as the two primary stream habitat unit types. These units are important attributes because they are the base stratification of habitats that support aquatic life.

A longitudinal profile at this reach reveals that stream gradient is at an average of 2.5% (Figure 1). The majority of the features are “fast water” at 53% while 47% of the reach is within “slow

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water."

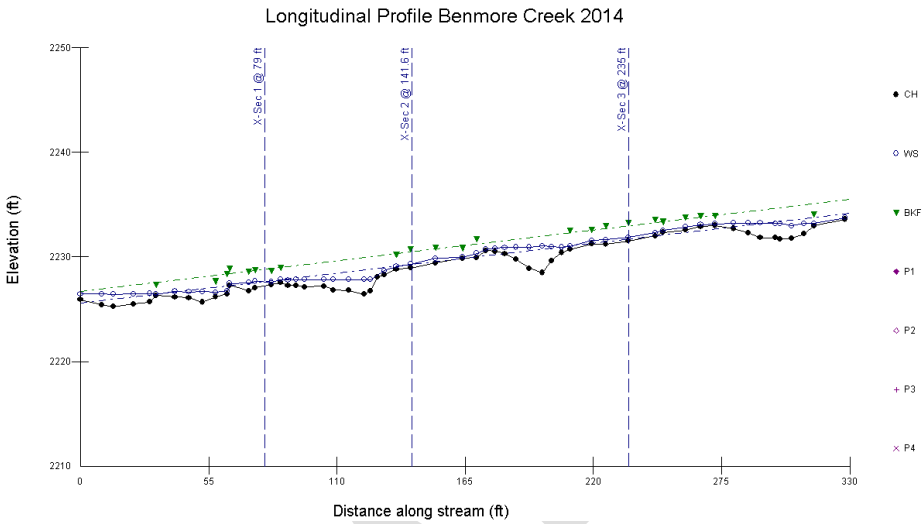

Figure 1. Longitudinal Profile of surveyed reach on Benmore Creek.

Cross Sections

Channel cross section measurements express the physical dimensions of the stream perpendicular to flow. They provide fundamental understanding of the relationships of width and depth, streambed and streambank shape, bankfull stage and floodprone area, etc. Three cross sections were surveyed within the reach at fast water (riffles) features. Table 1 describes the dimensions of the cross sections while figures 2-4 depict their shape.

Table 1. Cross Section dimensions of surveyed reach on Benmore Creek.

	X-Sec 1	X-Sec 2	X-Sec 3
Bankfull Width	13.43	12.96	17.56
Floodprone Width	26	22.93	25.06
Entrenchment	1.94	1.77	1.43
Mean Bankfull Depth	0.64	0.97	0.58
Max Bankfull Depth	1.5	1.37	1.22
Cross Sectional Area	8.56	12.61	10.14
Width/Depth	20.98	13.36	30.28

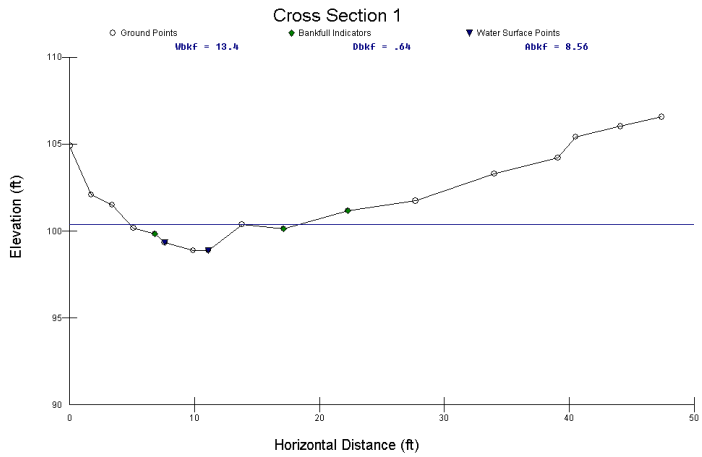

Figure 2. Cross section 1 of Benmore Creek.

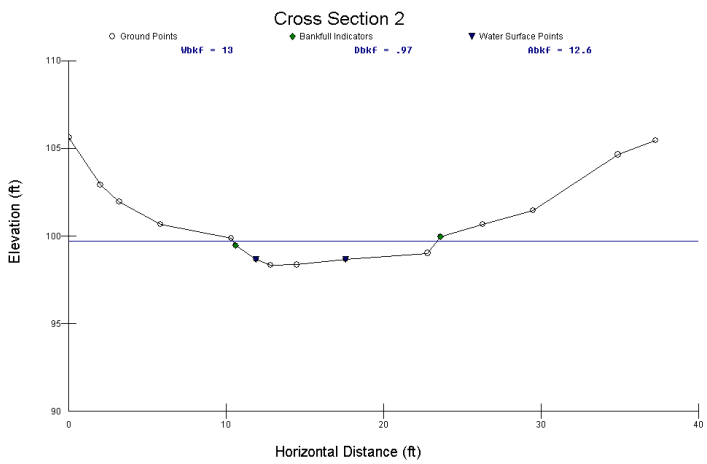

Figure 3. Cross section 2 of Benmore Creek.

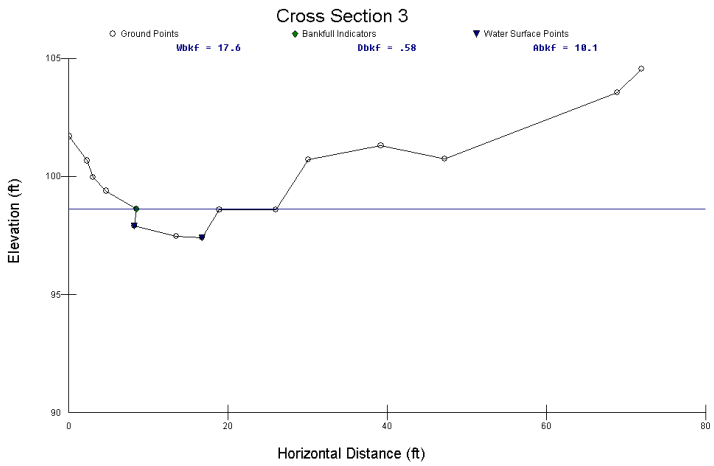

Figure 4. Cross section 3 of Benmore Creek.

Particle Size Distribution

Streambed materials are key elements in the formation and maintenance of channel morphology. These materials influence channel stability, resistance to scour during high flow events, and also act as a supply of sediment to be routed and sorted throughout the channel. The amount and frequency of bedload transport can be critically important to fish spawning and other aquatic organisms that use stream substrate for cover, breeding, or foraging. Particle size distribution can change over time as a result of management activities and/or natural disturbances.

Particle size distribution surveys were conducted at each of the cross sections and along the longitudinal profile survey. Figure 5 show that particle size distribution is fairly similar among the three cross sections. "Weighted particle size distribution" was collected according to the amount of fast versus slow water within the reach. In other words, 53% of particles were collected from fast water while 47% were collected from slow water. By doing so, the result show there is a fair amount of fine sediment in the pools (Table 2 and Figure 5).

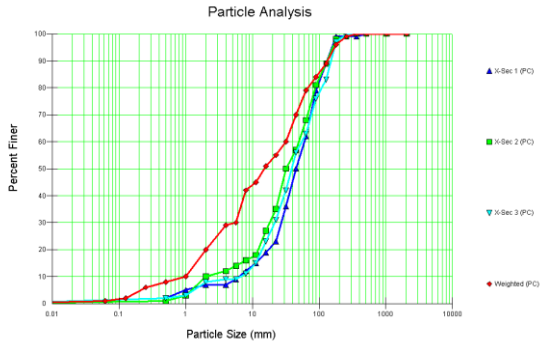

Figure 5. Particle size distribution analysis.

D50 (at a cross section) is the median particle size in the streambed used to classify stream type and can also provide a minimum estimate of the shear stress necessary to initiate general movement of mixed-size sediment (Rosgen, 2006; Elliot, 2002). D84 (84th percentile particle size) among the Weighted particle size distribution is used in part to estimate Manning's roughness coefficient. Manning's roughness coefficient is then used in part to estimate bankfull velocity and discharge (Figure 6).

Table 2. D50 and D85 distribution.

	X-Sec 1	X-Sec 2	X-Sec 3	Weighted
D50	45	32	39	15.22
D84	109	104	131	90

Stream type Discussion

Given results from the particle distribution analysis, longitudinal profile, and cross section, it is determined the reach is a Rosgen stream type of **B4**. These streams are dominated by gravel, moderately entrenched (ratio 1.4-2.2), have moderate width/depth ratio (>12), slope range of 0.02-0.039 and moderately sinuous (>1.2). These types of streams have the following generalized management interpretations (Rosgen, 2006):

- Moderate sensitivity to disturbance
- Excellent recovery potential
- Moderate sediment supply
- Low streambank erosion potential
- Moderate vegetation controlling influence

Bankfull Discharge

Bankfull stage is described by Leopold et al (1964) as the incipient point of flooding or where river water just begins to over top the natural channel and spills onto its floodplain. Analyses of over 40 years of gage station data throughout North America indicate a range in bankfull return intervals from 1.05-1.8 years (Rosgen, 2006). "The bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work results in the average morphologic characteristics of channels" (Dunne and Leopold, 1978). From observations by Wolman and Miller (1960), they acknowledge that large catastrophic floods may transport large amounts of sediment, cause great erosion and incise channels. However, "they occur so rarely that from the standpoint of transport their over-all effectiveness is less than that of the smaller and more frequent floods" This is mainly true in areas with perennial and intermittent flow.

Estimations of bankfull discharge can be made using morphological features collected in this survey. Under several methods, bankfull discharge varies between **58.18-71.57 cfs** (cubic feet per second) (Figure 6).

Shading and Stream Temperature

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Stream temperature has impacts on health, behavior, and survival of aquatic organisms and is strongly influenced by streamside shading. Streamside vegetation is a primary source of energy to most streams. Table 3 summarizes the stream shading along the surveyed reach of Benmore Creek. A temperature data logger was deployed in the creek to continually monitor stream temperature. This apparatus will be collected at a later date for data analysis.

Table 3. Shade along Benmore Creek.

Shade Calculations	
High	96%
Average	85%
Low	63%

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Bankfull VELOCITY & DISCHARGE Estimates

Stream:	Benmore Creek	Location:	Reach - Reach 1
Date:	2/4/2014	Stream Type: B4	Valley Type: II
Observers:	HK, JD, JK, RB	HUC:	1.80101E+13

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	12.61	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	0.97	d_{bkf} (ft)
Bankfull Riffle WIDTH	12.96	W_{bkf} (ft)	Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	13.71	W_p (ft)
D_{84} at Riffle	104.25	Dia. (mm)	D_{84} (mm) / 304.8	0.34	D_{84} (ft)
Bankfull SLOPE	0.0350	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	0.92	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	2.69	R / D_{84}
Drainage Area	3.3	DA (mi^2)	Shear Velocity $u^* = (gRS)^{1/2}$	1.018	u^* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [\,2.83 + 5.66 * Log\{R / D_{84}\}\,]\,u^*$	5.36	ft / sec	67.55	cfs
2. Roughness Coefficient: a) Manning's n from Friction Factor / Relativ Roughness (Figs. 2-18, 2-19) $u = 1.49*R^{2/3}*S^{1/2}/n$ $n =$ 0.057	4.61	ft / sec	58.18	cfs
2. Roughness Coefficient: b) Manning's n from Stream Type (Fig. 2-20) $u = 1.49*R^{2/3}*S^{1/2}/n$ $n =$ 0.057	4.61	ft / sec	58.18	cfs
2. Roughness Coefficient: c) Manning's n from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2}/n$ $n = 0.39*S^{0.38}*R^{-0.16}$ Note: This equation is applicable to steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems; i.e., $n =$ 0.111 for Stream Types A1, A2, A3, B1, B2, B3, C2 & E3	2.38	ft / sec	29.99	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Darcy-Weisbach (Leopold, Wolman and Miller)	5.68	ft / sec	71.57	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Chezy C	0.00	ft / sec	0.00	cfs
4. Continuity Equations: a) Regional Curves $u = Q / A$ Return Period for Bankfull Discharg Q = 0.0 year	0.00	ft / sec	0.00	cfs
4. Continuity Equations: b) USGS Gage Data $u = Q / A$	0.00	ft / sec	0.00	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure **"protrusion heights"** proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

Figure 6. Discharge estimates based on collected physical attributes.

Pfankuch scoring

The Pfankuch rating system was developed to systemize measurements and evaluations of the resistive capacity of mountain stream channels to the detachment of bed and bank materials and to provide information about the capacity of streams to adjust and recover from potential changes

in flow and/or increases in sediment production (Pfankuch, 1975). Although these ratings can be fairly subjective, they are still used as a way to identify key problem features.

Modified Pfankuch rating for stream type for the surveyed reach of Benmore Creek is **Fair**. Under Mendocino National Forest's Pfankuch rating, the result is **Low Good**. Largest concern based on this evaluation was the lack of vegetative bank cover in the upper banks.

Basic Water Chemistry

Table 4. Basic Water Chemistry

Total Dissolved Solids	127 ppm
pH	8.55
Conductivity	178.3 µs
Water Temperature	1.9ºC
Salinity	81 ppm

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Packsaddle Creek

Prepared by Hilda Kwan, West Zone Hydrologist (MNF)

A Stream Condition Inventory (SCI) (Frazier et. al, 2005) survey was performed on Packsaddle Creek on 3/10/2014. Location of this survey is on Forest Service land at SWSW Sec26 18N R10W, downstream of road 18N25. Drainage area above this survey is 2.1 mi^2. The surveyed reach itself is 294 feet.

A variety of physical data were collected, including: Longitudinal Profile, Cross Sections, Particle Size Distribution, Shading, Bank Stability, Bank Angle, Large Woody Debris, and Pool Tail Fine Sediment. Basic water chemistry data collected include: Total Dissolved Solids, pH, Water Temperature, and Salinity. A Temperature Data Logger was deployed to monitor continuous water temperature and will be retrieved at a later date for data analysis. Macroinvertebrate samples were also collected and will be sent to the Utah Bug Lab for further analysis.

Longitudinal Profile

The longitudinal profile characterizes water surface gradient and depths of riffles, pools, runs, glides, rapids and step pools. The average water surface slope is required for delineating stream types. At the broadest resolution level, fluvial geomorphologists recognize fast water (riffles, runs, and glides) and slow water (pools) as the two primary stream habitat unit types. These units are important attributes because they are the base stratification of habitats that support aquatic life.

A longitudinal profile at this reach reveals that stream gradient is at an average of 4.5% (Figure 1). The majority of the features are “fast water” at 76% while 24% of the reach is within “slow water.”

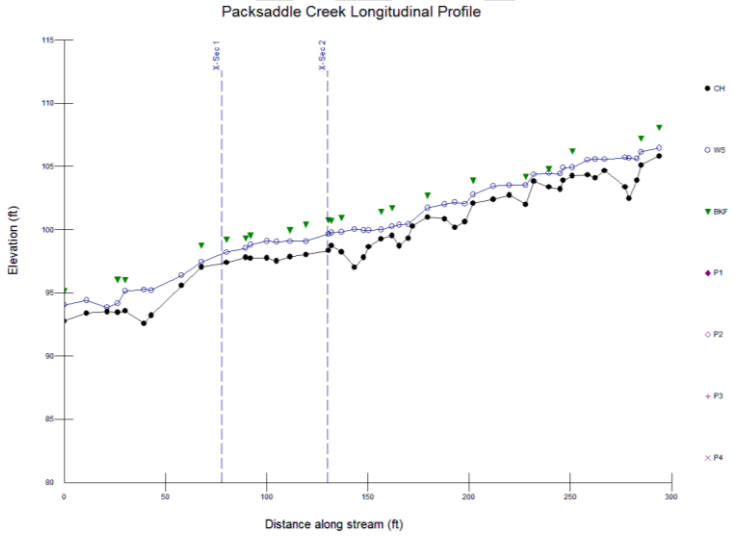

Figure 1. Longitudinal Profile of surveyed reach on Packsaddle Creek.

Cross Sections

Channel cross section measurements express the physical dimensions of the stream perpendicular to flow. They provide fundamental understanding of the relationships of width and depth, streambed and streambank shape, bankfull stage and floodprone area, etc. Two cross sections were surveyed within the reach at fast water (riffles) features. Table 1 describes the dimensions of the cross sections while figures 2-4 depict their shape.

Table 1. Cross Section dimensions of surveyed reach on Packsaddle Creek.

	X-Sec 1	X-Sec 2
Bankfull Width	19.96	22.2
Floodprone Width	41.39	44.61
Entrenchment	2.07	2.01
Mean Bankfull Depth	1.07	0.94
Max Bankfull Depth	1.73	2.13
Cross Sectional Area	21.38	20.8
Width/Depth	18.65	23.62

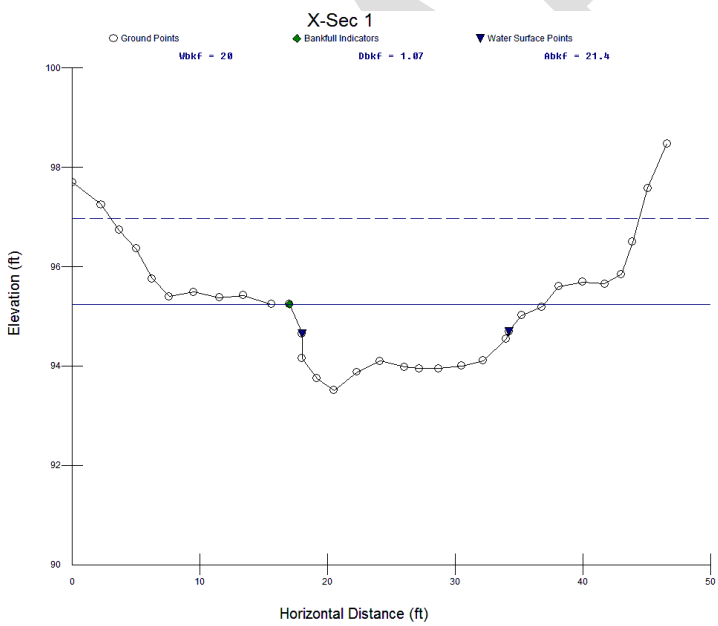

Figure 2. Cross section 1 of Packsaddle Creek.

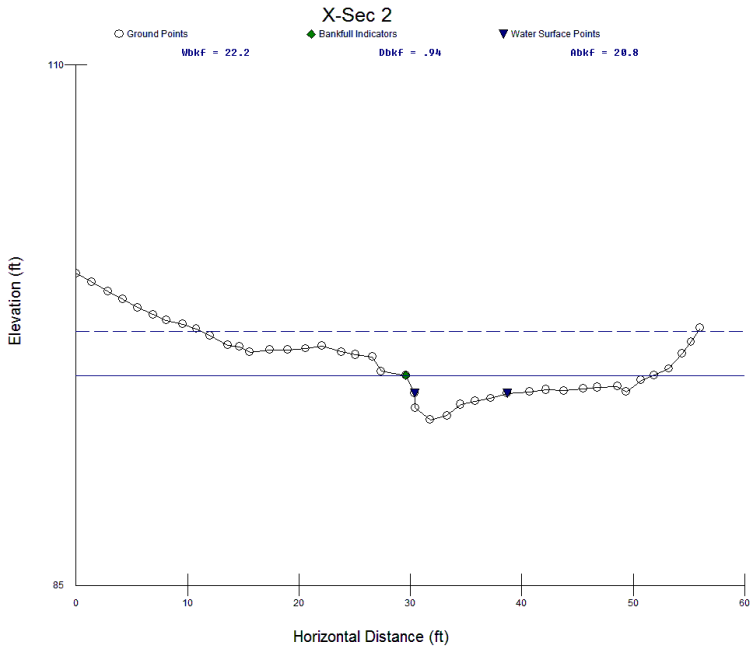

Figure 3. Cross section 2 of Packsaddle Creek.

Particle Size Distribution

Streambed materials are key elements in the formation and maintenance of channel morphology. These materials influence channel stability, resistance to scour during high flow events, and also act as a supply of sediment to be routed and sorted throughout the channel. The amount and frequency of bedload transport can be critically important to fish spawning and other aquatic organisms that use stream substrate for cover, breeding, or foraging. Particle size distribution can change over time as a result of management activities and/or natural disturbances.

Particle size distribution surveys were conducted at each of the cross sections and along the longitudinal profile survey. Figure 5 and Table 2 show that particle size distribution is fairly similar among the two cross sections. “Weighted particle size distribution” was collected according to the amount of fast versus slow water within the reach. In other words, 76% of particles were collected from fast water while 24% were collected from slow water.

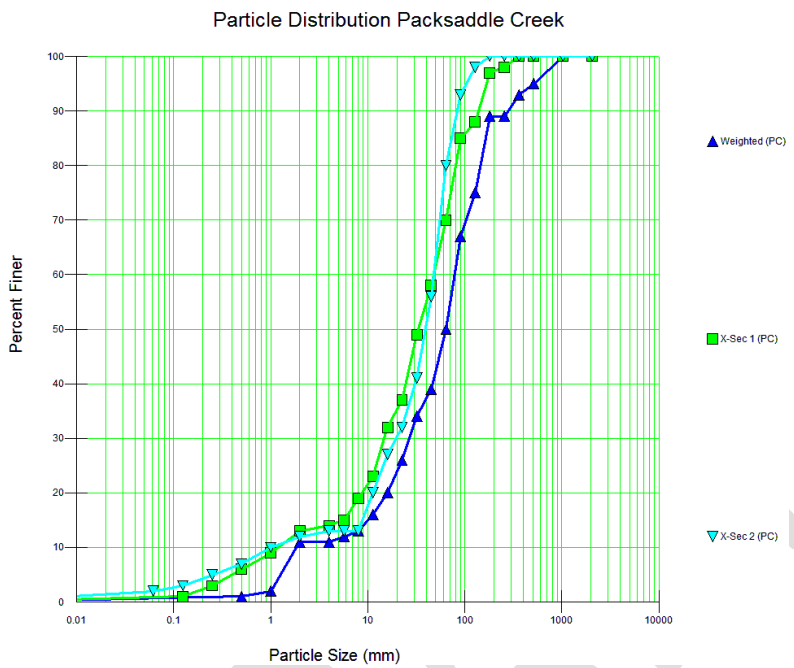

Figure 5. Particle size distribution analysis.

D50 (at a cross section) is the median particle size in the streambed used to classify stream type and can also provide a minimum estimate of the shear stress necessary to initiate general movement of mixed-size sediment (Rosgen, 2006; Elliot, 2002). D84 (84th percentile particle size) among the Weighted particle size distribution is used in part to estimate Manning's roughness coefficient. Manning's roughness coefficient is then used in part to estimate bankfull velocity and discharge (Figure 6).

Table 2. D50 and D85 distribution.

	X-Sec 1	X-Sec 2	Weighted
D50	33.44	39.8	64
D84	88.27	72	161

Stream type Discussion

Given results from the particle distribution analysis, longitudinal profile, and cross section, it is determined the reach is a Rosgen stream type of **B4a**. These streams are dominated by gravel, moderately entrenched (ratio 1.4-2.2), have moderate width/depth ratio (>12), slope range of 0.04-0.09 and moderately sinuous (>1.2). These types of streams have the following generalized management interpretations (Rosgen, 2006):

- Moderate sensitivity to disturbance
- Excellent recovery potential

- Moderate sediment supply
- Low streambank erosion potential
- Moderate vegetation controlling influence

Bankfull Discharge
Bankfull stage is described by Leopold et al (1964) as the incipient point of flooding or where river water just begins to over top the natural channel and spills onto its floodplain. Analyses of over 40 years of gage station data throughout North America indicate a range in bankfull return intervals from 1.05-1.8 years (Rosgen, 2006). "The bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work results in the average morphologic characteristics of channels" (Dunne and Leopold, 1978). From observations by Wolman and Miller (1960), they acknowledge that large catastrophic floods may transport large amounts of sediment, cause great erosion and incise channels. However, "they occur so rarely that from the standpoint of transport their over-all effectiveness is less than that of the smaller and more frequent floods" This is mainly true in areas with perennial and intermittent flow.

Estimations of bankfull discharge can be made using morphological features collected in this survey. Under several methods, bankfull discharge varies between **103.66-113.11 cfs** (cubic feet per second) (Figure 6).

Shading and Stream Temperature
Stream temperature has impacts on health, behavior, and survival of aquatic organisms and is strongly influenced by streamside shading. Streamside vegetation is a primary source of energy to most streams. Table 3 summarizes the stream shading along the surveyed reach of Packsaddle Creek. A temperature data logger was deployed in the creek to continually monitor stream temperature. This apparatus will be collected at a later date for data analysis.

Table 3. Shade along Packsaddle Creek.

Shade Calculations	
High	71%
Average	58%
Low	30%

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Bankfull VELOCITY & DISCHARGE Estimates

Stream:	Packsaddle 2014		Location:	Reach - Reach 1	
Date:	3/10/2014	Stream Type: ??	Valley Type:	II	
Observers:	H Kwan P Hoover		HUC:	1.80101E+11	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	20.80	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	0.94	d_{bkf} (ft)
Bankfull Riffle WIDTH	22.20	W_{bkf} (ft)	Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	23.72	W_p (ft)
D_{84} at Riffle	72.00	Dia. (mm)	D_{84} (mm) / 304.8	0.24	D_{84} (ft)
Bankfull SLOPE	0.0240	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	0.88	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	3.73	R / D_{84}
Drainage Area	2.1	DA (mi^2)	Shear Velocity $u^* = (gRS)^{1/2}$	0.825	u^* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [\,2.83 + 5.66 * Log\{R / D_{84}\}\,]\,u^*$	4.98	ft / sec	103.66	cfs
2. Roughness Coefficient: a) Manning's n from Friction Factor / Relativ Roughness (Figs. 2-18, 2-19) $u = 1.49*R^{2/3}*S^{1/2}/n$ $n =$ 0.0388	5.44	ft / sec	113.11	cfs
2. Roughness Coefficient: b) Manning's n from Stream Type (Fig. 2-20) $u = 1.49*R^{2/3}*S^{1/2}/n$ $n =$ 0	0.00	ft / sec	0.00	cfs
2. Roughness Coefficient: c) Manning's n from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2}/n$ $n = 0.39*S^{0.38}*R^{-0.16}$ Note: This equation is applicable to steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems; i.e. for Stream Types A1, A2, A3, B1, B2, B3, C2 & E3 $n =$ 0.097	2.19	ft / sec	45.47	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Darcy-Weisbach (Leopold, Wolman and Miller)	5.35	ft / sec	111.21	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Chezy C	0.00	ft / sec	0.00	cfs
4. Continuity Equations: a) Regional Curves $u = Q / A$ Return Period for Bankfull Discharg Q = 0.0 year	0.00	ft / sec	0.00	cfs
4. Continuity Equations: b) USGS Gage Data $u = Q / A$	0.00	ft / sec	0.00	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure **"protrusion heights"** proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

Figure 6. Discharge estimates based on collected physical attributes.

Pfankuch scoring

The Pfankuch rating system was developed to systemize measurements and evaluations of the resistive capacity of mountain stream channels to the detachment of bed and bank materials and to provide information about the capacity of streams to adjust and recover from potential changes in flow and/or increases in sediment production (Pfankuch, 1975). Although these ratings can be fairly subjective, they are still used as a way to identify key problem features.

Modified Pfankuch rating for stream type for the surveyed reach of Packsaddle Creek is **Fair**. Under Mendocino National Forest's Pfankuch rating, the result is **High Fair**. Largest concern based on this evaluation was the mass wasting potential in the upper banks.

Basic Water Chemistry

Table 4. Basic Water Chemistry

Total Dissolved Solids	ppm
pH	7.95
Water Temperature	9.6ºC
Salinity	ppm

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